



dino doom

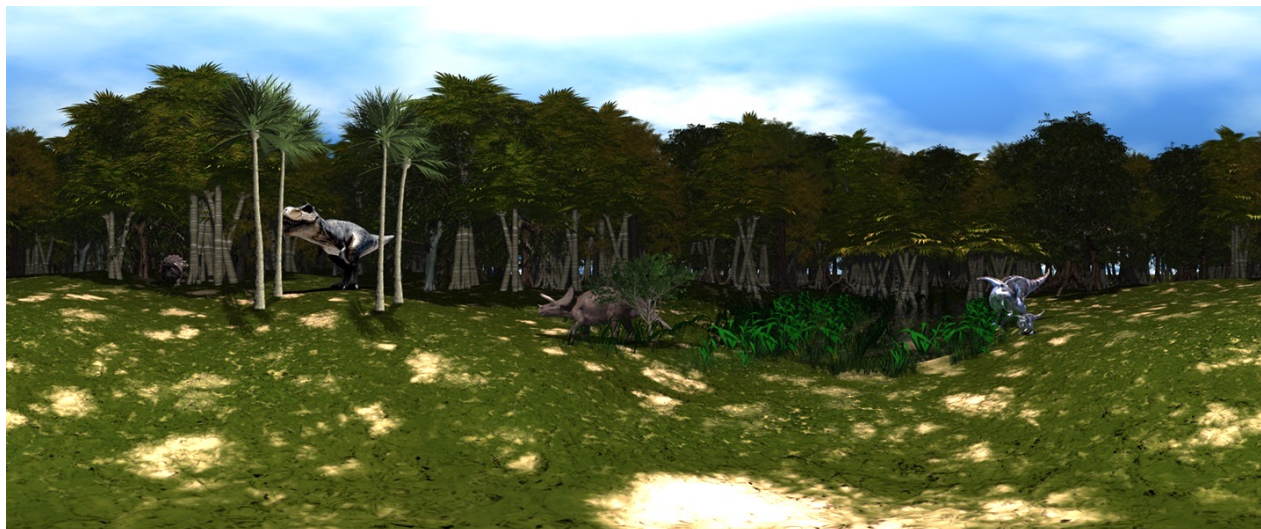


Dino Doom

Grades: 9-12

Prep Time: ~10 min

Lesson Time: 150 minutes



WHAT STUDENTS DO: Explore the extinction event at the KPg boundary.

Students will explore sites around the world searching for clues to the mass extinction event that occurred 66 mya. They will collect evidence from each site to tell a piece of the KPg story. Finally, students will combine all of the evidence to explain how natural events impact life on Earth.

NRC FRAMEWORK/NGSS CORE & COMPONENT QUESTIONS

HOW AND WHY DO ORGANISMS INTERACT WITH THEIR ENVIRONMENT AND WHAT ARE THE EFFECTS OF THESE INTERACTIONS?

NGSS Core Question: LS2: Ecosystems: Interactions, Energy, and Dynamics

How do organisms interact with the living and nonliving environments to obtain matter and energy?

NGSS LS2.A: Interdependent Relationships in Ecosystems

What happens to ecosystems when the environment changes?

NGSS LS2.C: Ecosystem Dynamics, Functioning, and Resilience

INSTRUCTIONAL OBJECTIVES (IO)

Students will be able to

IO1: Construct an explanation, using empirical and observational data from the rock record, for the impact of a natural event on the carrying capacities of an ecosystem and the natural selection that results from limited resources.

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HOW CAN THERE BE SO MANY SIMILARITIES AMONG ORGANISMS YET SO MANY DIFFERENT KINDS OF PLANTS, ANIMALS, AND MICROORGANISMS?

NGSS Core Question: LS4: Biological Evolution: Unity and Diversity

How does the environment influence populations of organisms over multiple generations?

NGSS LS4.C: Adaptation

HOW AND WHY IS EARTH CONSTANTLY CHANGING?

NGSS Core Question: ESS2: Earth Systems

How do Earth's major systems interact?

