Student Edition

California Education and the Environment Initiative

7

Science Standard
7.4.g.

Extinction: Past and Present

California Education and the Environment Initiative

Approved by the California State Board of Education, 2010

The Education and the Environment Initiative Curriculum is a cooperative endeavor of the following entities:

California Environmental Protection Agency

California Natural Resources Agency

California State Board of Education

California Department of Education

Department of Resources Recycling and Recovery (CalRecycle)

Key Partners:

Special thanks to **Heal the Bay,** sponsor of the EEI law, for their partnership and participation in reviewing portions of the EEI curriculum.

Valuable assistance with maps, photos, videos and design was provided by the **National Geographic Society** under a contract with the State of California.

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None required for this lesson.

Puzzle in the "Tar" Pits

Buried in the heart of Los Angeles sits one of the world's most impressive collections of ice age fossils in the La Brea Tar Pits. These bubbling black pits contain a snapshot of life from between 40,000 and 10,000 years ago. The Spanish word *la brea* means "the tar," but the sticky black ooze in these pits is like asphalt, with which we pave some streets.

Pieces of a Puzzle

The ocean covered Los Angeles more than 100,00 years ago. The plants and animals that lived there fell to the ocean floor when they died. Over time, they became part of the ocean's sedimentary layers, where they turned into crude oil as a result of heat and the pressure of one layer building upon another. When the ocean receded, tar from this oil seeped out of the ground and formed pools. More than 100 pools, called pits, are found in Los Angeles, though not all are visible.

Tens of thousands of years ago, the sticky material trapped animals, especially during the warmer summer months when it softened and was hidden by a layer of dust and leaves that stuck to its surface. The animals died and decayed there. Scientists believe that bones from other dead animals likely washed into the pits from nearby streams. When the tar hardened in the cooler winter months, the bones became sealed in the pits. When summer returned, the tar softened again, forming new traps. Today the pits contain millions of bones and other debris from plants and animals.

Scientists did not realize the significance of the fossils in the pits until approximately 100 years ago. The first excavations of the site began in 1901. Since then scientists have collected more than 3.5 million fossils belonging to more than 650 species of plants, animals, and insects from the late Pleistocene.

Fitting the Pieces Together

The great number and variety of fossils at La Brea make it a unique site; the tar there has preserved the full spectrum of Pleistocene life. The millions of bones at La Brea come in all sizes: the pits contain microfossils too small to see with the naked eye, as well as bones from larger animals, or megafauna, such as the American mastodon, saber-toothed cat, and ancient bison. Using fossils as puzzle pieces, we can assemble a picture of climate, landscape, and plant and animal life in the Pleistocene. This picture includes evidence of climate change, biodiversity, and extinction.

Evidence of Climate Change

Modern-day Los Angeles experiences a warm, dry climate. Microfossils reveal that the late Pleistocene climate was a little different. Although Southern California was not covered by a glacier during the last ice age, it was still cooler than it is today. Seeds from La Brea fossils include those of coast redwoods, incense cedars, and cottonwoods, all trees that need a steady water supply throughout the year. The large numbers of fish, frog, and turtle fossils show that the climate must have been wet enough to support the streams and ponds these animals need to survive. In fact, the climate of Los Angeles during that period may have been much like the moist, cool climate of present-day San Francisco.

La Brea Tar Pits, Los Angeles, California

Water-loving plants and animals no longer live in Los Angeles. From fossil evidence, scientists estimate that the climate became warmer and drier between 18,000 and 11,500 years ago.

Evidence of Biodiversity

Scientists continue to use fossils to reconstruct the entire ecosystem at La Brea. The collection includes microfossils, such as those of seeds or small insects, large plant eaters (herbivores), meat eaters (carnivores), and even scavengers. Using seed fossils, scientists have identified 158 different plant species. The fossil collection also includes more than one million invertebrates, such as grasshoppers, flies, and scorpions. Small vertebrate fossils from frogs, toads, salamanders, snakes, turtles, and fish number in the thousands. Most of these species still live in California today.

Scientists have discovered many large animals in the tar pits. They look at the shape of fossilized teeth and jawbones to figure out what these animals ate. For example, the broad, flat molars of the Columbian mammoth were ideal for grinding grasses. Its relative, the American mastodon, probably dined on leaves and twigs. Other herbivores in the tar include the ancient bison, western camel, and giant ground sloth.

