

Natural Selection & Adaptation Lesson Key

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: Why have some animal groups survived environmental changes over time, while others have failed and gone extinct?

Instructional Objective: Explain how natural selection leads to the rise of beneficial traits and the extinction of organisms in a changing environment.

Learning Outcomes

Learning Outcome #1: Explain the benefits of specific anatomical (structural), behavioral or physiological adaptations or traits for species' survival.

Learning Outcome #2: Correlate certain animal's adaptive traits with the survival or extinction of its group in a mass extinction event.

Prerequisites

- Trait or adaptation
- Mass extinction
- Geologic time
- Ecosystem

Natural Selection & Adaptation

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 what adaptations helped mammals, reptiles and their ancestors survive mass extinctions.

NRC FRAMEWORK/NGSS CORE & COMPONENT QUESTIONS

WHAT ADAPTIVE TRAITS HELPED VERTEBRATE GROUPS SURVIVE MASS EXTINCTIONS?

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



What are the benefits of specific traits in the survival of mammals, reptiles and birds?



How have environmental changes during mass extinctions affected the survival of species over time?

HS.Natural Selection and Evolution; LS4.C Adaptation

INSTRUCTIONAL OBJECTIVE (IO)



Learners will be able to

IO1: Explain how natural selection leads to the rise of beneficial traits and extinction of organisms in a changing environment.

1.0 Materials

Required Materials:

Please Supply:

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

Please Print:

From Learner Guide

- (A) Adaptation Observations Recording Sheet - 1 per learner
- (B) Mammal Adaptation Recording Sheet - 1 per learner
- (C) Bird Adaptation Recording Sheet - 1 per learner
- (D) Construct an Explanation - 1 per learner
- (E) Surviving Extinction Tally Sheet (Optional) - 1 per learner
- (F) Surviving Extinction Survey - 2 per learner

Optional Materials:

EarthViewer

https://media.hhmi.org/biointeractive/earthviewer_web/earthviewer.html

Great Transitions Interactive: Exploring Transitional Fossils

<https://media.hhmi.org/biointeractive/click/great-transitions/>

Understanding Evolution 101

https://evolution.berkeley.edu/evolibrary/article/evo_01

Understanding Evolution Misconceptions

https://evolution.berkeley.edu/evolibrary/misconceptions_faq.php

2.0 Lesson Timeline

Natural Selection & Adaptation 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) Surviving Extinction Survey
- Watch video
- (A) Adaptation Observations 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

- Watch videos
- List of traits using (B, C) Recording Sheets
- (D) Construct an explanation sheet

Day 4
(~30-40 min)

Elaborate

- Human traits discussion (or) Classification activity

Day 5
(~20 min)

Evaluate

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



(A) Adaptation Observations Recording Sheet - Key

Name: _____

Watch the videos shown by the teacher and complete the following:
 (Natural Selection and the Rock Pocket Mouse; <https://youtu.be/sjeSEngKGrgI>)

1. In your own words, describe natural selection.

Natural selection is the process through which populations of living organisms adapt and change. Individuals in a population are naturally variable, meaning that they are all different in some ways. This variation means that some individuals have traits better suited to the environment than others. Over time these favorable traits are transmitted through generations.

2. Sketch a mammal, bird or reptile of your choosing in this space.

#2-3 depend on the animal chosen.


3. For your animal, list one adaptation or trait of each type and its possible function.

| | Adaptation or trait | What is it used for? |
|--|---|--|
| Anatomical (structural) Adaptation <i>(physical feature an organism has that helps it survive in its natural habitat, such as huge fangs or wings)</i> | <i>Example: Retractable claws</i> | <i>Protects and keeps the claws very sharp, and shields them from making noise when walking to help sneak up on prey</i> |
| Behavioral Adaptation <i>(activity that an organism does that helps it survive in its natural habitat, such as burrowing or herding)</i> | <i>Example: Herding behavior</i> | <i>Provides safety in numbers, cooperation in finding food and defense, and easier access to mates</i> |
| Physiological Adaptation <i>(process occurring inside an organism that enables it to survive in its natural habitat; such as venom or warm-blooded metabolism)</i> | <i>Example: Warm-blooded metabolism</i> | <i>Allows a stable body temperature regardless of the external environment, letting animals stay active at night or when it's cold</i> |

