Mass Extinction Lesson Description and Keys

Explore how your vertebrate ancestors survived three mass extinctions and gave rise to the great variety of groups alive on Earth today. Learn what adaptations helped make some groups more successful than others. Test your ability to predict which physical, behavioral and physiological traits were instrumental in helping some groups cope with environmental changes. Find out how to survive extinction!

Central Question: How have environmental changes during mass extinctions caused some vertebrates and their ancestors to go extinct?

Instructional Objective: Evaluate how changes in environmental conditions during mass extinctions may result in the appearance of new species and the extinction of other species over time.

Learning Outcomes

Learning Outcome #1: Explain the advantages and disadvantages of specific adaptive traits for species survival.

Learning Outcome #2: Evaluate and categorize key mammalian and reptilian adaptive traits.

Learning Outcome #3: Describe environmental changes and how they led to mass extinctions.

Prerequisites

- Traits (anatomical or structural, behavioral, physiological)
- Extinction
- Geologic time
- Ecosystem

Surviving Mass Extinctions

Grades: 10-12   Prep time: ~15 min   Lesson time: 5 days

WHAT LEARNERS DO: Play the online game *Surviving Extinction*.

Through playing *Surviving Extinction,* learners follow vertebrate evolution through the last 350 million years to discover how mass extinctions affected the evolution of mammals, reptiles and their ancestors.

NRC FRAMEWORK/NGSS CORE & COMPONENT QUESTIONS

HOW DID ENVIRONMENTAL CHANGES DURING MASS EXTINCTIONS AFFECT THE SURVIVAL OF VERTEBRATE GROUPS OVER TIME?

NGSS Core Question: HS.Natural Selection and Evolution, Adaptation

What is the evidence for the effects of environmental changes on the survival of mammals, reptiles and birds over the past 350 million years?

What were the causes of mass extinctions during the Mesozoic Era?

NGSS DISCIPLINARY CORE IDEAS

HS-LS4-5

Students who demonstrate understanding can:

HS-LS4-5. **Evaluate the evidence supporting claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.** [Clarification Statement: Emphasis is on determining cause and effect relationships for how changes to the environment such as deforestation, fishing, application of fertilizers, drought, flood, and the rate of change of the environment affect distribution or disappearance of traits in species.]

The performance expectation above was developed using the following elements from *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Engaging in Argument from Evidence Engaging in argument from evidence in 9-12 builds on K-8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current or historical episodes in science. Evaluate the evidence behind currently accepted explanations or solutions to determine the merits of arguments.	**LS4.C: Adaptation** - Changes in the physical environment, whether naturally occurring or human induced, have thus contributed to the expansion of some species, the emergence of new distinct species as populations diverge under different conditions, and the decline — and sometimes the extinction — of some species. - Species become extinct because they can no longer survive and reproduce in their altered environment. If members cannot adjust to change that is too fast or drastic, the opportunity for the species' evolution is lost.	**Cause and Effect** Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

INSTRUCTIONAL OBJECTIVE (IO)

Learners will be able to

IO1: Evaluate how changes in environmental conditions during mass extinctions may result in the appearance of new species and the extinction of other species over time.

1.0 Materials

Required Materials:

Please Supply:

- Computer or Laptop   - 1 per learner
  - Supported Browsers: Chrome or Firefox
- Headphones or earbuds   - 1 per learner

Please Print:

From Learner Guide

(A) Anthropocene Recording Sheet	- 1 per learner
(B) Mass Extinction (Mammals) Recording Sheet	- 1 per learner
(C) Mass Extinction (Dinosaurs/Birds) Recording Sheet	- 1 per learner
(D) Mass Extinction Causes and Ranking Recording Sheet	- 1 per learner
(E) Surviving Extinction Tally Sheet (Optional)	- 1 per learner
(F) Mass Extinction Survey	- 2 per learner

HHMI Interactives used in the worksheets:

(A) Anthropocene Recording Sheet
       The Anthropocene: Human Impact on the Environment
         https://media.hhmi.org/biointeractive/click/anthropocene/

(D) Mass Extinction Causes and Ranking Recording Sheet
       https://media.hhmi.org/biointeractive/click/extinctions/