Among the large fossils at La Brea, carnivores outnumbered herbivores almost nine to one. Scientists believe this ratio results from the fact that plant eaters trapped in the tar attracted meat eaters to the pits. The carnivores became trapped while feeding on the carcasses. Scavengers, in turn, also became stuck while feeding. The most common mammal fossil in the pits is a carnivore called the dire wolf. Scientists believe this wolf hunted in packs, as a result many of them got trapped at one time. Researchers have found other carnivore fossils too, including short-faced bears, American lions, and saber-toothed cats. Some types of carnivores found in the pit, such as the bobcat, coyote, and weasel, still live in California today.

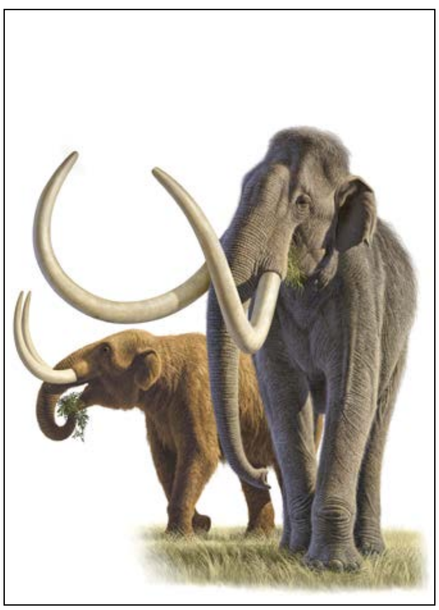
Hunter in the ice age

Bird fossils are less common than fossils of many other animals because their bones are hollow and fragile, making them less likely to be preserved. Even so, scientists have discovered more than 100,000 bird fossils in La Brea's tar, comprising one of the largest collections in the world. These remains include ancestors of birds, such as the California condor, that still live in California. Others, such as the Merriam's teratorn, are now extinct. The teratorn is the largest bird fossil pulled from La Brea; it stood more than two-feet tall with a wingspan of more than 10 feet.

Evidence of Extinction

The fossil record at La Brea bears witness to the demise of many species at the end of the last ice age. Around 12,000 years ago many animals began dying out. Scientists know these animals died out then because there are no fossils of these animals in the youngest, uppermost parts of the tar pits. The most affected were large mammals. Large herbivores, such as the mammoth, mastodon, ground sloth, ancient bison, and western camel, disappeared. Carnivores like the dire wolf, short-faced bear, American lion, and saber-toothed cat also went extinct. Scientists believe one or more of three factors—disease, overkill by humans, and climate change—may explain this extinction event.

People brought diseases with them when they began settling North America about 500 years ago. Some scientists think the pets of these settlers spread the diseases to vulnerable wild animals. The second possible factor, nicknamed the "overkill theory," suggests that humans caused extinctions through hunting too much. Perhaps humans killed large herbivores for food, starving the predators that ate the herbivores? Scientists at La Brea do not have much evidence for these theories, especially because they have found only one human skeleton there. At other fossil sites in North America, scientists have found sharpened stone points they believe were used for hunting. Scientists wonder about a connection between the extinctions and the arrival of humans because the two events happened at around the same time.