(B) Mammal Adaptation Recording Sheet - Key

Name: _____

As you are following one of the **mammal pathways** in the *Surviving Extinction* game, list one main adaptation or trait and its general benefit for eight main animals that appear in the environments that you explore. Describe how this key adaptation aided the animal’s survival. *Hint: Look for the animals with a DNA icon to access this information. Learners will select eight, but since there are many options depending on the path they take, this list contains all the possible answers.*


| Main animal’s name | Age (millions of years) | Animal group | Key adaptation (Hint: look for the DNA icon)  | General benefit of adaptation on survival |
|---------------------------|-----------------------------------|----------------------|--|---|
| <i>Pederpes</i> | <i>350</i> | <i>Tetrapod</i> | <i>Lives on land</i> | <i>Able to find new food sources on land and get out of water with many predators</i> |
| <i>Hylonomus</i> | <i>312</i> | <i>Early reptile</i> | <i>Laying eggs on land</i> | <i>Ability to lay eggs anywhere on land away from water allowing to it to colonize new habitats on land</i> |
| <i>Ophiacodon</i> | <i>298</i> | <i>Synapsid</i> | <i>Synapsid skull with one hole behind each eye</i> | <i>Makes your skull more flexible and provides space for bigger jaw muscles for a stronger bite</i> |
| <i>Biarmosuchus</i> | <i>267</i> | <i>Therapsid</i> | <i>Specialized teeth for eating meat</i> | <i>Specialized teeth such as huge canines for eating meat making it a better predator</i> |
| <i>Thrinaxodon</i> | <i>252</i> | <i>Cynodont</i> | <i>Warm-blooded (endothermic) so it can maintain a constant body temperature regardless of the surrounding environment</i> | <i>Allows it to stay active over a wide range of temperatures (such at night or when it’s cold) so it can avoid predators</i> |
| <i>Chiniquodon</i> | <i>231</i> | <i>Cynodont</i> | <i>Larger body size</i> | <i>Helps it compete with larger predators such as early dinosaurs and other reptiles</i> |
| <i>Megazostrodon</i> | <i>201</i> | <i>Mammaliaform</i> | <i>Larger brain with sharp senses</i> | <i>Allows the processing of more sensory information needed for being active at night when there are fewer predators</i> |

| | | | | |
|--------------------|-----|------------------------------|--|---|
| <i>Juramaia</i> | 160 | <i>Protomammal</i> | <i>Limbs with claws for climbing</i> | <i>Gives it the ability to climb so it can access new resources in the forest and protect itself from predators</i> |
| <i>Eomaia</i> | 125 | <i>Early mammal</i> | <i>Middle ear bones separate from jaw</i> | <i>To improve hearing, several small bones in the jaw joint get smaller and become part of the middle ear</i> |
| <i>Sinidelphys</i> | 125 | <i>Early marsupial</i> | <i>Young raised in a pouch (marsupium)</i> | <i>Raising its underdeveloped or larval young in a pouch protects them as they grow</i> |
| <i>Cimolestes</i> | 66 | <i>Early mammal</i> | <i>Larger body, rat-sized</i> | <i>By increasing body size, its group can exploit new food resources and adapt to colder climatic conditions.</i> |
| <i>Paroodectes</i> | 50 | <i>Mammal, carnivoran</i> | <i>Retractable claws</i> | <i>Its retractable claws are used to catch prey, but then can be retracted to keep them sharp when not in use</i> |
| <i>Darwinius</i> | 50 | <i>Mammal, early primate</i> | <i>Opposable thumbs</i> | <i>Opposable thumbs allow it to grasp and pick up small objects, and eat with one hand</i> |

(C) Bird Adaptation Recording Sheet - Key

Name: _____

As you are following one of the **bird pathways** in the *Surviving Extinction* game, list one main adaptation or trait and its general benefit for eight main animals that appear in the environments that you explore. Describe how this key adaptation aided the animal’s survival. *Hint: Look for the animals with a DNA icon to access this information. Learners will select eight, but since there are many options depending on the path they take, this list contains all the possible answers.*

