The Road to Extinction

Lesson Set 5 of 5

NCSE
National Center for Science Education

Teacher Prep

Age Levels: 9th-12th grade

Time Commitment: 8 days
(if all activities completed)

Key Vocabulary/Concepts:
extinction, extinct, mass extinction, species, ecosystem, impact, carrying capacity, biodiversity, background, qualitative, quantitative, index, population, reactive, proactive, conservation, variation, inheritance, selection, time, adaptation, anthropogenic

Materials:
- Sticky notes
- Hula hoop
- Hand-sized balls, such as tennis balls or Hacky Sacks—about a dozen
- Computer with internet access
- Colored pencils, markers, or other coloring materials
- Pennies or other small items for tallying

Apps and Software:
- Google Jamboard or Google Drawings
- Spreadsheet software (Excel or Google Sheets)

Introduction

This lesson set explores the relationships among extinction, evolution, and biodiversity. Students investigate mass extinctions, current issues in extinction, and the process by which organisms adapt to pressures caused by humans.

Teacher Goals

1) Provide structured opportunities for students to ask questions that drive the learning process.
2) Facilitate student use of scientific practices, including refining a simulation and making claims based on scientific evidence.
3) Develop students' ability to use evidence to justify their point of view in regard to current issues.
4) Guide students as they apply their understanding of natural selection to unfamiliar situations.

Student Learning Goals

1) Ask clarifying questions in order to establish the relationship between extinction and evolution.
2) Compare and contrast outcomes from ancient mass extinctions in order to apply their understanding to current issues.
3) Revise a simulation in order to test a potential solution to mitigate adverse impacts of human activity on biodiversity.
4) Obtain and communicate information in order to describe how populations are currently adapting to human pressures.
5) Create a timeline of events in order to explain what role evolution plays in Earth's history.

Evolution Lesson Set Series

https://ncse.ngo/supporting-teachers/classroom-resources

EVOLUTION

Lesson Set 1: The Origin of a Species
Lesson Set 2: Good is Good Enough?
Lesson Set 3: It's Time to Lose the Ladder
Lesson Set 4: No More Monkeying Around
Lesson Set 5: The Road to Extinction

Background

Teacher Knowledge

Nature of Science

It's recommended that students work through the NCSE Nature of Science lesson sets at some point during the year. However, if this is not possible, be sure to introduce students to FLICC, a framework for understanding science denial, prior to presenting this lesson set. Part E: The Characteristics of Science Denial in Nature of Science Lesson Set 1: Science is a Way of Knowing is especially valuable. It takes students through several examples of FLICC in action while dismantling common misconceptions about the COVID-19 pandemic. Learn more about FLICC.

Evolution

Evolution explains many aspects of biology and is an indispensable part of a life science curriculum. The scientific community sees evolution as the unifying principle of all biology. The biological unity of life on our planet can be understood by examining anatomical features, genetics, or embryological development; this evidence can be used to identify a common ancestry of different species. Likewise, the diversity of life on our planet can be understood through the lens of evolution. Understanding the role that extinction plays in the geologic history of planet Earth is part of the story of the diversification of life on Earth, along with how humans are influencing the development of adaptations in populations.

This lesson set is meant to help students understand extinction and how populations have adapted to human-driven pressure. If a refresher on evolution is necessary, consider checking out the University of California Museum of Paleontology "Understanding Evolution" resource or Nature Education's primer "Speciation: The Origin of New Species" before introducing this curriculum to your students.

Discussion Points

- How do scientists know that mass extinctions have happened in the past?
- How can we apply lessons from past mass extinctions to current and future extinction events?
- How do humans drive extinction and what can we do to mitigate our impact?
- How do species adapt to human pressures?
- What trends do we see in evolution over time?
- What is the relationship between evolution and extinction?

Prerequisite Student Knowledge

Before starting the activities below, students should have some knowledge of extinct species, be able to identify some modern species, and describe how they resemble species from Earth's past. They should also be able to express what the fossil record is and how the fossil record gives us information about the existence, diversity, and extinction of past organisms. Students should be able to express that populations have genetic variability, and that genetic variations may provide advantages to some individuals and disadvantages to others leading to natural selection when variations are inheritable. When the environment changes and individuals with beneficial traits survive, the genetic makeup of the population changes. The process of adaptation is ongoing and can lead to speciation.