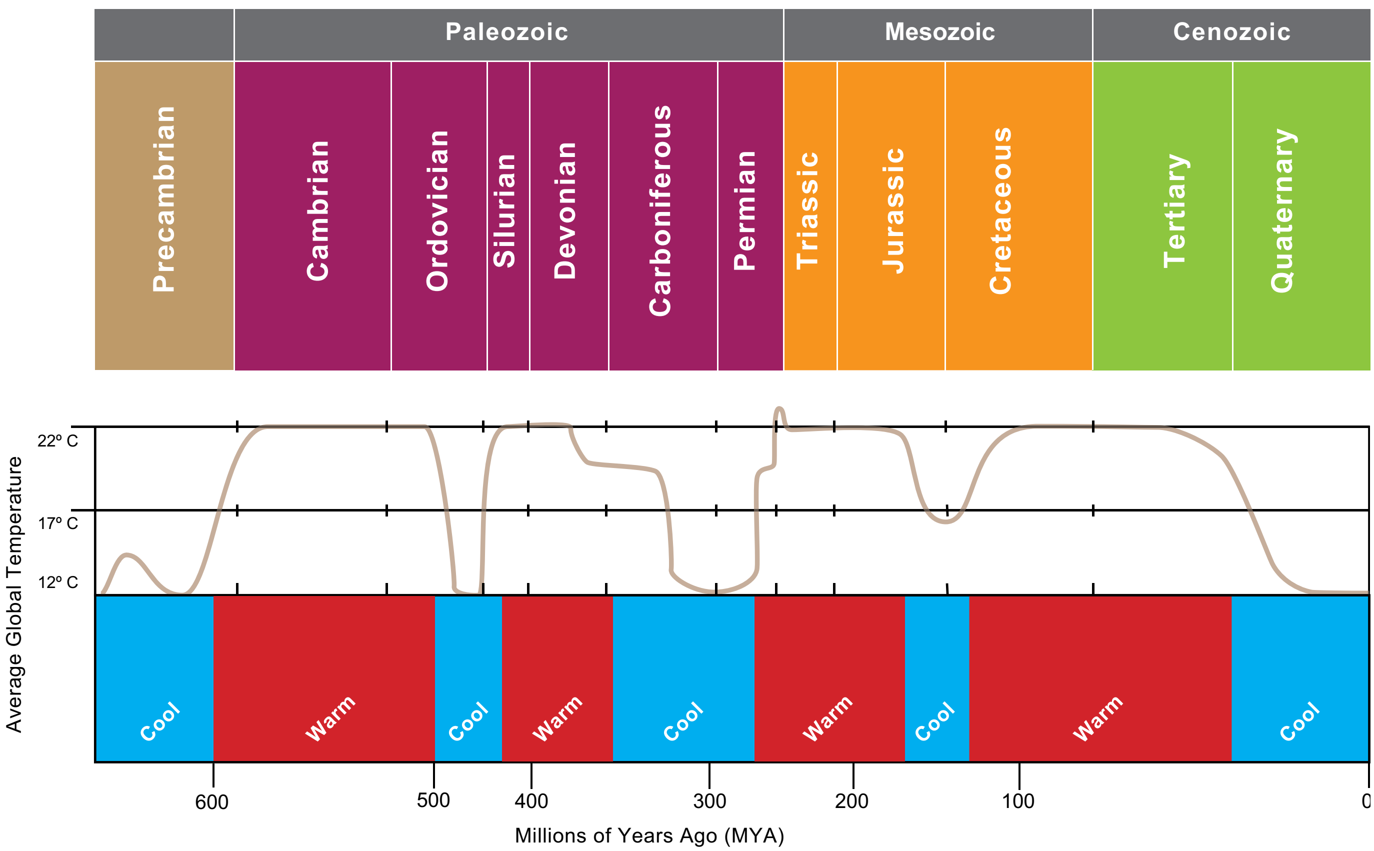
Mammoth and Mastodon

Scientists who believe the third factor, climate change, is responsible for extinctions think that as the climate warmed, streams and ponds dried up. The plants near the water died or adapted to a more arid environment. A chain reaction went all the way up the food web, starting with the herbivores. As the herbivores struggled to survive, the carnivores had fewer prey to hunt. Some scientists believe a combination of all three factors contributed to the extinctions.

What Does This Mean for the Future?