Mass Extinction Lesson Timeline:
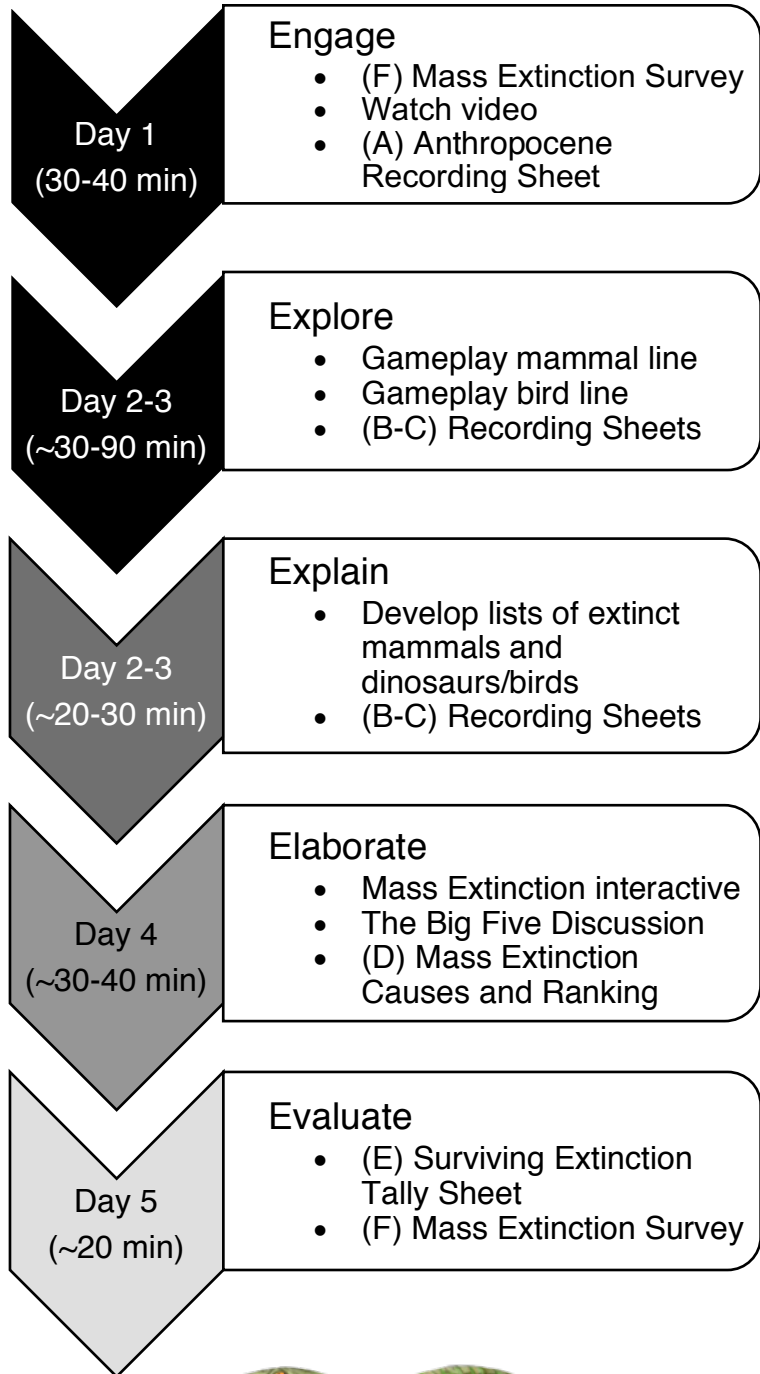
Time:

- 5 days

Materials:

- Laptop computer
- Internet connection
- Student Guide pages

5-E Inquiry Process:

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

Day 1
(30-40 min)

Engage
- (F) Mass Extinction Survey
- Watch video
- (A) Anthropocene Recording Sheet

Day 2-3
(~30-90 min)

Explore
- Gameplay mammal line
- Gameplay bird line
- (B-C) Recording Sheets

Day 2-3
(~20-30 min)

Explain
- Develop lists of extinct mammals and dinosaurs/birds
- (B-C) Recording Sheets

Day 4
(~30-40 min)

Elaborate
- Mass Extinction interactive
- The Big Five Discussion
- (D) Mass Extinction Causes and Ranking