Core Misconceptions

✘ **MISCONCEPTION:** ***Evolution only occurs slowly and gradually.***

✔ **FACT: Rapid evolution has been documented many times in evolutionary history.**

✘ **MISCONCEPTION:** ***Evolution is not supported by the fossil record.***

✔ **FACT: Paleontologists have an amazing array of fossils currently available (and more being found every day) that provide evidence of evolution in action.**

✘ **MISCONCEPTION:** ***Gaps in the fossil record are evidence against evolution.***

✔ **FACT: Gaps in the fossil record are expected, because fossilization can be an extremely rare event, depending on the organism and its environment. (Hard-bodied organisms and those living in marine environments tend to fossilize better.)**

Teacher Instructions

Anchoring Phenomenon

Anchor: The Permian Purge

- Ask students to think about the following questions:
  - *What organisms do you know that have gone extinct?*
  - *What does it mean for a species to go extinct?*
- Provide students with time to discuss in either pairs or small groups. Ask them to create a list of all the species they can think of that are extinct. Ask them to share out their lists and while they do so, compile a class list.
- Create a working definition for the word "extinct" and post it in the classroom.
- Show students the video Ancient Earth (Season 1) — The Permian (1:59). Only show the first minute and 30 seconds of the video. Showing more may answer some of the questions students may have, removing an aspect of inquiry.
- After showing the video, complete a Think-Pair-Share activity with students using the following question:
  - *What could possibly have caused the Earth's biggest mass extinction? This event caused the extinction of 96% of all marine life and 70% of all terrestrial life.*
- As students are sharing their ideas, it is important to accept any ideas that are appropriate for the classroom, whether they are correct or not. If the correct answer is mentioned, do not indicate to students that it is more or less correct than any other idea. Keep a list that includes all your students' ideas. For any idea that might be unclear, follow up by asking students "What makes you say that?" to prompt them in a neutral way to clarify their thinking.
- After some classroom discussion, ask students to consider the following questions:
  - *Which of these ideas could wipe out multiple plant and animal species within the same ancient ecosystem?*
  - *Which of these ideas are natural disasters that could cause a mass extinction?*
  - *How might the extinction of one species negatively impact another species?*

Driving Question Board: The Road to Extinction

- If you're working in-person or without access to digital media, then create a physical version of the Driving Question Board that can be displayed prominently in the classroom. Provide students with sticky notes so they can add their questions to the board.
  Note: The sample Driving Question Board (DQB) can be found in the Teacher Resource Folder above. Please make a copy of the template provided before beginning the activity.)

Anchoring Phenomenon (continued)

Driving Question Board: : The Road to Extinction (continued)

- Organize students into pairs. This will allow them to have someone to help develop their questions. On the class DQB, have each student pair type or write one or more open-ended extinction questions on separate sticky notes, along with their initials. Open-ended questions require answers beyond yes or no or a single word. If students are struggling to think of open-ended questions, have them consider questions related to human-driven extinction, the relationship between extinction and evolution, or mass extinctions in general. Sample open-ended questions include:
  - *What impact are humans having on the extinction of species today?*
  - *Can species ever re-evolve into existence after going extinct?*
  - *How many mass extinction events have occurred in Earth's history and what were their causes?*
- Read a few of the student-generated questions aloud to the class. Inform the class that you will read all sticky notes later and organize them into groups. After class ends, arrange similar questions into categories and add subtitles above the sticky notes.
- The DQB is meant to guide instruction and therefore should be referenced periodically, such as at the start of a class or when transitioning between activities, to highlight what questions have been answered and where the storyline is headed next. Not all student-generated questions will be answered. At the end of the storyline, teachers may elect to have students do research to address the unanswered questions.

Storyline Activities

Part A: Lessons Learned from the Ancient Past

- Ask students to brainstorm a list of factors that can limit a population's growth. Student responses may include:
  - Food availability
  - Predation
  - Competition
- Inform students that they will be learning about carrying capacity. Note: it is important to not define this phrase yet. Reveal a hula hoop and enough hand-sized balls, such as tennis balls or Hacky Sacks, for the class.
- Place the hula hoop on the ground and explain that it represents the habitat in which a species lives. Direct a student to stand in the hula hoop. Let students know that asexual reproduction for this species happens by throwing a ball into the air and catching it, resulting in a new individual. On the board, write "Generation 1 - 1".

