Paleontology: The Study of Ancient Life

Paleontology is the study of ancient life. The history of past life on Earth is interpreted by scientists through the examination of fossils, the preserved remains of organisms which lived in the geologic past (more than 10,000 years ago). There are two main types of fossils: body fossils, the preserved remains of actual organisms (e.g. shells/hard parts, teeth, bones, leaves, etc.) and trace fossils, the preserved evidence of activity by organisms (e.g. footprints, burrows, fossil dung).

Chances for fossil preservation are enhanced by (1) the presence of hard parts (since soft parts generally rot or are eaten, preventing preservation) and (2) rapid burial (preventing disturbance by biological or physical actions). Many body fossils are skeletal remains (e.g. bones, teeth, shells, exoskeletons). Most form when an animal or plant dies and then is buried by sediment (e.g. mud or sand). Over a period of thousands to millions of years, minerals from underground water (which is moving through the buried sediment) slowly precipitate into the pore spaces within the organism’s remains, thereby hardening it. Eventually, the organism’s remains are mostly replaced by minerals through this process. Body fossils also commonly form as impressions of the original material. For example, when mud covers a leaf or dead organism, it may eventually dry and harden around it. The outline or imprint of the organism’s shape and often its surface details are preserved in the hardened mud. Trace fossils, such as footprints, tracks, trails, and burrows, are typically preserved when mud/sand infills a depression or mark left by the organism in the underlying mud/sand. These mud layers harden and later separate as rock layers to reveal the trace fossils.

Paleontologists study fossils to learn about the past history of life. Current knowledge of the life’s ancient history comes from the piecing together of findings of a multitude of studies on fossils and rocks found around the world. When these many findings are examined together, large-scale trends emerge (“the fossil record”) which provide an understanding of patterns in the history of life. The fossil record tells us how past plants and animals (many of which have long been extinct) interacted with each other and their environments, and how groups of organisms have changed through time (including patterns of evolution and extinction). Information from the fossil record also provides a better understanding of ancient climate, geography, oceanography and much more.
Scientists divide the Earth’s history, or Geologic Time, into chunks of time (e.g. Eons, Eras, Periods and Epochs) based on prominent changes in the fossil and rock record (on a global scale). Geo-logic time is subdivided into 2 main time blocks: Precambrian Time and the Phanerozoic Eon. The Phanerozoic is subdivided into three eras: the Paleozoic, the Mesozoic and the Cenozoic. Below are brief descriptions of these major time divisions in the Earth’s history:

**Precambrian Time** (4600-542 million years ago): The Precambrian represents an enormous portion (nearly 7/8ths) of the Earth’s history. This vast amount of time is represented in the rocks formed 100s to 1000s of millions of years ago. Life began during this early time in the earth’s history. The earliest life forms include impressions of bacteria/algae and carbon films and impressions of soft-bodied multicellular life. The first mineralized (or hard) skeletons appear in the late Precambrian but most Precambrian fossils were soft-bodied forms.

**Paleozoic Era** (542 – 251 m.y.a.): Most major fossil groups (phyla) appear within the first 10 million years of the Paleozoic. Invertebrate life continued to diversify and proliferate in the seas, including common trilobites, crinoids, eurypterids, and many more. Primitive fishes (the first vertebrates) and amphibians first appear. This time also marks the transition of organisms onto land, with the appearance of land plants, insects, and fossil reptiles.

**Mesozoic Era** (251 – 65 m.y.a.): During this “Age of Reptiles,” terrestrial organisms include conifers, cycads, primitive mammals, reptiles, flying reptiles (pterosaurs), and the ever-popular dinosaurs. Birds and flowering plants first appear. In the oceanic (or marine) realm, diversity and abundance continue to grow, including the appearance of swimming reptiles (mosasaurs, plesiosaurs & ichthyosaurs) and many strange forms of ammonites.

**Cenozoic Era** (65 m.y.a. – present): Small mammals lived during the Age of Reptiles (Mesozoic), but it was not until the extinction of the dinosaurs and the beginning of the Cenozoic that mammals diversified and dominated. This era is called the “Age of Mammals.” It also marks a time of unprecedented marine diversity. Modern man appeared about 120,000 years ago, very late in the Cenozoic. We are presently in the Cenozoic.