Day 5
(~20 min)

Evaluate
- (E) Surviving Extinction Tally Sheet
- (F) Mass Extinction Survey

(A) **Anthropocene** *Recording Sheet - Key*

Name: _____

Open up **The Anthropocene: Human Impact on the Environment** on your computer: (https://media.hhmi.org/biointeractive/click/anthropocene/)

1. Check off the impacts as you view them and then rank them in order according to what you think are the **three biggest impacts** on Earth today and **explain why** you feel this way. 1 = highest impact, 2 = lower impact, and 3 = lowest impact
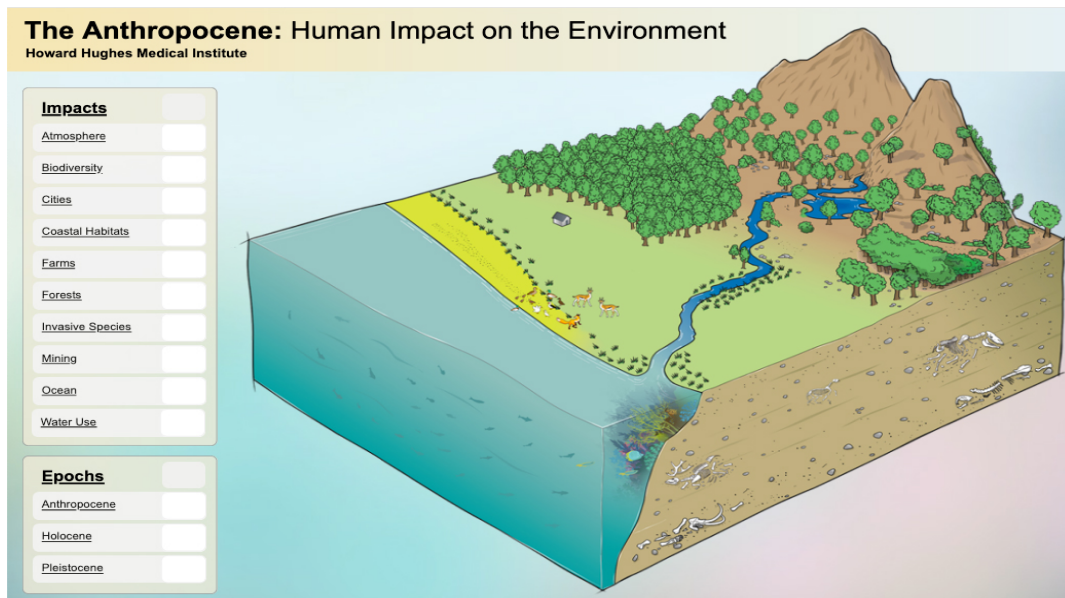
Note: There can be any combination of answers below and it's up to the learn to justify and explain their ranking. You can also pose the question of what happens when there is more than one impact in an area like most places today.

	Impacts	Reason(s) behind your ranking?
1	*Cities*	*Building of cities uses large areas of land, generates pollution and destroys wildlife habitats.*
2	*Mining*	*Mining destroys large areas of wildlife habitats and can generate toxic chemical runoff.*
3	*Forests (logging)*	*Logging destroys forest habitats, degrades the land and cause more soil erosion.*

(B) Mass Extinction (Mammals) Recording Sheet - Key

Name: _____

As you are following one of the **mammal pathways** in the *Surviving Extinction* game, record the age, name, environmental changes that were occurring during the time of the extinction, and the theory for the group's extinction for each *Extinction Animal* you encounter along the pathway. Also, pay attention to the animals that rose to dominance after the extinction event. If you miss the extinction animals, you can go back down your pathway and choose other animals to find them.