Storyline Activities (continued)

Part A: Lessons Learned from the Ancient Past (continued)

- Ask the student to throw and catch the ball, and then have another student stand in the hula hoop with the original. On the board, write "Generation 2 - 2".
- Repeat this process, keeping track of how many students are in each generation. If a student does not catch the ball, they should not reproduce. If the student steps out of the hula hoop while attempting to catch the ball, they "die" and have to leave the circle.
- Repeat this process for multiple generations until the "carrying capacity" has been identified. It may be a range. Ask students to define the phrase "carrying capacity."
- Ask students the following questions:
  - *What are the limitations of this model in simulating real-world situations?*
  - *What would happen to the carrying capacity if the size of the hula hoop was increased? What could we do, other than change the hoop size, to simulate this?*
  - *What would happen to the carrying capacity if the size of the hula hoop was decreased? What could we do, other than change the hoop size, to simulate this?*
  - *Which could result in extinction?*
- Pass out the *Lessons from the Ancient Past Student Handout*. Preview the questions with students. Divide students into five groups and assign each group one of each of the five extinctions. Each group of students should also receive the page from the *Extinction Resources* handout that coordinates with the extinction event they are researching. The *Extinction Resources* contain a list of resources students may want to use for their research. In addition to the questions on the four-square, ask students to do additional research to answer the questions generated about their assigned extinction event.
- Provide students with sufficient time to complete their research and practice a short presentation to share their findings with their classmates. After students have completed their research, pass out *Lessons Learned from the Ancient Past – Presentation Capture Sheet* and guide students on how to complete it.
- After students have completed their presentations, captured the relevant information, and answered the analysis questions, introduce them to the Sixth extinction: Holocene. Ask students to go back to the list of extinct animals they made the previous day and identify if they think any went extinct within the last 11,700 years. Explain to students that they will be thinking about this current period of extinction and one of the questions about it that scientists are investigating.
- Introduce students to a Socratic Seminar, If you have never done a Socratic Seminar in your classroom before, set a routine and expectations for its completion. Choose one of the following topics below and present it to students as the "big question" for this activity.
  - *Should we ever purposefully drive a species to extinction?*
  - *Should we bring an animal back from extinction?*
  - *Should we save all organisms from extinction?*

Storyline Activities (continued)

Part A: Lessons Learned from the Ancient Past (continued)

- Provide students with the *Socratic Seminar Articles* associated text and *Socratic Seminar Student Handout*. Students should be allowed to read through the text and answer the questions on the student handout. Once students are ready, set expectations for the structure of the Socratic Seminar then provide students with the opening question from the *Teacher Instructions*. If students have never participated in a Socratic Seminar, it is best to allow students to have only a brief conversation — at most 15 minutes. However, if students have completed Socratic Seminars in the past, then it is possible to make the discussion longer.
- **Anchor to Activity** — Revisit the Driving Question Board with students. Were any of their questions answered? Did any new questions emerge for them? For any answered questions, ask students to identify evidence from the activity that supports the answer and provide reasoning for how the evidence does this. Any new questions should be written on a sticky note and added to the DQB; ask students to identify what from the lesson inspired this new question.

Part B: Halting the Holocene Extinction

- Share When will the mass extinction occur? — Births, D'Emic, and Pritchard (5:00). Direct students to consider the following questions as they watch:
  - *How did the ideas in this video connect to what you already knew?*
  - *How did the ideas in this video extend your thinking in new directions?*
  - *What questions do you still have about mass extinction events?*
- Highlight for students a vocabulary word introduced by the video: **biodiversity**. Tell students that mass extinction events negatively affect biodiversity. WIth students, identify the roots of this word:
  - Bio, meaning life
  - Diversitas, meaning variety
- Using these roots and what students already know, create a classroom definition for the word biodiversity. Under the definition, create a T-chart. On one side of the T-chart, ask students to identify factors that would maintain or improve biodiversity. On the other side of the T-chart, ask students to identify factors that would limit or reduce biodiversity.
- Explain to students that they will be participating in a simulation to explore the current Holocene mass extinction event and potential solutions to it.
- Pass out *Halting the Holocene Student Handout*. Together with the students, read the instructions. Provide direct instruction for students on how to use the pennies or other small objects to track the number of species by stacking them on the species cards. For example, four pennies on one species means that there are four individuals of that species in the population.