NGSS ESS2.A: Earth Materials and Systems

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1.0 Materials

Required Materials:

Please supply:

- Computer or Laptop – 1 per student
- Supported Browsers: Chrome; Edge; Firefox; Safari

Please Print:

From Student Guide

- (A) Story of Fossils (Section 1) Recording Sheet – 1 per student
- (B) Origin of Iridium (Section 2) Recording Sheet – 1 per student
- (C) Finding the Diameter of the Asteroid (Section 3) Recording Sheet – 1 per student
- (D) Locating the Crater (Section 4) Recording Sheet – 1 per student
- (E) Mass Extinction (Section 5) Recording Sheet – 1 per student
- (F) Adaptation and Recovery (Section 6) Recording Sheet – 1 per student
- (G) Dino Doom Evaluation – 1 per student

Optional Materials:

From Teacher Guide

- (A) Story of Fossils (Section 1) Recording Sheet (KEY)
- (B) Origin of Iridium (Section 2) Recording Sheet (KEY)
- (C) Finding the Diameter of the Asteroid (Section 3) Recording Sheet (KEY)
- (D) Locating the Crater (Section 4) Recording Sheet (KEY)
- (E) Mass Extinction (Section 5) Recording Sheet (KEY)
- (F) Adaptation and Recovery (Section 6) Recording Sheet (KEY)
- (G) Dino Doom Evaluation (KEY)

From Alignment Document

- (N) Dino Doom Alignment Rubrics

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2.0 Lesson Timeline

Dino Doom Lesson Timeline:

Time:

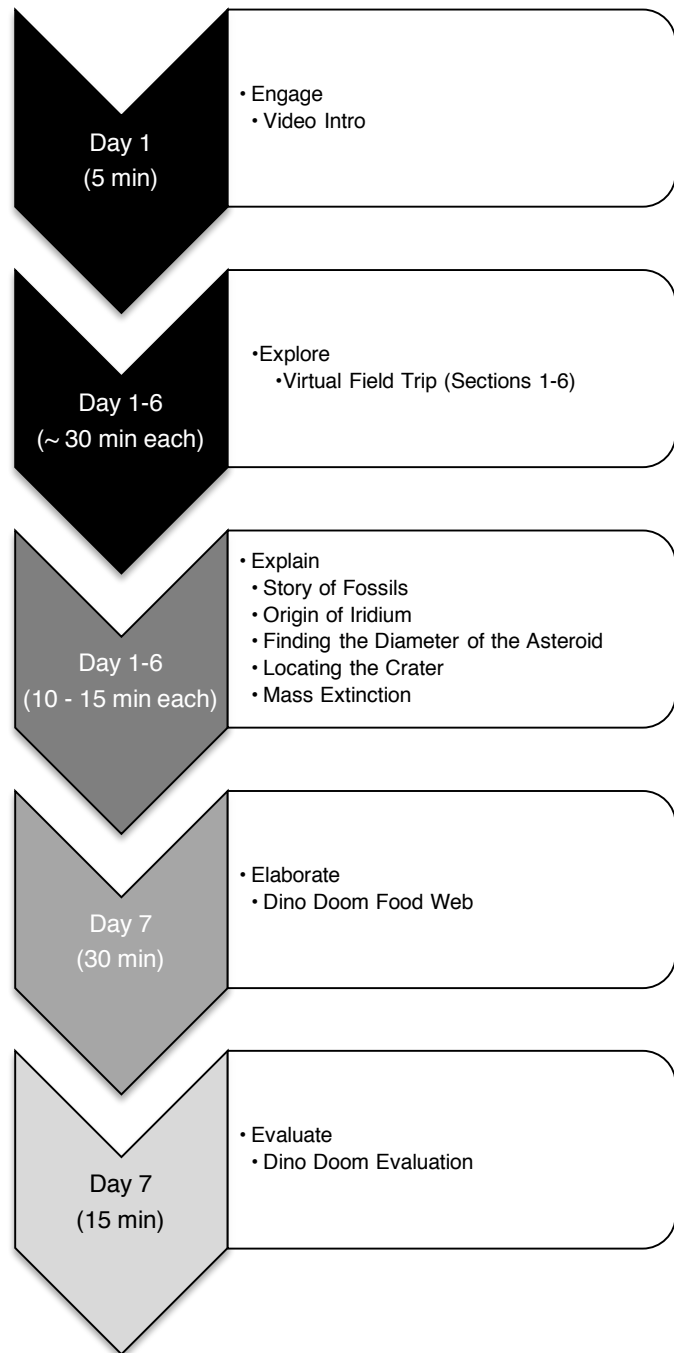
- 290 - 320 minutes

Materials:

- Student Guide pages

5-E Inquiry Process:

- The arrow color represents the 5-E step students will be primarily engaging in for that class session



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3.0 Vocabulary

analyze	consider data and results to look for patterns and to compare possible solutions
beds	a layer of rock that is distinct from other layers above and below it
carrying capacity	the maximum number of organisms of a species within a region that can be supported without environmental degradation
calcium carbonate	a white, insoluble solid occurring naturally as chalk, limestone, marble, and calcite, and forming mollusk shells and stony corals
concentration	the amount of solute per unit volume of solution
density	a measure of mass per unit volume that represents the compaction of a substance
diversity	variability among all living organisms
elemental abundance	a quantity of elements present in a specific area, volume, or sample
empirical evidence	knowledge gained through direct or indirect observation
explanations	logical descriptions applying scientific information
extinction	the disappearance of a species from Earth
foram	a class of single-celled microorganisms known as protists; short for foraminifera
igneous rock	rock that is formed through the cooling and solidification of magma or lava
iridium	one of the rarest elements on Earth; a platinum ore
limestone	a hard sedimentary rock, composed mainly of calcium carbonate or dolomite, formed mainly through the accumulation of organic remains such as shells or coral
metamorphic rock	previously formed rock that has been changed through heat and/or pressure
observations	specific details recorded to describe an object or phenomenon
outcrop	a rock formation that is visible at the surface
ppb	short for "parts per billion"; representing the concentration
predict	to declare what will happen based on reason and knowledge
scale	a comparative relation between objects such as size or distance
sedimentary rock	rock formed from the cementation of material deposited in oceans or on Earth's surface

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4.0 Procedure

PRIOR KNOWLEDGE & SKILLS

- A. Food Webs
- B. Relative Age Dating
- C. Evolution Concepts
- D. Geologic Time Scale
- E. Carrying Capacity

PREPARATION

- A. Reserve computers or tablets for Exploration Days.
- B. Enroll students in the Dino Doom Virtual Field Trip Lesson if you would like to make their progress available outside of class and track the analytics of their learning behavior.
- C. PRINT THE FOLLOWING:
 - Student **Recording Sheets (A-G)** – 1 per student

STEP 1: ENGAGE (~5 minutes)

Set Up Dino Doom Experience

- A. Hand out or assign computers and ask students to access the [Dino Doom VFT](#). (This is the full version).
- 🕒 **Time Management Tip:** The version found on the Infiniscope website is the full VFT. For time management purposes, each section of the larger VFT has been broken out for you. Please use the following links to access each section individually.
 - [Section 1](#)
 - [Section 2](#)
 - [Section 3](#)
 - [Section 4](#)
 - [Section 5](#)
 - [Section 6](#)
- B. Students will access a video introduction in the beginning of the Dino Doom VFT (full version and Section 1), setting the stage to answer the questions:
 - a. What happened to the dinosaurs?
 - b. What event triggered this mass extinction?
 - c. How did we come to discover what happened 66 million years ago?"

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STEP 2: EXPLORE (180 minutes for all sections of VFT)

Dino Doom Virtual Field Trip

- A. Students will complete the VFT in sections, alternating between Explore and Explain.
- B. Use the following links to access each section individually and reference the timeline on page 3 to judge the amount of time needed to complete each section.
 - [Section 1](#)
 - [Section 2](#)
 - [Section 3](#)
 - [Section 4](#)
 - [Section 5](#)
 - [Section 6](#)

- 🍏 **Classroom Management Tip:** If the next class will be using the same computers, ask students to click the profile icon in the upper right corner and select “Restart Lesson.” This will ensure your next group starts at the beginning of the VFT.
- 🍏 **Teacher Tip:** If students seem to be stuck in the activity, it isn’t responding in a way that seems correct, or if an error occurs, students can attempt to refresh their browser or click the profile icon in the upper right corner and select “Restart Lesson.” “Restart Lesson” will clear all of their progress and bring them back to the start screen. Hitting the browser’s “Refresh” button will not restart the activity.
- 🍏 **Teacher Tip:** If you would like to analyze student interactions in this activity, you can sign up to join the [Infiniscope Teaching Network](#) and enroll your class into the activity. By enrolling, you will gain access to the analytics of the activity by student to see how students progressed through the activity. You also have the ability to adopt the activity and adapt it to the specific needs of your classroom, school, or community.