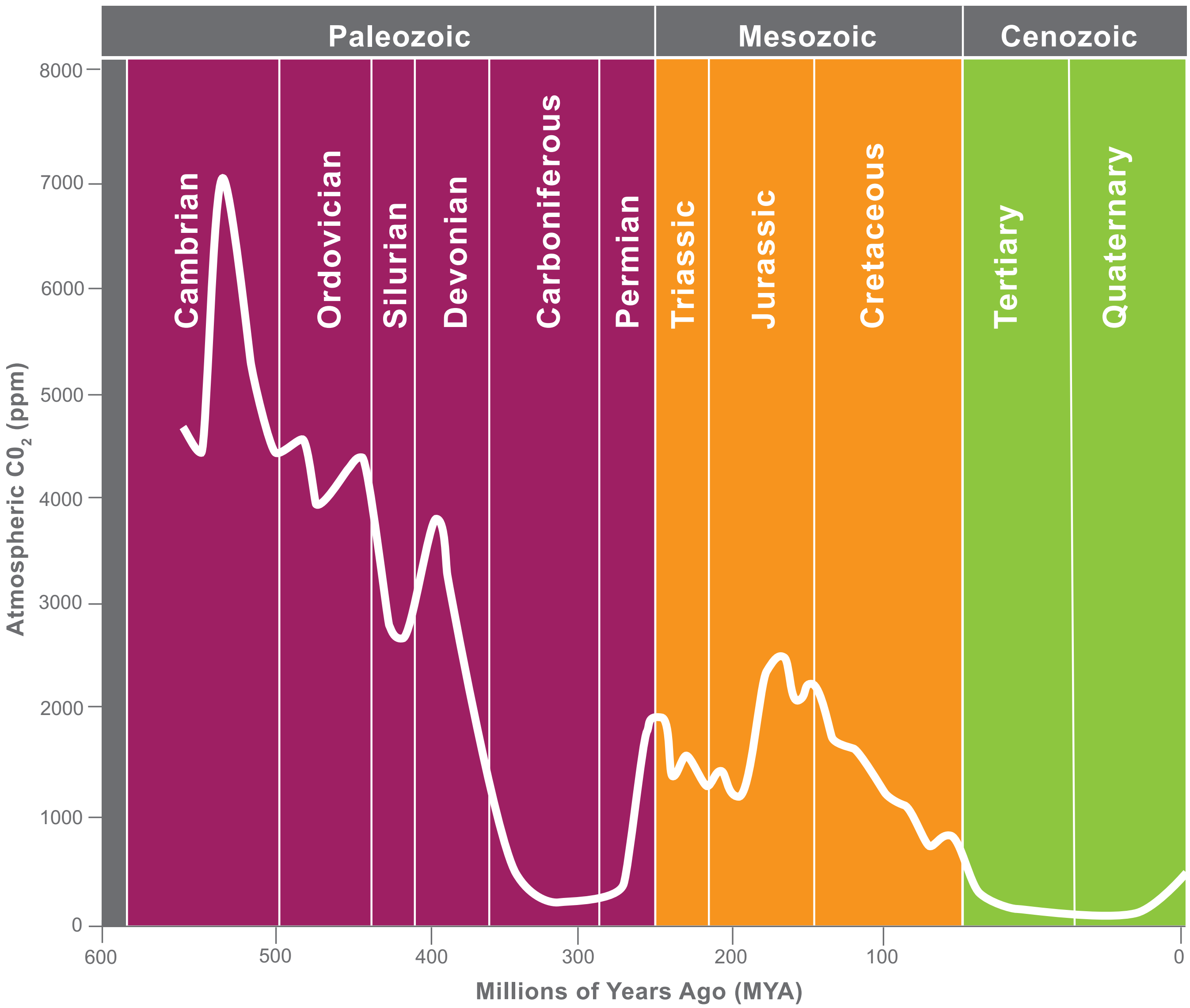
The La Brea Tar Pits offer a unique glimpse of changes around the end of the last the ice age. The fossil record excavated from the tar pits helps us understand climate change during Earth's past. Scientists can apply this knowledge to their study of current climate changes. Dr. Blaire Van Valkenburgh, a UCLA researcher, describes how understanding the ice age climate can help scientists predict the influence of present-day global climate change. "When environmental change happens very rapidly, animals cannot adapt. They have nowhere to move and competition becomes fierce. Some will become extinct."

Data on Global Temperature



Source: Scotese, Christopher R. "Paleomap Project: Climate History." http://www.scotese.com/climate.htm

Data on Atmospheric CO_2



Millions of Years Ago (MYA)	Era	Period	Fossil Evidence
0	Cenozoic	**Quaternary**	■ many mammal species, including marine mammals and humans ■ no evidence of dinosaurs and certain marine invertebrates (ammonites)
	Cenozoic	**Tertiary**	
65	Mesozoic	**Cretaceous**	■ many flowering plant and bird species ■ variety of dinosaurs (including pterosaur) ■ marine invertebrates (ammonites)
144	Mesozoic	**Jurassic**	■ increasing variety of dinosaurs ■ first birds and first flowering plants ■ no evidence of marine reptiles or approximately 35% of other animal families from Triassic
206	Mesozoic	**Triassic**	■ early dinosaurs ■ first mammals ■ variety of marine reptiles ■ no evidence of 90% of species, including trilobites—from Permian
248	Paleozoic	**Permian**	■ first herbivores with skeletons ■ increase in number of insect and amphibian species living during this time
290	Paleozoic	**Carboniferous**	■ first herbivores (insects) ■ first reptiles and flying insects ■ parts of scale trees and seed ferns ■ no evidence of more than 70% of invertebrates—most notably marine invertebrates—from Devonian
354	Paleozoic	**Devonian**	■ number of land-based plants increased during this time ■ first trees ■ bony fish ■ first amphibians
417	Paleozoic	**Silurian**	■ vascular plants ■ number of jawless fish increased and spread ■ evidence of large coral reefs in oceans ■ no evidence of 60% of marine invertebrates from Ordovician
443	Paleozoic	**Ordovician**	■ first jawless fish ■ lichens ■ first land plants
490	Paleozoic	**Cambrian**	■ animals with (exo)skeletons ■ algae ■ fossils indicate the number of marine invertebrates (mostly trilobites) increased during this time
543			