No.	Time of extinction (millions of years)	Extinction Animal Name	Environmental changes during time of extinction	Theory for group's extinction	Name at least one other group that has survived and diversified
1	272	Dimetrodon	Climate change due to massive volcanic eruptions	Runaway greenhouse effect causing an increase in temperature	Therapsids
2	252	Lycaenops	Climate change due to massive volcanic eruptions	Runaway greenhouse effect causing an increase in temperature	Archosaurs (reptiles)
3	201	Exaeretodon	Climate change due to massive volcanic eruptions	Runaway greenhouse effect causing an increase in temperature	Dinosaurs and primitive mammals
4	200	Pachygenelus	Hot and humid climate with lush jungles over much of the Earth	Competition with protomammals and dinosaurs	Dinosaurs, pterosaurs and protomammals
5	66	Didelphodon	Climate change due to asteroid impact & volcanic eruptions	Catastrophic climate change causing heating and cooling	Some reptiles, amphibians, mammals and birds
6	66	Zalambdalestes	Climate change due to asteroid impact & volcanic eruptions	Catastrophic climate change causing heating and cooling	Some reptiles, amphibians, mammals and birds
7	10,000	Smilodon	Ice age was ending, and the climate was warming	Prey died out from over hunting by early humans	Other mammal groups; humans

(C) Mass Extinction (Dinosaurs/Birds) Recording Sheet - Key

Name: _____

As you are following one of the **bird pathways** in the *Surviving Extinction* game, record the age, name, environmental changes that were occurring during the time of the extinction, and the theory for the group's extinction for each *Extinction Animal* you encounter along the pathway. Also, pay attention to the animals that rose to dominance after the extinction event. If you miss the extinction animals, you can go back down your pathway and choose other animals to find them.

No.	Time of extinction (millions of years)	Extinction Animal Name	Environmental changes during time of extinction	Theory for group's extinction	Name at least one other group that has survived and diversified
1	*252*	*Pareiasaurus*	*Climate change due to massive volcanic eruptions*	*Runaway greenhouse effect causing an increase in temperature*	*Archosaurs (reptiles)*
2	*145*	*Allosaurus*	*Climate changes due to asteroid impacts & volcanic eruptions*	*Warm, humid climate suddenly became colder*	*New groups of dinosaurs and mammals*
3	*93*	*Carcharo-dontosaurus*	*Increasing hot and humid conditions*	*Competition with other meat-eating dinosaurs*	*New armored, horned & carnivorous dinosaurs; mammals*
4	*66*	*Tyrannosaurus*	*Climate change due to asteroid impact & volcanic eruptions*	*Catastrophic climate change causing heating and cooling*	*Some reptiles, amphibians, mammals and birds*
5	*66*	*Velociraptor*	*Climate change due to asteroid impact & volcanic eruptions*	*Catastrophic climate change causing heating and cooling*	*Some reptiles, amphibians, mammals and birds*
6	*66*	*Enantiornis*	*Climate change due to asteroid impact & volcanic eruptions*	*Catastrophic climate change causing heating and cooling*	*Some reptiles, amphibians, mammals and birds*
7	*93*	*Rayososaurus*	*Increasing hot and humid conditions*	*Competition with other plant-eating dinosaurs*	*New armored, horned & carnivorous dinosaurs; mammals*
8	*66*	*Patagotitan*	*Climate change due to asteroid impact & volcanic eruptions*	*Catastrophic climate change causing heating and cooling*	*Some reptiles, amphibians, mammals and birds*

Other possible answers depending on the pathway the learner has followed.

No.	Time of extinction (millions of years)	Extinction Animal Name	Environmental changes during time of extinction	Theory for group's extinction	Name at least one other group that has survived and diversified
9	*125*	*Wuerhosaurus*	*Hot and humid climate with lush jungles*	*Poorly understood ecosystem changes*	*New armored, horned & carnivorous dinosaurs; mammals*
10	*66*	*Edmontosaurus*	*Climate change due to asteroid impact & volcanic eruptions*	*Catastrophic climate change causing heating and cooling*	*Some reptiles, amphibians, mammals and birds*
11	*66*	*Triceratops*	*Climate change due to asteroid impact &volcanic eruptions*	*Catastrophic climate change causing heating and cooling*	*Some reptiles, amphibians, mammals and birds*
12	*148*	*Rhampho-rhynchus*	*Hot and humid climate with lush jungles*	*Competition with other pterosaurs and early birds*	*New dinosaurs, early birds, pterosaurs and protomammals*
13	*66*	*Quetzalcoatlus*	*Climate change due to asteroid impact & volcanic eruptions*	*Catastrophic climate change causing heating and cooling*	*Some reptiles, amphibians, mammals and birds*
14	*201*	*Postosuchus*	*Climate change due to massive volcanic eruptions*	*Runaway greenhouse effect causing an increase in temperature*	*New dinosaurs and primitive mammals*
15	*66*	*Archelon*	*Climate change due to asteroid impact & volcanic eruptions*	*Catastrophic climate change causing heating and cooling*	*Some reptiles, amphibians, mammals and birds*
16	*90*	*Platypterygius*	*Climate change causing increase in ocean temperatures*	*Extinction of main prey species in the oceans*	*Other marine reptiles, dinosaurs, birds and mammals*
17	*66*	*Elasmosaurus*	*Climate change due to asteroid impact & volcanic eruptions*	*Catastrophic climate change causing heating and cooling*	*Some reptiles, amphibians, mammals and birds*
18	*66*	*Mosasaurus*	*Climate change due to asteroid impact & volcanic eruptions*	*Catastrophic climate change causing heating and cooling*	*Some reptiles, amphibians, mammals and birds*
19	*58*	*Titanoboa*	*Hot and humid climate with lush jungles*	*Climatic cooling made it harder for giant snakes to survive*	*Other reptiles, birds and many groups of mammals*

