



## WEIGHING THE EVIDENCE FOR A MASS EXTINCTION PART 1: IN THE OCEAN

### OVERVIEW

This hands-on activity supports the HHMI short film [The Day the Mesozoic Died](#), and in particular *Act 1: An Earth-Shattering Hypothesis*. Students will make observations and measurements on photomicrographs of research samples of fossilized protists called foraminifera (or forams). Their observations mirror those made by researchers documenting a mass extinction event at the end of the Cretaceous period about 66 million years ago.

### KEY CONCEPTS AND LEARNING OBJECTIVES

- There is a relationship between the geological time scale and the layered patterns of exposed rocks in the landscape, specifically that deeper layers are older.
- The change in foram sizes in for fossil record and extinction of a number of foram species is one piece of evidence suggesting that a mass extinction event occurred at the K-T boundary.

Students will be able to:

- measure and compare irregularly shaped objects (fossil forams), and to identify patterns that can be correlated to a dependent variable, in this case rock layers above and below the K-T boundary.
- convert scaled images and make direct size comparisons between specimens.
- collect and categorize multiple observations of forams.
- analyze information contained in graphs.

### CURRICULUM CONNECTIONS

Curriculum	Standards
NGSS (April 2013)	MS-LS2-1, MS-LS2-4, MS-LS4-1, MS-ESS2-2 MS-LS2.A, MS-LS2.C, MS-LS4.A, MS-S4.B, MS-LS4.C, MS-ESS1.C HS-LS2-1, HS-LS2-2, HS-LS4-2, HS-LS4-4, HS-LS4-5, HS-LS4.B, HS-LS4.C, HS-ESS1.C
Common Core (2010)	CCSS.ELA-Literacy.RST.6-8.3, CCSS.ELA-Literacy.RST.6-8.4, CCSS.ELA-Literacy.RST.6-8.7, CCSS.Math.Content.8.EE.C.7, CSS.Math.Practice.MP2, CCSS.Math.Practice.MP5, CCSS.ELA-Literacy.RST.9-10.3, CCSS.ELA-Literacy.RST.9-10.4, CCSS.ELA-Literacy.RST.9-10.7, CCSS.ELA- Literacy.RST.11-12.3, CCSS.ELA-Literacy.RST.11-12.4, CCSS.ELA-Literacy.RST.11-12.7, CCSS.Math.Content.HSN-Q.A.1
AP Biology (2012-13)	1.3.A, 1.A.4, 1.C.1, 2.D.1, 4.A.6, 4.B.3, 4.B.4
IB Biology (2009)	Topic 1, 5.4, D.2, G.1, G.2

### KEY TERMS

Cretaceous period, Tertiary period, Paleogene period, foraminifera, extinction, fossil, sediment

### TIME REQUIREMENTS

This lesson is designed for three 50-minute class periods including watching the 30 minute short film in class. To save time, you may wish to have your students watch the film at home.



## SUGGESTED AUDIENCE

This activity is appropriate for middle school life sciences and high school biology (all levels including AP and IB).

## PRIOR KNOWLEDGE

Students should know what a fossil is and understand that older fossils are found in deeper rock layers than younger fossils. Fossils provide information about what organisms existed at different times. Students should also be aware of Earth's geological time scale and that it is used to analyze the timing and relationships between past events.

## MATERIALS

Each pair of students will need:

- The student handout
- Foraminifera cards
- Ruler
- Scissors
- Color pencils (optional)
- Calculator (optional)

## TEACHING TIPS

### *Prior to Lesson:*

- Hang a poster showing the geologic time scale in your classroom and point it out to your students so that they can refer to it during the activity. You can also refer students to the Geological Society of America website at <http://www.geosociety.org/science/timescale>.
- It might be useful to provide students with some basic information about the geologic time scale.
  - Researchers have divided Earth's 4.6-billion-year history into a geologic time scale with divisions of varying increments reflecting major visible changes revealed in rock and sediment layers.
  - Geologic time is often called "deep time" to emphasize the very long scale of planetary history and to distinguish it from more common perceptions of time in terms of personal and human history.
  - Geologic time is divided into a four-level hierarchy of time units, which correspond to major geologic events, environmental conditions, and/or major changes in life forms. Eons, the largest division of geologic time, are divided into eras, which in turn are divided into periods, epochs, and ages.
- Students may notice that the Tertiary period is not found on more recent geologic time scales. In 1989, the International Union of Geological Sciences (IUGS) renamed the interval between the Cretaceous and the Quaternary periods as the Paleogene (Pg) and Neogene periods. As a result, recent papers refer to the K-T boundary as the K-Pg boundary. In this activity we refer to it as the K-T boundary, as that was the term used when the asteroid impact hypothesis was proposed.