Storyline Activities (continued)

Part B: Halting the Holocene Extinction (continued)

- Organize students into small groups and assign the following roles:
  - Ornithologist — this student's role is to count the number of birds
  - Botanist — this student's role is to count the number of plants
  - Data Analyst — this student's role is to track the number of species on the recording sheet
  - Optional Roles: Materials Manager, Facilitator, Spokesperson, Timekeeper
- Distribute the *Species Cards*, pennies or other small objects, *Starting Population Card, and Recording Sheet* to students. Instruct students to arrange their pennies to match the initial population and record this information in their Recording Sheet.
- Project the first event card and read it out loud. Students should record the name of the event on the *Recording Sheet* and add or subtract counters from the species card based on the outcomes. The Data Analyst should identify the number of remaining species on the *Recording Sheet*. Repeat this process until all the cards have been drawn.
- After all events have been recorded, students should count the number of species and total number of individuals for both birds and plants.
- Share with students that using qualitative vocabulary can mean different things to different people. What seems like "a lot" to one person might look different to another person. For this reason, researchers prefer to quantify their findings; biodiversity can be quantified using an index, known as the Shannon Index (also known as Shannon-Wiener or Shannon-Weaver index).
- Provide students with the *Halting the Holocene Excel Spreadsheet*. Students should record the Shannon Index for each species.
- To begin a brief classroom discussion, ask students to share out their Shannon Index. Then follow up with the following questions:
  - *How did the starting populations compare to the ending populations?*
  - *Which of the events were caused by people? Were these events negative or positive?*
  - *What other things might people do that could influence biodiversity and prevent extinction?*
- Tell students they will have an option to test one of their ideas to improve the population's biodiversity. Pass out the Halting the *Holocene Impact* Card and ask each group to identify an action humans could take that would increase the biodiversity of this population. Let students know that this action should counteract one of the cards they already have in the deck and should be grounded in what they already know about conservation.
- After students have designed their card, have them reset their counters based on the initial populations. Add the *Placeholder Card* to your deck and shuffle. When this card is drawn, each group should use the card they created.
- Read through the event cards again and have students record changes in the population of each species. Again, when the *Placeholder Card* is drawn, students should apply the effect of the card they designed.

Storyline Activities (continued)

Part B: Halting the Holocene Extinction (continued)

- Bring students back together for a class discussion. Open the discussion by allowing groups to present what impact their solution had on the biodiversity index and why it had that impact. Drive the conversation using the following questions:
  - *Which groups created their solution card as a response (i.e., a reactive solution) to a specific event card? Was your solution effective against that event?*
  - *Which groups created their solution as a defense against (i.e., a proactive solution) a specific card? Was your solution effective against that event?*
  - *What is the difference between proactive and reactive conservation solutions? When should they be used? Is one better than the other?*
  - *What is a limitation of this simulation? What role does bias play?*
  - *What could be done to make this simulation more realistic?*
  - *What role do you think bias plays in the study of biodiversity? In species conservation?*
- **Anchor to Activity** — Remind students that this unit of study began with the exploration of catastrophic mass extinctions. Based on what we have done in this lesson, do they think there is enough evidence that humans are driving a sixth mass extinction event? Ask students to identify evidence from their background knowledge, from the Anchor and Part A, and from this lesson.
- **Acknowledgement:** "Halting the Holocene Extinction" was developed using resources created by Loyola Marymount University. The original resources can be found at "RP Circle — Biodiversity Game" by Center for Urban Resilience.

Part C: Anthropogenic Evolution — Living with the Consequences

- Reintroduce students to the VISTA acronym for natural selection introduced in Lesson Set 2: variation, inheritance, selection, time, and adaptation. Provide Students with the *Anthropogenic Evolution — Living With the Consequences Vocabulary and Definitions* card sets. Provide students with 2-3 minutes to match the vocabulary to the definitions. Once students have successfully accomplished this task, provide them with *VISTA Vocabulary, Definition, and Story* card sets. Ask students to place the appropriate rabbit adaptation story card with the correct vocabulary word and definition.
  Note: Prior to passing out card sets, shuffle the cards. When the cards print, they will print in the correct order. It is important that students receive a shuffled deck in order for them to have to think through this task.
- **Activity Variation** — If time allows, ask students to choose another organism and describe how its adaptations might have developed using VISTA. Consider providing students with a species and the adaptation in order to give structure to the activity. Some options include:
  - Zebras and their striped coat pattern
  - Lions and their manes
  - Prairie dogs and their underground tunnels
  - Parrots and their large beaks
  - Snakes and their lack of legs
  - Hummingbirds and their long beaks