Trilobite fossil

Case Study 1: Permian

Trilobites were early arthropods that lived in the shallow waters of the ocean. They lived on Earth for almost 300 million years. The last trilobite families disappeared during the late Permian period. At the same time, about 95% of other marine animals also went extinct. About 70% of land species also disappeared. By the end of the Permian, almost all tree species had gone extinct. The late-Permian extinction happened at a time of many rapid environmental changes. It is the largest extinction we know about.

Scientists debate what could have caused the late-Permian extinction. Because it happened so long ago, fossil evidence is hard to find because the rocks that contain it have been eroded or buried. Scientists have learned a few things about this time. Many volcanoes erupted at the end of the Permian. These volcanoes covered land almost □ the size of our modern United States. The volcanoes may have erupted for as long as a million years, creating one of the biggest volcanic events of the past 600 million years. The gases released from these volcanoes would have caused acid rain and changes in global temperatures.

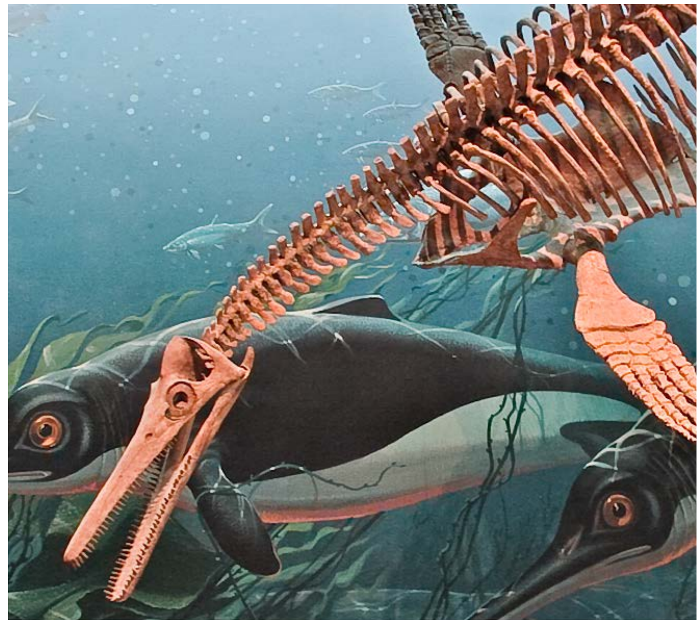
Also during the Permian the continents came together to form Pangaea. This change would have reduced the areas of shallow ocean water (reefs) in which many organisms live. In addition, glaciers formed during the Permian. The glaciers would have lowered sea levels around the globe. When the sea level goes down, ocean water becomes saltier and its temperature changes. Some marine life would not have survived these changes. All of these changes may have contributed to the end of the trilobites and many other species.

Some scientists think an asteroid might have caused the Permian extinction. As of 2008, no one had found a crater or other direct evidence to support this hypothesis.

Case Study 2: Mesozoic

Ichthyosaurs were marine reptiles that lived during the Mesozoic era. Ichthyosaurs were large-eyed carnivores that swam fast. Some species of Ichthyosaurs were more than 49 feet (15 meters) long—longer than a city bus! Ichthyosaurs went extinct during the late Cretaceous period, 25 million years before the dinosaurs.