| Main animal’s name | Age (millions of years) | Animal group | Key adaptation (Hint: look for the DNA icon)  | General benefit of adaptation on survival |
|----------------------|-------------------------|--------------------------------|--|---|
| <i>Pederpes</i> | 350 | <i>Tetrapod</i> | <i>Lives on land</i> | <i>Able to find new food sources on land and get out of water with many predators</i> |
| <i>Hylonomus</i> | 312 | <i>Early reptile</i> | <i>Laying eggs on land</i> | <i>Ability to lay eggs anywhere on land away from water allowing to it to colonize new habitats on land</i> |
| <i>Proterosuchus</i> | 252 | <i>Reptile</i> | <i>Large skull with eyes on top</i> | <i>Large skull with eyes on top allows hiding partially submerged underwater</i> |
| <i>Eunotosaurus</i> | 252 | <i>Reptile</i> | <i>Thick overlapping ribs</i> | <i>Thick overlapping ribs protect delicate internal organs</i> |
| <i>Megachirella</i> | 242 | <i>Reptile</i> | <i>Overlapping scales (presumed)</i> | <i>Overlapping scales help prevent water loss and give added protection</i> |
| <i>Teleocrater</i> | 242 | <i>Reptile</i> | <i>Ankle joints with side-to-side motion</i> | <i>Ankle joints with 90-degree rotation improves maneuverability and agility</i> |
| <i>Mandasuchus</i> | 242 | <i>Reptile</i> | <i>Two rows of bony plates down back</i> | <i>Two rows of bony plates down back for protection of vulnerable areas on the back</i> |
| <i>Eodromaeus</i> | 231 | <i>Early theropod dinosaur</i> | <i>Partially open hip socket</i> | <i>Partially open hip socket allows the legs to be positioned more underneath the body to run faster and with greater endurance</i> |
| <i>Eoraptor</i> | 231 | <i>Sauropodomorph dinosaur</i> | <i>Hollow bones</i> | <i>Hollow bones are strong without being heavy and can</i> |

| | | | | |
|--------------------------|------------|-------------------------------|--|---|
| | | | | <i>even have air sacs inside for more efficient breathing</i> |
| <i>Pisanosaurus</i> | <i>231</i> | <i>Ornithischian dinosaur</i> | <i>Leaf-shaped cheek teeth and a beak on snout</i> | <i>Leaf-shaped teeth and a beak help with feeding on tough plants</i> |
| <i>Protosuchus</i> | <i>201</i> | <i>Reptile</i> | <i>Partial secondary palate</i> | <i>A partial secondary palate makes it possible for it to eat and breath at the same time</i> |
| <i>Sichuanosuchus</i> | <i>160</i> | <i>Reptile</i> | <i>Long snout with saw-like teeth</i> | <i>Long snout with saw-like (serrated) teeth enables it to catch a wide variety of prey</i> |
| <i>Borealosuchus</i> | <i>66</i> | <i>Reptile</i> | <i>Secondary palate</i> | <i>Secondary palate or bony plate on roof of its mouth allows it to breathe and eat at the same time</i> |
| <i>Eudimorphodon</i> | <i>201</i> | <i>Early pterosaur</i> | <i>Furry coat of hair-like feathers</i> | <i>Feathers covering the body help insulate and prevent heat loss</i> |
| <i>Heterodontosaurus</i> | <i>201</i> | <i>Ornithischian dinosaur</i> | <i>Pubis bone (part of hip) points backwards</i> | <i>A pubis bone pointing backwards forms a place where muscles can attach</i> |
| <i>Jeholosaurus</i> | <i>125</i> | <i>Ornithischian dinosaur</i> | <i>Possible herding</i> | <i>Safety from predators with more individuals watching for danger</i> |
| <i>Ledumahadi</i> | <i>201</i> | <i>Sauropod dinosaur</i> | <i>Massive body size</i> | <i>Massive body and long neck and tail, can be used for defense against predators</i> |
| <i>Coelophysis</i> | <i>201</i> | <i>Theropod dinosaur</i> | <i>Open hip socket</i> | <i>Open hip socket allows legs to be positioned more directly under the body for better support and maneuverability</i> |
| <i>Yangchuanosaurus</i> | <i>160</i> | <i>Theropod dinosaur</i> | <i>Large body size</i> | <i>Large body size allows it to hunt much bigger prey such as sauropods</i> |
| <i>Guanlong</i> | <i>160</i> | <i>Theropod dinosaur</i> | <i>Bony crest on snout</i> | <i>The thin bony crest on its snout is used for display to attract mates and intimidate rivals</i> |
| <i>Aorun</i> | <i>160</i> | <i>Theropod dinosaur</i> | <i>Most likely covered with feathers</i> | <i>Feathers covering its body can be used for display and insulation, helping to stay warm and to shed excess heat</i> |