(D) Mass Extinction Causes and Ranking - Key

Name: _____

Part A. Based on the information that you recorded in *(B) Mass Extinction (Mammals) Recording Sheet* list and explain three causes of mass extinctions. *(Multiple answers are possible)*

	Time (millions of years)	Main cause or causes?
1	*272, 252, 201*	*Massive volcanic eruptions*
2	*66*	*Asteroid impact and massive volcanic eruptions*
3	*200*	*Competition with other groups*
4	*10,000*	*Overhunting of the group's prey by early humans*

Part B. Based on the information in *The Making of Mass Extinctions* interactive, rank the "Big Five" mass extinctions in terms of the percentage of species that died out. 1 = greatest % to 5 = lowest % *(ranking of 2-3 are interchangeable)*

Rank	% Species extinct	Mass extinction name	Time of mass extinction (millions of years)	What main groups went extinct?
1	*96%*	*End Permian*	*252*	*Amphibians, early reptiles, insects, trilobites, sea scorpions, corals*
2	*80%*	*End Triassic*	*201*	*Amphibians, reptiles, bivalves, conodonts, corals, ammonites, brachiopods*
3	*80%*	*End Ordovician*	*444*	*Trilobites, corals, brachiopods, bryozoans, echinoderms, graptolites, nautiloids, conodonts*
4	*76%*	*End Cretaceous*	*66*	*Dinosaurs, pterosaurs, mosasaurs, plesiosaurs, mammals, ammonites, shell-building species, plants*
5	*75%*	*Late Devonian*	*359*	*Armored fish, corals*

(F) Mass Extinction Survey - Key

Name: _____

Complete the following:

1. Which of the following groups of animals went extinct 66 million years ago?
   a. Mammals
   b. Birds
   c. Reptiles
   d. *Dinosaurs*

2. What environmental changes led to the dinosaur's extinction 66 million years ago?
   a. Massive flooding and earthquakes
   b. Reversal of the Earth's magnetic field
   c. *Asteroid impact and volcanic eruptions*
   d. Gamma ray burst from space
   e. None of these

3. What does it mean when a group of animals goes extinct?
   a. Disappearance of a group from one area because it has moved away
   b. Appearance of a group in an area where it has never lived before
   c. *Total disappearance of a group on Earth*
   d. Disappearance of a group with reappearance of it later in time
   e. None of these

4. Which one of these mass extinctions was the largest that the Earth has ever experienced?
   a. Cretaceous-Paleogene (K-T or K-Pg) boundary 66 million years ago
   b. *Permian-Triassic (P-T) boundary 252 million years ago*
   c. Triassic-Jurassic (T-J) boundary 201 million years ago
   d. Cambrian-Ordovician (C-O) boundary 485 million years ago

5. Over the past 500 million years, life on Earth has experienced five main mass extinctions. Have you heard of the sixth extinction? If so, explain what could be causing this mass extinction.
   Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species (NGSS). There is widespread consensus among scientists that human activity is accelerating the extinction of many animal species through the destruction of habitats, production of pollutants, over consumption of animals as resources, and the elimination of species that humans view as threats or competitors.