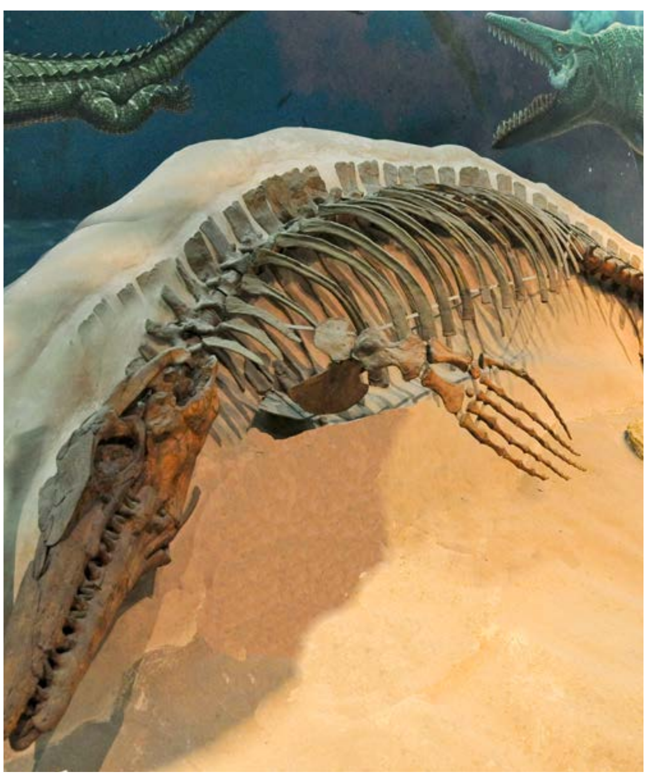
Scientists have found fossils of the contents of ichthyosaur intestines. This discovery tells them what ichthyosaurs ate. Many fossils show that ichthyosaurs ate belemnites, squid-like animals that also went extinct during the Cretaceous. Gradually, belemnites began to decrease in the Cretaceous period, perhaps due to warming global temperatures during that time. For many years, scientists thought the decline of belemnites might have caused the extinction of ichthyosaurs.



Ichthyosaur skeleton

A few years ago, researchers found other fossil evidence from the intestines of ichthyosaurs. One ichthyosaur contained fossilized pieces of turtle meat and ancient bird meat. This evidence showed ichthyosaurs could survive on food other than belemnites.

At the same time, fossil evidence showed that the numbers of other predators in the ocean increased. Mosasaurs, other giant reptiles with snake-like bodies, increased in number during the Cretaceous. These powerful swimmers probably competed with the ichthyosaurs for territory and food. Mosasaur fossils show that these animals were bigger than the largest ichthyosaurs. The mosasaurs likely outcompeted the ichthyosaurs and other predators, causing the ichthyosaur population to decline and these animals to gradually go extinct.



Mosasaur skeleton

Nomingia partial skeleton

Case Study 3: Cretaceous

Based on the fossil record, all organisms in the order Dinosauria, except for birds, disappeared 65 million years ago, at the end of the Cretaceous period. Scientists still debate how this extinction happened.

Most agree that an asteroid hit Earth and caused a series of changes that contributed to the extinction of the dinosaurs. A large asteroid would have created a giant cloud of dust, as well as global forest fires and giant ocean waves. The big dust cloud would have blocked the Sun, causing temperatures to drop. The huge fires would have increased the amounts of carbon dioxide and soot in the atmosphere. This change would have increased global temperatures, affecting the ability of plants and animals on land and in the oceans to survive.

What do fossils show from this time? The fossils reveal that along with the dinosaurs, many land plants rapidly went extinct. Scientists have also found evidence of burned plants in the fossil layer that formed immediately after the impact. Insects that fed on only one or a few types of plants also disappeared. Flying reptiles, called pterosaurs, and all marine reptiles went extinct. Many types of microscopic marine plankton disappeared, along with other kinds of ocean life. In all, almost 50% of all species living at that time were extinct by the end of the Cretaceous.

These two pages provide information about the fossils and rocks you may find in your core sample.

Geologic Information

For some samples, the rock in the layers of your core sample may tell you something about what happened in the past. For samples with:

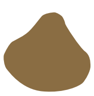
Glitter: These samples contain “iridium,” a rare metal commonly found in asteroids and other extraterrestrial objects.

Poppy or Sesame Seeds: These samples contain “lava,” indicating that they must have experienced volcanic eruptions.

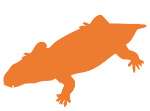
Fossil Information

Ammosaur: This dinosaur was an herbivore and stood as tall as 16.5 feet (5 meters), which is taller than two grown humans.

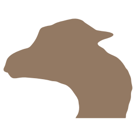
Brachiopod: This organism is an invertebrate. It has shells to protect its body. Brachiopods are also known as lampshells.