**The Raymond M. Alf Museum of Paleontology**

The Raymond M. Alf Museum of Paleontology is located on the campus of The Webb Schools. The museum was founded by Dr. Raymond M. Alf, a math and science teacher who first took Webb students in search of fossils in the early 1930s. In 1936, Alf and student Bill Webb (son of the school’s founder) discovered the skull of a new species of fossil pig, or peccary. The discovery of the peccary sparked in Alf a life-long commitment to the study of paleontology and led to the founding of the museum that bears his name. After the discovery of the peccary, student fossil collecting trips were known as Peccary Trips. Over 95% of the 150,000 fossils in the museum’s collection were unearthed by students and staff on Peccary Trips. In 1998, the Raymond M. Alf Museum of Paleontology gained national accreditation from the American Association of Museums, the highest honor a museum can achieve. Thus, the Alf Museum is the only nationally accredited museum located on a high school campus in the United States.

The Alf Museum has two large circular exhibition floors: The Hall of Life and The Hall of Footprints. The Hall of Life traces the history of life from the first cells through human civilization. On display are the remains of some of the oldest multicellular organisms, fossil invertebrates including trilobites, crinoids and eurypterids and fossil vertebrates including dinosaurs and extinct reptiles. Displays include skeletal casts of the dinosaurs *Allosaurus* and *Centrosaurus*, a wing of the great pterodactyl *Quetzalcoatlus*, casts of a *T. rex* skull, real dinosaur eggs, and a wide range of fossil mammals from Western North America. The Hall of Life includes many exciting, informative and interactive exhibits.
The Hall of Footprints is the largest, most diverse collection of animal footprints on display in North America. The dozens of trackways on exhibit include rare footprints from extinct spiders and scorpions and trackways that were left by ancient birds, dinosaurs, amphibians, reptiles, and other animals. Highlights include the oldest fossil elephant (proboscidean) footprints from North America and a cast of the giant bear-dog, *Amphicyon*, mounted directly above the only known trackway of this large carnivorous mammal. This and other unique fossil footprints make the museum’s collection of tracks its most significant scientific asset. The Hall of Footprints offers interactive exhibits and a children’s activity area with a dig pit and more!

**The Optimal Alf Museum Experience**

In the Alf Museum, careful observation and hands-on discoveries of the fossils can provide your students with a very fulfilling learning experience. The museum’s guided tour is designed to educate your group about the museum’s major exhibits while also allowing your students opportunity for hands-on, self-paced learning. The group will also learn about paleontological field and lab work through a short film which highlights the museum’s hadrosaur dinosaur skull discovery. Students tend to gain more from their museum experience if they arrive with prior knowledge of the major concepts to be covered, as well as what to expect from their visit. It is useful, in advance, to inform them of basic information about where they are going and what they will see, as well as specific details such as what is expected of them.

Before your visit, we ask that you be aware of a few important rules: (1) We ask that all adults accompanying your class stay with your group at all times. Please remind parent chaperones that, while their interest in the exhibits is appreciated, they are volunteering their time to help manage your class. The docent leader has been trained to teach your students about the exhibits but is not responsible for monitoring the group’s behavior. He or she will begin your tour by stating what is expected of the group. Typically, students are asked to behave as they would in class, *i.e.* listen to the leader, raise hands to ask or answer questions, etc. It would be helpful if you would review rules of proper conduct with your group and make them aware before the visit that (2) students are not allowed to touch any displays unless they are told that they may do so. (3) They are also not to climb, sit or lean on the displays unless instructed by signs in the museum. It is very tempting to touch the exhibits but the fossils are irreplaceable and need to be treated with care.

We strongly suggest that you prepare your students by introducing major concepts (such as fossilization and others included in this guide) and by having them complete one or some of the suggested activities before your visit. The activity sheets in this curriculum guide are designed to strengthen and reinforce your class’ museum experience and to exercise your students’ critical thinking skills. Completion of some of these worksheets before your visit should stimulate your students’ interest in the exhibits. Information about how each activity is aligned with California Science Content Standards is listed on the Activity Guide table on page eight.