STEP 3: EXPLAIN (~ 60-90 minutes)

Reading Rock Evidence

- A. Hand out **(A) Story of Fossils (Section 1) Recording Sheet**. Students will complete this Recording Sheet as they work through Section 1 of the VFT.
- B. Hand out **(B) Origin of Iridium (Section 2) Recording Sheet**. Students will complete this Recording Sheet as they work through Section 2 of the VFT.
- C. Hand out **(C) Finding the Diameter of the Asteroid (Section 3) Recording Sheet**. Students will complete this Recording Sheet as they work through Section 3 of the VFT.
- D. Hand out **(D) Locating the Crater (Section 4) Recording Sheet**. Students will complete this Recording Sheet as they work through Section 4 of the VFT.

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- E. Hand out **(E) Mass Extinction (Section 5) Recording Sheet**. Students will complete this Recording Sheet as they work through Section 5 of the VFT.
 - F. Hand out **(F) Adaptation and Recovery (Section 6) Recording Sheet**. Students will complete this Recording Sheet as they work through Section 6 of the VFT.
 - G. Many of these questions were addressed within the Virtual Field Trip. They should be a review of concepts for the students. You may also choose to discuss in class as opposed to completing the Recording Sheet.
- 🕒 **Time Management Tip:** If you have chosen to enroll students in class through the Infiniscope Teaching Network and you run out of class time for students to complete this section they can log in at home or at school at another time and pick up where they left off.

STEP 4: ELABORATE (~ 30 minutes)

KPg Food Web

- A. After exploring the Dino Doom VFT's, ask students to recall what information is contained in a food web. Challenge them to create a food web that would represent life before the impact. Once it is completed, put an X across the producers affected by the meteor impact and color in the primary consumers, secondary consumers and apex predators affected by the loss of those producers. Put an X across any organisms that go extinct in the food web. Additional research may be necessary to complete this task.

STEP 5: EVALUATE (~ 15 minutes)

Evaluate Dino Doom

- A. Take a few minutes to review **carrying capacity** with students and discuss their findings during the Dino Doom Exploration.
- B. Hand out **(G) Dino Doom Evaluation**.

5.0 Evaluation/Assessment

Use the **(N) Dino Doom Alignment Rubric** as a formative assessment, allowing students to improve their work and learn from mistakes during class. The rubric evaluates the activities using the Learning Outcomes identified in the Alignment Documents for the activity.

6.0 Extensions

1. Investigate other mass extinction events that have occurred on Earth and identify the organisms that inherit the Earth as a result of the extinction event.

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(A) Story of Fossils (Section 1) Recording Sheet

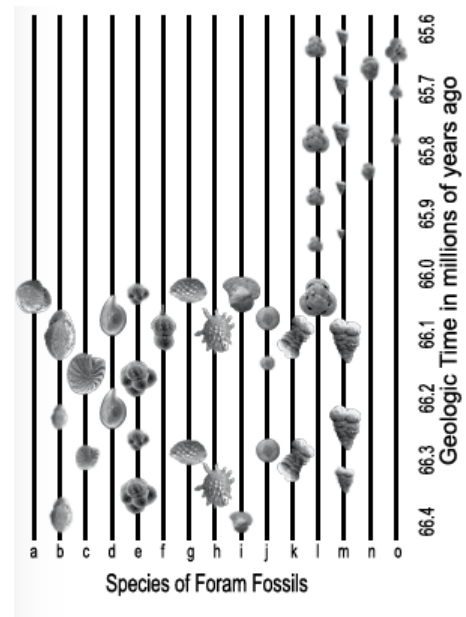
Name: _____

Instructions:

Complete the following based on what you've discovered in the Dino Doom VFT.