### *Part 1*

- Do the foram-sorting activity and have students answer questions 1-6 **before** watching the film. Show the film after question #6 or assign the film as homework.
- Consider asking students to check in after completing the measurements and conversion for the first foram (question 6) to make sure they're doing the calculation correctly before doing forams 2-4.
- If assigning the film for homework, you may want to provide students with the URL that leads directly to the film (<http://media.hhmi.org/mesozoic/index.html>). Alternatively, you can download the film and repost onto a separate website. This will minimize the chance of students finding and using the teacher version of this document.



**ANSWER KEY**

**Part 1: Observing and Measuring the Forams Near the K-T Boundary**

You are a scientist studying forams and you have excavated fossil forams just below and just above the K-T boundary from an ocean drilling site off the coast of Florida. The scanning electron microscope images on the cards are fossilized foram tests. Separate the cards into Cretaceous and Tertiary piles.

**Circulate around the classroom. Make sure students have one pile that contains only Cretaceous forams and a second pile that contains only Tertiary forams. Make sure that students understand that even though these cards are labeled Cretaceous and Tertiary, these particular forams are found very close to the K-T boundary. This means that the forams are found in the late Cretaceous period and early Paleogene (Tertiary) period.**

1. Which pile of cards represents the older forams? **Cretaceous**
2. The younger forams? **Tertiary**
3. Which foram species are generally larger: those from the Cretaceous period, just below the K-T boundary, or those present in the Tertiary period, just above the K-T boundary?

**The foram species found during the Cretaceous period (just below the K-T boundary) are generally larger than those from the Tertiary period (just above the boundary).**

4. The outward appearance, or morphology, of forams is highly variable. Other than the forams' sizes, describe other morphological features that are different between forams from the Cretaceous and Tertiary periods.

**Many of the Cretaceous forams are more elaborate in shape than the Tertiary forams.**

5. In one or two sentences, summarize how forams differ across the K-T boundary. Refer to the observations you have made so far in questions 3 and 4.

**The forams that exist after the K-T boundary are smaller and less elaborate than those found before the K-T boundary. Note: Students should be made aware that answers such as "large forams went extinct" are inferences, not observations.**

You would like to look at forams from other K-T boundary sites to see whether the differences you observed between the Cretaceous and Tertiary forams are also observed in other parts of the world. A colleague has extracted forams from soils just below and above the K-T boundary at separate site and she has sent those images to you for you to analyze.

6. You realize that the images were taken at different magnifications, so you are unable to directly compare foram sizes by eye. However, you can calculate the exact size of the forams by using the scale bar. Follow the directions below for step-by-step instructions on how to calculate the foram size for Sample 1.

**Sample 1  
Cretaceous**



Scale bar →  0.1mm

- a. Measure the foram's **maximum length** in centimeters (cm). The maximum length is the longest length of the foram (The bold line, drawn on the foram above, show the maximum length.) **3.1cm**
- b. Measure the scale bar in cm. This line represents 0.1 millimeters (mm). **0.6cm** = 0.1mm
- c. Calculate the conversion value. To do this, determine how many mm is equal to one centimeter.



Hint: To calculate how many mm equals one cm, you divide both sides of the equation by the length of the scale bar. For example, if the scale bar was 5cm in length (5cm = 0.1mm), you would divide by 5 on both sides of the equation ( $\frac{5\text{cm}}{5} = \frac{0.1\text{mm}}{5}$ ) to have 1 cm = 0.02mm.

1cm = **0.167mm**

- d. Calculate the exact size of the forams in mm. To do this, take the maximum length of the foram (answer in a) and multiply by the conversion factor (answer to c). What is the size of sample #1? **3.1 x 0.167 = 0.517mm**. Write the actual foram size in mm in Table 1 for sample 1.
- e. Repeat this process for samples 2-4 shown below. Write the actual size of the forams in table 1.

**Sample 2**  
Tertiary



0.1mm

**Sample 3**  
Cretaceous



0.1mm

**Sample 4**  
Tertiary



0.1mm

**Table 1**

Sample number	Age of rock where foram was found	Foram maximum length (cm)	length of scale bar (cm)	Conversion Value (mm/cm)	Actual foram size (mm)
1	Cretaceous	3.1	0.6	0.167	0.517mm
2	Tertiary	2.6	1.4	0.071	0.186mm
3	Cretaceous	2.9	0.6	0.167	0.483mm
4	Tertiary	2.2	2.1	0.048	0.105mm

- 7. Compare your foram samples (on the cards) to your colleague's. Write your observations of how forams differ across the K-T boundary. Provide specific measurements or calculations when appropriate.