By visiting the Alf Museum and completing the suggested activities, your students will:

- Observe fossil specimens that inhabited the Earth at different times in its history.
- Watch a short film which focuses on paleontological field and lab work conducted by the museum.
- Compare the two types of fossils, how they form and what information they provide about ancient life.
- Describe modern and fossilized animals according to their characteristics.
- Discuss how adaptations affect how organisms can exist within environments.
- Determine the relative timing of events based on data from fossils and sedimentary rock sequences.
- Describe & compare the animals and environments of prehistoric and present-day California.
- Discuss how paleontologic research (collecting, preparing and curating fossils) is conducted.
- Read and construct simple tables to organize, examine and evaluate information.
During their visit, your group will not only have a museum tour but will be shown a short film in the museum’s lecture hall. The 15-minute film “Jurassic High” features Webb students on a museum Peccary Trip discovering and excavating a hadrosaur dinosaur skull in Utah. The film focuses on the field and research work conducted by the museum; it shows paleontologists and Webb students in all aspects of their paleontological work both in the field and back at the museum—from prospecting to curation of fossils. This presentation is an exciting component of your museum experience by showing your group the more dynamic scientifically active side of the museum. Below is an outline of the material highlighted in the film. We encourage you to introduce this material to your students before their visit and/or to reinforce the concepts in your class afterwards.

Also, please note that if your tour group arrives late for your visit that time constraints may prevent the opportunity for them to view the film. Although we wish for every group to see “Jurassic High”, if time is very limited then touring the exhibits will take priority.

**Paleontology:** The study of prehistoric times using fossils.

**Fossil:** The remains of an animal or plant from the past preserved in rock. Fossils are our only evidence of past life.

**A Paleontologist's Tasks:**
1. Prospecting for fossils
2. Fossils discovered and collected and proper field data recorded
3. Fossils safely brought back to the museum
4. Fossils prepared
5. Fossils curation
6. Fossils either placed on exhibit or put safely in collection for later research

**Prospecting (paleontologically speaking):** Finding fossils exposed on the ground.

**How to Quarry (Collect) a Fossil:**
1. Remove most of the surrounding rock
2. Apply Hardener to preserve bone
3. Cover with burlap soaked in plaster
4. When dry, take it back to the museum

**Tools used to collect fossils:** Rock hammer, pickaxe, bone hardener, shovel, basin for mixing plaster, awl, brush, plaster/burlap, toilet paper, water.

**Field data:** Information about the fossils and where they are found.

**Fossil preparation:** Cleaning the fossils by removing surrounding rock and piecing them together if necessary; making them ready to be studied or put on display.

**Curation:** Creating good written records and organizing the museum collection.

**Paleontology research:** Using fossils to learn something new about past life that no one ever knew before.
What is a paleontologist?
Paleontology is the study of ancient life (through fossils); therefore, a paleontologist is a scientist who studies fossils to better understand what life was like long ago.

What is a fossil? What are the two types of fossils?
Fossils are the preserved remains of organisms which lived in the geologic past (over 10,000 years ago). They can be divided into body fossils and trace fossils. Body fossils are the preserved remains of actual organisms (like bones, teeth, shells and impressions) and trace fossils are the preserved evidence of activity by organisms (like footprints and fossilized dung).

How can you tell the difference between a carnivore and an herbivore by looking in their mouths?
Carnivores eat meat so they need/have sharp/pointed teeth for piercing and tearing meat. Herbivores eat plants so they need/have lots of grinding teeth (with large flat grinding surfaces) to break up vegetation.

What is it called when a kind of animal or plant is no longer found alive anywhere?
Extinction. A type or species of organism is considered extinct when no more of its kind can be found living on Earth.