| | | | | |
|------------------------|-----|---------------------------|---|---|
| <i>Archaeopteryx</i> | 150 | <i>Bird-like dinosaur</i> | <i>Wings for powered flight</i> | <i>Its wings allow it to fly so it can reach new food sources, escape predators and display</i> |
| <i>Lithornis</i> | 66 | <i>Bird</i> | <i>Warm-blooded (endothermic)</i> | <i>Being warm-blooded it can maintain a constant body temperature regardless of the external environment</i> |
| <i>Australochelys</i> | 201 | <i>Early turtle</i> | <i>Bony shell covering body</i> | <i>Bony shell covering its body protects vital organs from predators</i> |
| <i>Toxochelys</i> | 93 | <i>Early sea turtle</i> | <i>Limbs modified into flippers</i> | <i>Limbs are modified into to flippers to improve its swimming abilities</i> |
| <i>Adocus</i> | 66 | <i>Turtle</i> | <i>Limbs with sharp claws</i> | <i>Limbs with sharp claws allow it to dig in the mud for food and to make a burrow for shelter</i> |
| <i>Ichthyosaurus</i> | 201 | <i>Marine reptile</i> | <i>Fish-like tail with limbs modified into flippers</i> | <i>Its fish-like tail and flippers make it a fast swimmer so it can catch fish and other prey</i> |
| <i>Thalassiodracon</i> | 201 | <i>Marine reptile</i> | <i>Long neck with limbs modified into flippers</i> | <i>Limbs modified into flippers make it a powerful swimmer and its long neck allow it to sneak up on prey</i> |
| <i>Eophis</i> | 160 | <i>Reptile</i> | <i>Elongate backbone with many ribs</i> | <i>Vertebrae making up its backbone give it extreme flexibility so it can slither</i> |
| <i>Python</i> | 66 | <i>Snake</i> | <i>Loss of front and back limbs</i> | <i>Loss of front and back limbs makes it possible to slither on its belly more efficiently</i> |

(D) Construct an Explanation - Key

Name: _____

How did natural selection lead to the rise of adaptations that are still found in groups and organisms today?

Natural selection is the process through which populations of living organisms adapt and change. Individuals in a population are naturally variable, meaning that they are all different in some ways. This variation means that some individuals have traits better suited to the environment than others. Individuals with adaptive traits—traits that give them some advantage—are more likely to survive and reproduce. These individuals then pass the adaptive traits on to their offspring. Over time, these advantageous traits become more common in the population. Through this process of natural selection, favorable traits are transmitted through generations.

Natural selection can lead to speciation, where one species gives rise to a new and distinctly different species. Living animal groups are the result of speciation over time and have inherited adaptations from their ancestors. This is one of the processes that drives evolution and helps to explain the diversity of life on Earth.

How did natural selection play a role in the extinction of groups in changing environments?

If the environment changes rapidly, some species may not be able to adapt fast enough through natural selection. Through studying the fossil record, we know that many of the organisms that once lived on Earth are now extinct. Dinosaurs are one example.

The one-two punch of an asteroid impact and massive volcanic eruptions that took place 66 million years ago, caused catastrophic environmental changes that wiped out 76% of all species on Earth including the dinosaurs, pterosaurs, marine reptiles, ammonites, many groups of birds and mammals.

(F) Surviving Extinction Survey - Key

Name: _____

Complete the following:

- Which of the following is an example of how natural selection works?
 - Random mutation causes a beneficial change in an organism's DNA
 - New organisms migrate into an area and add their genes to the population
 - Some organisms have traits better suited to their environment than others*
 - Due to chance events, some organisms survive while others are wiped out
- About how far back in evolutionary history did mammals and reptiles share a common ancestor?
 - About 1 million years ago
 - About 65 million years ago
 - About 320 million years ago*
 - About 540 million years ago
 - These groups have no common ancestor

- The image here shows a skeleton of an extinct type of cynodont.

This animal had the following traits: It lived in a burrow; was warm-blooded; had specialized teeth; and laid eggs on land. Natural selection favored these traits and they have been passed on to which modern descendants?



- Mammals*
 - Birds
 - Reptiles
 - Fish
- Why might an animal evolve the ability to burrow? List two benefits that an animal might gain from being able to burrow. *1) Protection from predators, 2) stable underground shelter for protection from harsh environmental conditions, 3) secure place to raise young and hibernate, and 4) place to store and protect food.*
 - At times in the history of life on Earth, there have been “mass extinctions” in which many species of animals went extinct all at once. Describe one example of an environmental change that could lead to mass extinctions. What kind of adaptations would significantly decrease a group's ability to survive that environmental change? What kind of adaptations would increase a group's ability to survive? *Massive volcanic eruptions causing greenhouse effect or an asteroid impact. Being a specialist and requiring special conditions and types of foods versus being a generalist and able to tolerate environmental changes and eat a wide variety of foods.*