My Samples	My Colleague's Samples
This should be similar to their answer in question #5. Students should note that the Cretaceous Forams are larger and more elaborate than the Tertiary Forams which are smaller and less elaborate	Students should note that the two Cretaceous samples are larger (0.517mm and 0.483mm across its maximum length) than the forams found in the Tertiary rocks (0.186mm and 0.105mm).



8. Complete the following statement:

My samples are similar to my colleagues in that **at both sites, forams from the Cretaceous period (just below the K-T boundary) are larger than the forams from the Tertiary period (just above the K-T boundary).**

9. You decide you need more data in order to make a conclusion. You analyze 200 forams both at your site and your colleague's site from above and below the K-T boundary and your data is very similar to what you described above. You then analyze other five other sites scattered throughout the globe and also observe similar patterns. What conclusions can you draw from such observations?

**Whatever happened between the Cretaceous and Tertiary period to cause the change in size of the forams, must have occurred in other parts of the world.**

## Part 2: Analyzing Data on Forams Found Near the K-T Boundary

10. How many foram species are represented in Figure 2? **42**

11. (a) Based on the figure, how many different species of Cretaceous forams appear to have gone extinct at the K-T boundary? **33 (Note: 2 species went extinct before the K-T boundary.)**

(b) Explain how you can tell from the figure that these foram species became extinct.

**The lines on the graph for these species stop right at the K-T boundary and do not extend farther.**

12. (a) How many species appear to have survived the K-T event? **2**

(b) Explain how you can tell from the figure that these foram species survived.

**The lines on the graph for these species span both the Cretaceous and Tertiary periods through the K-T boundary.**

13. Calculate the percentage of forams that went extinct at the K-T boundary.  **$33/35 = 94\%$  (Note: there are 35 species of forams at the K-T boundary; 33 went extinct and 2 survived.)**

14. Calculate the percentage of forams that survived the K-T event.  **$2/35 = 6\%$**

15. The graph shows that some species were found only in the Tertiary period and not in the Cretaceous period. What do you think these species represent?

**The unique species found in Tertiary samples are likely new species descended from foram species that survived. Students may also write that forams that did not live in this particular location during the Cretaceous period moved to this location sometime after the K-T event. Both answers are acceptable.**

16. Based on the film, what event do scientists think caused the extinction of a large percentage of forams?

**An asteroid struck Earth. Students may also elaborate on the effects of that asteroid strike. They include plumes of smoke obliterating the sun, causing shutdown of photosynthesis, and acid rain due to increased sulfuric acid in the air.**



### Part 3: Size Matters

17. In Part 1, you looked at the differences in size between forams in the Cretaceous and Tertiary periods. Based on your data were small or large forams more likely to survive after the K-T event?

**Students should say that small forams are more likely to survive, unless they did not do Part 1 correctly.**

18. Why do you think size would make a difference in the ability of some foram species to survive?

**Students' answers will vary. They could, for example, speculate that it might be due to the food available and what types of food specific forams prefer to eat.**

19. The table below describes some differences between large and small forams. Considering the information in the table above, explain how some of the characteristics of large and small foram species could have made them more likely to survive an extinction event. (Hint: An extinction event is usually triggered by rapid environmental change; organisms more likely to adapt more quickly tend to survive.)

**Students' answers will vary. The key is that students understand that the ability to reproduce more quickly is an advantage at times of rapid environmental change. Organisms that reproduce more quickly are better able to adapt to a new environment than slower growing organisms. Another point to mention is that "generalists" are better able to survive if their primary food sources disappear, compared to specialists. This is not the case at times of environmental stability. During those times, larger, more complex, and specialized forams with symbiotic relationships with algae are more likely to survive.**

20. The images below are composite photographs showing forams to scale above and below the K-T boundary. Which image, the one on the right or the left, shows fossil forams found below the K-T boundary? Support your answer with information from this activity and the film.

**The right-hand image shows forams found below the K-T boundary. They are much larger and more complex in shape than the forams shown on the left.**

21. Extinctions are a normal part of evolutionary history. The K-T extinction is considered to be one of five major mass extinction events in Earth's history. From what you have learned doing this activity and from the film, why is this considered to be a major mass extinction event?

**Many organisms became extinct in a short amount of time; a significant part of all life on Earth became extinct.**

### REFERENCES

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