The Earth’s history is divided into different chunks of time (which together are called the Geologic Time Scale). Can you name the three main eras during which lots of different animals appear?
Most animal life existed during the Paleozoic, the Mesozoic and the Cenozoic. The Paleozoic Era is when many types of animals first appear; initially they all live in the oceans but later some are found on land. The Mesozoic Era comes after the Paleozoic and is the Age of the Reptiles. Dinosaurs rule at this time. The Cenozoic Era comes after the Mesozoic and is called the Age of the Mammals. Lots of different mammals lived during this time (including Ice Age creatures). The Paleozoic and Mesozoic both ended with very large extinctions (lots of animals went extinct at one time). We are still living in the Cenozoic.

Suggested Vocabulary
paleontology fossil body fossil
trace fossil invertebrate vertibrate
extinct scientist museum
herbivore carnivore omnivore
organism predator prey
skeleton cast or replica Geologic Time Scale
Glossary

**Adaptation**: a special characteristic, or the way an animal or plant species has developed over time resulting in an improved relationship to its environment. (It is important when teaching this concept to stress that adaptations are not ways that organisms/species have decidedly adjusted to their environments but instead that adaptations are the results of a long process, natural selection, which weeds out less successful variations of body plans thereby resulting in the success of organisms that have characteristics more in-tune with their environmental conditions.)

**Cenozoic**: The latest of the Phanerozoic eras of geologic time, extends from the end of the Mesozoic Era (65 million years ago) to the present; the Age of Mammals

**Collection**: An accumulation of objects gathered for study, comparison or exhibition

**Carnivore**: An organism that eats meat

**Curator**: A person who organizes and exhibits objects of art, science, or historical interest for a museum department

**Environment**: The air, water, and land in and on which organisms live

**Extinction**: The disappearance of a plant or animal species; no longer in existence or living

**Fossil**: Preserved remains of organisms which lived in the geologic past (>10,000 years ago)

**Geologic time**: The vast amount of time (4.6 billion years) interpreted to represent the Earth’s history

**Herbivore**: An organism that eats plants

**Invertebrate**: An organism (e.g. insects, jellyfish, etc.) which lacks a backbone or spinal column

**Mesozoic**: The second and middle era of the Phanerozoic, after the Paleozoic and before the Cenozoic; the Age of the Dinosaurs

**Museum**: An institution where objects are exhibited that is devoted to the collection, care, study, and display of objects of historical, scientific, or artistic interest

**Omnivore**: An organism that eats a mixed diet of plants and meat

**Paleontology**: The study of ancient life through the examination and interpretation of fossils

**Paleozoic**: The first era of the Phanerozoic, after Precambrian Time and before the Mesozoic Era

**Permineralization**: The process of fossilization wherein the original hard parts of an organism have additional mineral material deposited in their pore spaces

**Phanerozoic**: The part of geologic time represented by rocks in which evidence of ancient life is abundant

**Plate tectonics**: The theory that the earth’s crust is divided into a number of plates that slowly move over the mantle; most earthquake and volcano activity occurs along plate boundaries

**Precambrian Time**: The part of geologic time preceding the Phanerozoic, representing 7/8th of the Earth’s history

**Predator**: An organism that feeds by preying on other organisms, killing them for food

**Prehistoric**: Relating to the times before recorded/written history began

**Specimen**: A single item of fossil, rock, animal, plant, or other natural object that is part of a museum or research collection