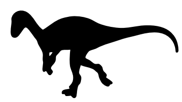
Clam: This organism is a type of mollusk. It is an invertebrate and has two shells to protect its body.



Dicynodont: This mammal-like reptile was an herbivore.



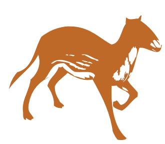
Dilophosaur: This dinosaur was a fast-moving carnivore. It stood as high as 19.7 feet (6 meters) tall and had large crests on top of its head.



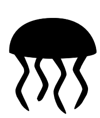
Eoraptor: This animal may have been the first dinosaur. It was a medium-sized carnivore that stood on two feet.

Fern spores: Spores from ferns are often the first evidence of plant life to be found after a catastrophic change in an ecosystem.

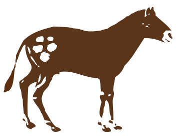
Glossopterid: This plant has leaves like ferns and seeds, instead of spores, attached to its leaves.



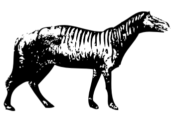
Hyracotherium: This small, dog-shaped animal may have been the earliest ancestor of the horse. It was about 10–20 inches (25.4–50.8 centimeters) tall. It had three grinding molar teeth on each side of its jaw.



Jellies: Sometimes called jellyfish, the name is misleading because this animal is not a fish. Jellies are marine invertebrates.

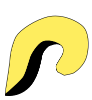


Mesohippus: This animal was about 24 inches (61 centimeters) tall at the shoulder. It looked less like a dog than the hyracotherium and orohippus. It had six grinding molar teeth on each side of its jaw. These allowed it to eat tough plant material.

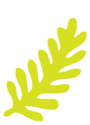


Orohippus: This small, dog-shaped animal looked much like the hyracotherium in size and shape. It had four grinding molar teeth on each side of its jaw. This allowed it to eat tough plant material.

Scaphonyx: This rhyncosaur, an early reptile, was an herbivore.



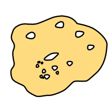
Sea pen: A sea pen consists of a colony of polyps. Polyps are anemone-like structures that work together to survive. They are invertebrates.



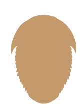
Seed fern: This fern-like plant reproduced using seeds. All modern ferns reproduce with spores.

Segmented worm: This invertebrate has a soft, segmented body.

Snail: This marine invertebrate has a single shell to protect its body.



Sponge: The sponge is a marine invertebrate with no specialized tissues.



Trilobite: The trilobite is a marine arthropod. It has a hard exoskeleton covering its body.

1. California Freshwater Shrimp

The California freshwater shrimp eats decaying plants and animals. It requires clean fresh water to survive. This shrimp lives in coastal streams in Marin, Sonoma, and Napa counties. These counties are north of San Francisco and contain cities, such as Santa Rosa, San Rafael, and Napa. Many factors have endangered this shrimp. Humans have altered habitat by mining for gravel in the shrimp's streams, harvesting timber along banks, and building farms and dams in these counties. The shrimp are also threatened by nonnative fish species that people have stocked in streams. These fish eat the shrimp. Water pollution poses another threat, since the shrimp require clear, clean water to survive.

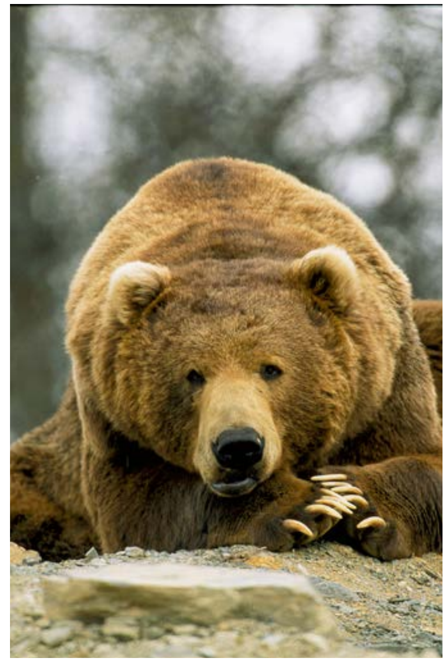
Status: endangered

2. California Golden Trout

The California golden trout lives in cold, clear mountain streams and pools in Inyo National Forest in the eastern Sierra Nevada mountains. This forest sits next to the town of Mammoth Lakes. The trout feeds on insects and their larvae. People have introduced brown trout and rainbow trout into the golden trout's habitat. The golden trout cannot compete with these other fish for the same food resources. In addition, brown trout often eat golden trout. Cattle ranching has also hurt the California golden trout. When cattle graze in meadows next to streams, they often strip the streams of plants or damage the banks that help hide the golden trout from predators.