1. Describe how relative age dating is applied to the fossil record.

2. Use the graph to explain how forams evolved as a result of the impact.



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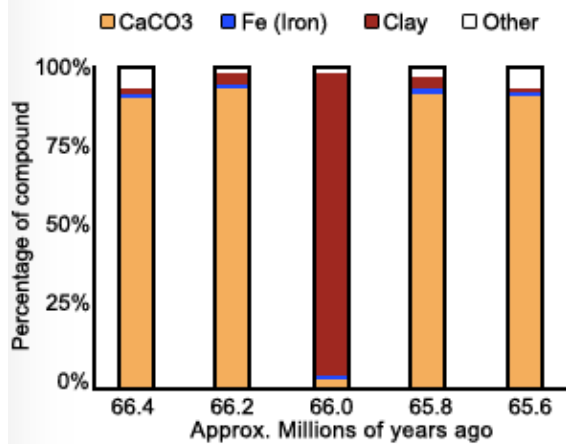


(B) Origin of Iridium (Section 2) Recording Sheet

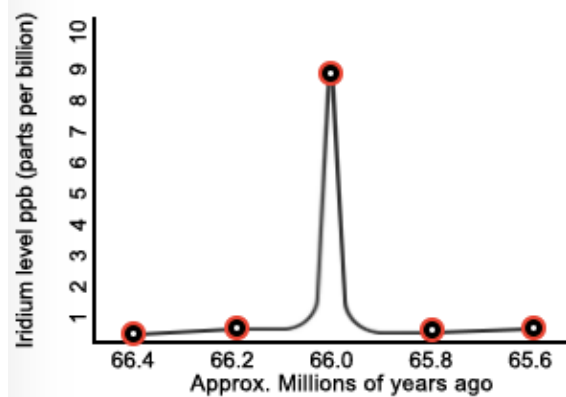
Name: _____

Complete the following based on what you've discovered in the Dino Doom VFT.

Compositional Analysis and Iridium Abundance



1. Explain what these graphs represent?



2. Describe iridium levels you found in Zumaia, Spain, Stevns Klint, Denmark, and Hell Creek, USA.

3. What was the purpose of calculating the ratio of iridium AT the boundary vs AWAY from the boundary?

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(C) Finding the Diameter of the Asteroid (Section 3) Recording Sheet

Name: _____

Complete the following based on what you've discovered in the Dino Doom VFT.

What are the steps Max used to find the diameter of the crater, which may have been responsible for the extinction event at the KPg boundary?

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____



(D) Locating the Crater (Section 4) Recording Sheet

Name: _____

Complete the following based on what you've discovered in the Dino Doom VFT.

1. Circle all of the locations that are possible impact sites based on the diameter of the crater?

- | | | |
|---------------|------------|-------------|
| Acraman | Aorounga | Araguainha |
| Barringer | Chicxulub | Clearwater |
| Gossess Bluff | Lonar | Manicouagan |
| Popigai | Roter Kamm | Siljan Ring |
| Sudbury | Vredefort | |

2. Which crater is the most likely candidate based on its age?

3. What is the significance of the Hvar Breccia found in Croatia?



(E) Mass Extinction (Section 5) Recording Sheet

Name: _____

Complete the questions below based on what you've discovered in the Dino Doom VFT.

1. Describe the characteristics that enabled organisms to survive the extinction event.

2. Describe the characteristics of organisms that went extinct or were dramatically impacted by the changing environment.

3. Why were mammals able to evolve and "inherit the Earth?"

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(F) Adaptation and Recovery (Section 6) Recording Sheet

Name: _____

Complete the questions below based on what you've discovered in the Dino Doom VFT.

1. Compare and contrast the organisms observed in Hell Creek above and below the boundary.

2. In terms of life on Earth, why is this boundary significant?

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(G) Dino Doom Evaluation

Name: _____

Respond to the following:

Construct an explanation for the effects of the impact on the carrying capacity of the global ecosystems and the natural selection that resulted from the limited resources. In your explanation include empirical and observational data from the locations you've explored around the world and an overview of how the climate changed as a result of the impact. (Use an extra sheet of paper if you need more room.)