**Vertebrate**: An organism (e.g. mammals, reptiles, etc.) which has a backbone/spinal column

*Amphicyon* am-fi-SY-on *Coelophysis*: SEE-Ioh-FY-sis

*Eurypterid* yoo-RIP-ter-id *Quetzalcoatlus*: KET-zal-koh-AHT-lus

*Crinoid*: CRY-noid

*Trilobite*: TRY-Ioh-bite
# The Geologic Time Scale

| Phanerozoic Eon  
| (542 mya to present) | Cenozoic Era  
| (65 mya to today) | Quaternary (2.6 mya to today)  
| | Holocene (11,700 years to today)  
| | Pleistocene (2.6 mya to 11,700 yrs)  
| | Tertiary (65 to 2.6 mya)  
| | Pliocene (5 to 2.6 mya)  
| | Miocene (23 to 5 mya)  
| | Oligocene (34 to 23 mya)  
| | Eocene (56 to 34 mya)  
| | Paleocene (65 to 56 mya)  
| | Mesozoic Era  
| (251 to 65 mya) | Cretaceous (146 to 65 mya)  
| | Jurassic (200 to 146 mya)  
| | Triassic (251 to 200 mya)  
| | Paleozoic Era  
| (542 to 251 mya) | Permian (299 to 251 mya)  
| | Carboniferous (359 to 299 mya)  
| | Pennsylvanian (318 to 299 mya)  
| | Mississippian (359 to 318 mya)  
| | Devonian (416 to 359 mya)  
| | Silurian (444 to 416 mya)  
| | Ordovician (488 to 444 mya)  
| | Cambrian (542 to 488 mya)  
| | Precambrian Time  
| (4,600 to 542 mya) | Proterozoic Era  
| (2500 to 542 mya) | Neoproterozoic (1000 to 542 mya)  
| | Vendian (650 to 542 mya)  
| | Mesoproterozoic (1600 to 1000 mya)  
| | Paleoproterozoic (2500 to 1600 mya)  
| | Archaean  
| (4000 to 2500 mya)  
| | Hadean  
| (4600 to 4000 mya) |

(mya = million years ago)

Please note the hierarchy:  
Eons  
Eras  
Periods  
Epochs  
EX: Phanerozoic Eon  
Cenozoic Era  
Tertiary Period  
Miocene Epoch
Useful Resources

Books for Young Readers (preK- 4th grade)


Books for Older Readers (4th grade & older)


Online Resources – Five of our favorite educational websites

- University of California Museum of Paleontology website (UC Berkeley) – detailed information & activities on fossils, evolution, geologic time & more – [www.ucmp.berkeley.edu](http://www.ucmp.berkeley.edu)

- Evolution and the Nature of Science Institutes website – information & lesson plans on evolution & the nature of science; geared for high school biology classes but can be adapted to middle school levels - [www.indiana.edu/~ensiweb/](http://www.indiana.edu/~ensiweb/)

- The Kentucky Geological Survey’s Earth Science Classroom Activities website – includes numerous activities and demonstration suggestions/handouts as well as a “Geologic and Paleontologic Cookbook” - [www.uky.edu/KGS/education/activities.html](http://www.uky.edu/KGS/education/activities.html)

- Society of Sedimentary Geology (SEPM) Earth Science On-line Activities website – includes the on-line version of their popular educational publication that has 42 earth science lesson plans arranged by topic & grade level - [www.beloit.edu/sepm/index.html](http://www.beloit.edu/sepm/index.html)

- PBS’s Evolution Teacher’s Guide website – includes the online version of their 40-page guide filled with engaging, curriculum-based activities and multimedia resources on science and evolution - [www.pbs.org/wgbh/evolution/educators/teachstuds/tguide.html](http://www.pbs.org/wgbh/evolution/educators/teachstuds/tguide.html)
Activity Guide

Grade-appropriate materials are included in this packet for your use. All other exercises can be obtained from the museum upon request.

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FIFTH - EIGHTH GRADE (these exercises can be obtained from the museum upon request)

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<td>Creature Calculations (more complex version of “How Big Was I?”)</td>
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<td>Life in Prehistoric California</td>
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Raymond M. Alf Museum of Paleontology

EDUCATOR’S GUIDE
EVALUATION FORM

Date of Field Trip:
School:
Grade Level:
Number of Students:
Teacher’s name & email (optional):

On a scale of 1 (poor) to 5 (excellent), please rate the following:

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How useful was the Educator’s Guide & its activities in helping you prepare your students for their visit?

How useful were the activities in helping you reinforce your students’ field trip experience and knowledge of paleontology?

Did you use any of the Educator’s Guide’s activities provided in the Educator’s Guide? If so, how many? Were any of them particularly useful (& if so, which ones)? Or not useful?

How could the Educator’s Guide be improved to better serve your needs?

Any final comments or suggestions? Please continue on the back of this sheet, if necessary.