Storyline Activities (continued)

Part C: Anthropogenic Evolution — Living with the Consequences (continued)

- Pass out the *Anthropogenic Evolution — Living with the Consequences Student Research* handout. With students, read the background information and directions out loud. Provide them with copies of the *Anthropogenic Evolution — Living with the Consequences Stamp Rubric* and show students the exemplar.
- Give students one class period to complete their research and create a rough draft of their stamp. Allow students a second day to finish their stamp and write their explanation of how this species is adapting to human pressure.
- Once students have completed their stamps, allow students to complete a silent gallery walk to review them. Give three sticky notes to each student. For each sticky note, students should choose a student project and write the answer to the following questions:
  - *What human pressures exist?*
  - *How is this organism adapting?*
  - *What is one question you have?*

Anchor to Activity — Return to the Anchor activity The Permian Purge. Remind students that extinction is a normal part of the story of life on Earth. Ask students to identify what the relationship between evolution and extinction is, if one exists. Students may respond with:
- *Extinction of one species can provide opportunities for other species to evolve.*
- *Evolution can drive species to extinction. Environments can change in such a way that makes it impossible for a species to remain adapted to them.*
- *Extinction ends evolution in a species. When a species goes extinct, it can't change any more, so it can't evolve.*

Part D: Time After Deep Time

- **Variation 1: Stand-Alone Activity**
  - *Note: This variation of Time After Deep Time is meant for classes who have not been adding to and revising their individual timelines throughout the National Center for Science Education Evolution Lesson Sets using the Time After Deep Time Check-Ins. If your students have been completing the check-in activities, then refer to the next variation,* Time After Deep Time Integrated Activity.
  - To begin, ask students to create a timeline of major events in their life. These events do not have to be connected to their academic life; students should create a timeline of at least 5 events.
  - Ask the class to consider the following questions:
    - *What is the purpose of using timelines?*
    - *Should we consider a timeline to be a type of scientific model? Why or why not?*
    - *If we were to create a timeline of evolutionary history, what important events might we want to include?*

Storyline Activities (continued)

Part D: Time After Deep Time (continued)

- Organize students into small groups and provide students with the *Time After Deep Time Student Handout* and provide each group of students with 5–10 of the *Time After Deep Time Cards*. Ask students to predict the order they think these events occurred by adding them to their timeline.
- *Note: It is possible to give each group of students different sets of cards or to give the same set of cards to each group. However, it is important to limit the number of cards so as to provide students with plenty of time to think deeply about a few events, rather than causing them to make quick decisions about many events.*
- Reveal to students the correct order of the cards and placement along the timeline. Ask students to consider the following questions:
  - *What about the correct order of events connected with what you already knew?*
  - *What about the correct order of events extended your thinking in new directions?*
  - *What questions emerged for you based on the correct order of events?*

Variation 2: Integrated Activity

- *Note: This variation of the Time After Deep Time Activity is meant to be included in the Time After Deep Time Check-Ins after each Evolution Lesson Set. If you are completing this lesson set separately from the others, or if you have not been completing the check-ins, refer to Variation 1: Stand-Alone Activity above.*
- Instruct students to find their *Time After Deep Time Student Handout*. Review the most recent events that have been added to the timeline.
- Organize students into small groups and hand out *The Road to Extinction Timeline Cards*. Ask students to work with their groups to put them in the order of occurrence they think best reflects geologic time.
- Ask groups to share their predictions. As students are sharing their predictions, follow up with "*What makes you say that?*" to prompt them in a neutral way to clarify their ideas.
- As this is the culminating timeline activity, reveal to students the correct order of the cards. Ask students to consider the following questions:
  - *What about the correct order of events connected with what you already knew?*
  - *What about the correct order of events extended your thinking in new directions?*
  - *What questions emerged for you based on the correct order of events?*
- Provide students time to reflect on the following misconception: Evolution is not supported because there are too many gaps in the fossil record. Ask students to write a response that explains why this misconception is incorrect.

Extension Activities

Deeper Dive

- Surviving Extinction, A Journey Through Time
- Extinction Over Time
- Bringing Back the Extinct
- Extinction, Speciation, and Macroevolution

Online Resources

» **Teacher Resource Folder**

» **Ancient Earth (Season 1) — The Permian (1:59)**

» **When will the mass extinction occur? — Births, D'Emic, and Pritchard (5:00)**

Primary Literature/Works Cited

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