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(A) Story of Fossils (Section 1) Recording Sheet (KEY)

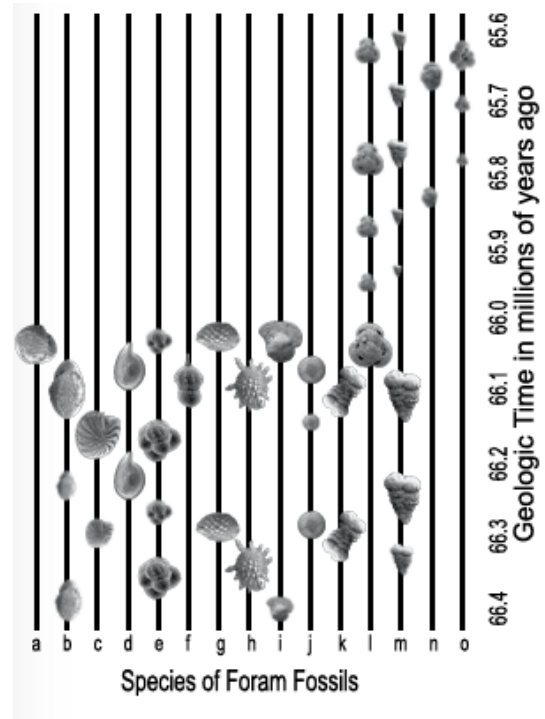
Instructions:

Complete the following based on what you've discovered in the Dino Doom VFT.

- Describe how relative age dating is applied to the fossil record. Fossils lower in the rock record are older than those higher in the rock record. The layers can be followed to see the evolution of life across time.

- Use the graph to explain how forams evolved as a result of the impact.

The graph demonstrates the diversity and size of forams before and after the mass extinction event. Here we can see there was great diversity and large size prior to 66 mya. All but 2 species of foram went extinct at 66 mya and those we see after 66 mya are significantly smaller and less varied.



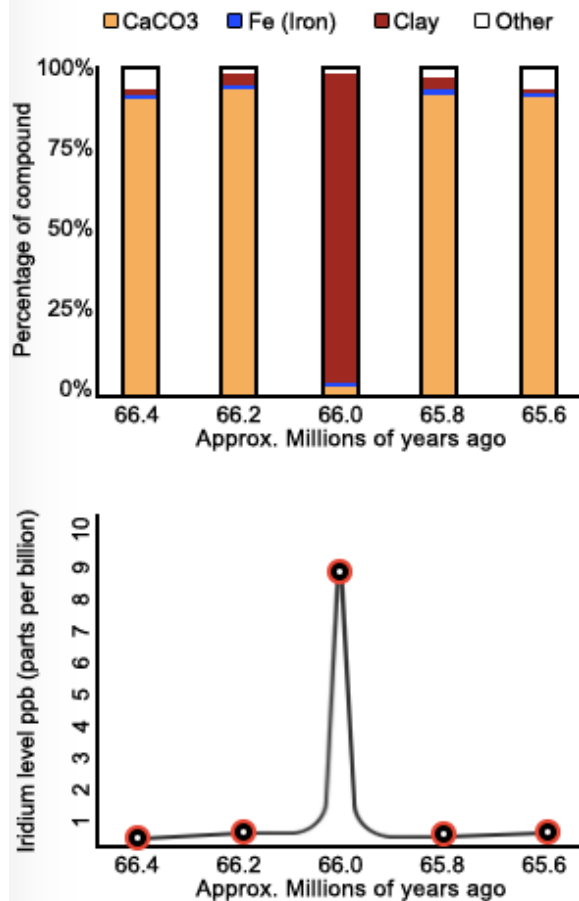
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(B) Origin of Iridium (Section 2) Recording Sheet (KEY)

Complete the following based on what you've discovered in the Dino Doom VFT.

Compositional Analysis and Iridium Abundance



1. Explain what these graphs represent?

The graph shows the amount of iridium found in the rock layers compared to rock composition. The clay layer contains the highest iridium reading at 66 mya. The surrounding layers are primarily CaCO₃ and Fe with low iridium levels.