Status: threatened. Conservationists are working to get the trout added to the endangered species list.

3. Grizzly Bear



The grizzly bear lived in hills and mountains throughout California. The grizzly bear eats both plants and animals, but is most famous as a fierce top predator. When large numbers of people came to California during the Gold Rush in 1849, they moved into grizzly bear habitat. People were afraid of the grizzly bear and did not want it to kill their livestock, so they began to hunt the bear. By 1922, fewer than 75 years after the discovery of gold, the last grizzly bear in California was killed. The grizzly bear still lives in North America, mostly in and around Canada, American national parks, and other and protected areas of the United States.

Status: threatened. Removed from the endangered species list in March 2007.

4. Guadalupe Fur Seal

The Guadalupe fur seal used to live along the coast of California. In the 1800s, fur seal hunters killed most of the 30,000 seals that lived in the ocean. In fact, so many were killed that scientists thought the seals were extinct. Some seals survived, however, and were rediscovered in 1954. Several thousand seals now breed in Mexico and swim off the coast of Southern California. They eat the plentiful squid and mackerel. Noise pollution from the space shuttle program harms the seals. In addition, oil exploration in the ocean disturbs its habitat.

Status: threatened. Conservationists are working to get it added to the endangered species list.

5. Island Fox

The island fox lives on the Channel Islands off the coast of California. This fox is the largest mammal native to the Channel Islands. It is only about the size of a house cat and eats mostly insects and fruit. It faces a variety of human threats. Golden eagles, which arrived in the islands in 1999, now kill and eat island foxes. Before 1999, bald eagles lived on the islands and scared away the golden eagles. Bald eagles ate fish instead of foxes, so the foxes had no natural predators on the islands. Pollution from DDT, a pesticide humans used in farming, killed off the bald eagle population on the islands. Golden eagles arrived after the bald eagles disappeared. In addition, dogs that humans introduced to the islands have brought diseases that kill some foxes.

Status: endangered. The population has dropped at least 50% since the 1990s. On Santa Cruz Island the population has dropped from 1,300 in 1995 to fewer than 100 today.

6. Salt Marsh Harvest Mouse

The salt marsh harvest mouse lives in the marshes of the San Francisco, San Pablo, and Suisun bays in northern California. About 84% of the salt marshes by these bays has disappeared since 1850 as humans have developed this land for cities, agriculture, and salt production. People have also affected the marshes by putting fresh water from wastewater treatment plants into the bay—adding fresh water makes marshes less salty and changes the plants that live there. The salt marsh harvest mouse needs marsh plants, such as pickleweed and saltgrass—without the right plants harvest mice cannot survive. Stray cats from the nearby houses prey on the harvest mouse. These are among the many threats faced by salt marsh harvest mice.

Status: endangered. Population has declined 50–90% in the past 150 years.

7. San Joaquin Antelope Squirrel

The San Joaquin antelope squirrel is a small ground squirrel with a stripe on its side. This squirrel eats plants, fungi, seeds, and insects. It lives in the San Joaquin Valley, an area significantly changed by humans in the past century. This squirrel used to live in a range of 3.5 million acres. Now it has only 102,000 acres of available habitat. Humans have altered the rest of this animal's habitat for farming, mining, building roads, and more. More humans continue to move to the San Joaquin Valley every year. Pesticides designed to kill other ground squirrels have also killed the San Joaquin antelope squirrel.

Status: threatened. Conservationists are working to get the squirrel added to the endangered species list.

8. San Joaquin Kit Fox

The San Joaquin kit fox is the smallest fox in North America. As its name suggests, it lives in the San Joaquin Valley. It eats different species of squirrels and other rodents, as well as birds and insects. The kit fox population has gone down as a result of many human activities. In the 1900s, much of the kit fox habitat was altered for farming and polluted with pesticides. By 1979, more than 93% of the San Joaquin Valley's land had been developed. People continue to move into the San Joaquin Valley. They threaten the kit fox population with their new farms, buildings, and more.
In addition, nonnative species, such as the coyote, the red fox, and domestic dogs prey on the kit fox.

Status: threatened. Conservationists are working to get the fox added to the endangered species list.

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