2. Describe iridium levels you found in Zumaia, Spain, Stevns Klint, Denmark, and Hell Creek, USA.

Iridium levels vary among locations, but they all demonstrate an iridium spike at 66 mya.

3. What was the purpose of calculating the ratio of iridium AT the boundary vs AWAY from the boundary?

The ratio shows the overall comparison of iridium at the 66 mya mark vs the layers surrounding it (older & younger than 66 mya).

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**(C) Determining the Diameter of the Asteroid (Section 3) Recording Sheet (KEY)**

Complete the following based on what you've discovered in the Dino Doom VFT.

What are the steps Max used to find the diameter of the crater, which may have been responsible for the extinction event at the KPg boundary?

1. *Find average iridium in ppb*
2. *Convert average iridium to mass*
3. *Find how much iridium fell to Earth*
4. *Find the asteroid's mass*
5. *Find the volume of the asteroid*
6. *Find the diameter of the asteroid*
7. *Find the diameter of the crater*

**(D) Locating the Crater (Section 4) Recording Sheet (KEY)**

Complete the following based on what you've discovered in the Dino Doom VFT.

1. Circle all of the locations that are possible impact sites based on the diameter of the crater.

Acraman

Aorounga

Araguainha

Barringer

Chicxulub

Clearwater

Gossess Bluff

Lonar

Manicouagan

Popigai

Roter Kamm

Siljan Ring

Sudbury

Vredefort

2. Which crater is the most likely candidate based on its age? Chicxulub

3. What is the significance of the Hvar Breccia found in Croatia?

The breccia contains fossils and rock fragments from the Late Cretaceous. This breccia was formed all at once from a mega-tsunami that moved debris across the ocean floor to Hvar 66 mya. It's another piece of evidence for the impact 66 mya.



(E) Mass Extinction (Section 5) Recording Sheet (KEY)

Complete the questions below based on what you've discovered in the Dino Doom VFT.

1. Describe the characteristics that enabled organisms to survive the extinction event.

Lived in freshwater swamps, were small, could hide in the environment, could burrow underground, could hibernate, were generalists eating a variety of foods, predators died off, could reproduce quickly

2. Describe the characteristics of organisms that went extinct or were dramatically impacted by the changing environment.

Large bodied animals, unable to hide, needed large quantities of food to survive, slow reproductive rates, usually a specialist in types of food they ate, relied on plankton as a food source

3. Why were mammals able to evolve and "inherit the Earth?"

Dinosaurs and other large reptiles died out opening up new niches



(F) Adaptation and Recovery (Section 6) Recording Sheet (Key)

Complete the questions below based on what you've discovered in the Dino Doom VFT.

1. Compare and contrast the organisms observed in Hell Creek above and below the boundary.

Organisms above the boundary were small and included mammals, turtles, and reptiles.

Below the boundary included dinosaurs.

2. In terms of life on Earth, why is this boundary significant?

The boundary represents the extinction event that caused the loss of the dinosaurs and the ability for mammals to inherit the Earth.

**(G) Dino Doom Evaluation (KEY)**

Respond to the following:

Construct an explanation for the effects of the impact on the carrying capacity of the global ecosystems and the natural selection that resulted from the limited resources. In your explanation include empirical and observational data from the locations you've explored around the world and an overview of how the climate changed as a result of the impact. (Use an extra sheet of paper if you need more room.)

Responses could include some of the following:

- The carrying capacity of dinosaurs and many other organisms was reduced to zero as they became extinct. The carrying capacity of other organisms remained the same or experienced a dip as their population remained the same or decreased slightly.
- Data used to support this claim includes the loss of dinosaurs and many other organisms at the boundary and the population maintenance of the remaining organisms past the boundary.
- Many larger organisms could not survive due to the amount of food they needed to consume to sustain life, while smaller organisms survived because they needed less food to sustain life.
- Organisms that could burrow into the mud or hide in the environment were able to survive the event.
- Organisms that reproduce rapidly could repopulate quickly and were able to maintain populations through the event.
- Organisms that could eat a wide variety of food were more suited to the changing environment and able to find food regardless of the conditions while specialists struggled to find food as their food sources died off.