Thank you for completing this evaluation! Your opinion matters greatly to us. Please return this form to: Alf Museum, 1175 W. Baseline Road, Claremont, CA 91711.
**Steps to Fossilization:** The correct order of the plesiosaur pictures in Part 2 from left to right is: The live, swimming plesiosaur (third picture) happens first. The dead plesiosaur on the bottom of the ocean (first picture) happens second. The skeleton buried under layers of rock (fourth picture) happens third. The exposed skeleton in the desert sun (second picture) happens fourth.

**Who Makes It into the Fossil Record?** “Preservable” community: the invertebrates include barnacles, mussels, snails and crabs that have preservable exoskeletons (shells). Some of the invertebrates pictured do not have hard outer shells but have some internal hard parts and may be considered preservable; Sea urchins can leave “sand dollar” fossils, starfish have inner plates and hard spines, squid have a inner cartilaginous structure called a “pen” and the octopus has a hard “beak.” The picture also includes, fish, a shark, dolphins and a turtle which are the only vertebrate animals present and are preservable. Early elementary grades may wish to do this activity as a group project as a mural on large paper instead of the smaller “Preservable” tidepool and ocean community worksheet provided.

**Who Made These Footprints?** 1. dog; 2. dinosaur (carnivore); 3. cat; 4. spider; 5. camel; 6. bird

**Limbs & Lifestyles:** Alligators are extant (still in existence), all others are extinct. Correct identity of limb pictures from left to right: *Liopleurodon*, *Allosaurus*, *Pteranodon*, *Camarasaurus*, Alligator. *Liopleurodon* used its paddle-like limb to swim, *Pteranodon* its wing for flight and the *Allosaurus*, *Camarasaurus* and alligator walked. The alligator limb is useful for pointing out the difference between dinosaurs & other reptiles: dinosaurs had hip structures causing their legs to extend straight down under their bodies, not sprawled out from their sides like alligators.

**Wings & Things:** Correct identity of skeletal wing pictures from top to bottom: pterodactyl, bat, bird and under the line, human. Similarity: All have arm and hand bone components. Differences: The different wings use different parts as support.

**Prehistoric Neighbors?** Ice Age animals that DO belong: wooly mammoth, ground sloth, sabertooth cat (*Smilodon*), Dire wolves, rabbits. The last Ice Age started about 110,000 years ago and ended about 10,000 years ago during a time called the Pleistocene epoch. Animals that DO NOT belong: pterodactyl, *Triceratops* - both are Mesozoic in age and went extinct 65 million years ago long before the last Ice Age.

**Paleo Puzzle:** The running bear dog (*Amphicyon*) caught the camel, ate it (leaving some of its bones behind) and walked away. For a more challenging puzzle, teachers may wish to hide the footprint “key.”

**It’s All in the Smile:** Correct identity of teeth in the column from top to bottom: *Coelophysis* (carnivore), *Centrosaurus* (herbivore), *Allosaurus* (carnivore), *Camarasaurus* (herbivore). Carnivores have sharp pointed teeth and herbivores have blunt or ridged teeth.

**How Big Was I?** Modern alligator’s skull is 1 foot long and the body length is 12 feet; fossil alligator’s skull is 3 feet long so its body length is estimated at 36 feet. This is almost as long as a school bus!
**DID YOU KNOW?**

Landslides can move rocks and soil as fast as 60 miles per hour or more! But most sediments (clay, mud, silt and sand) gather slowly over hundreds even thousands of years. It could take 1,000 years to add one inch to the bottom of the ocean floor!

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**STEPS TO FOSSILIZATION! - PART 1**

**Raymond M. Alf Museum of Paleontology**

1. Plesiosaurs (ancient swimming reptiles - not dinosaurs) like this one, lived in the oceans about 199-65 million years ago.

2. When Plesiosaurs died, they fell to the bottom of the ocean floor and for some of them, the process of fossilization began.

3. When an animal dies, most often it’s body decays or is eaten and destroyed. But if the remains of an animal are buried quickly before they are destroyed, fossilization can occur if the conditions in the sediment (sand, mud or clay) surrounding the remains are just right. Usually only the most durable parts of an animal, like teeth, bones and shells, become fossilized. Studying fossils allows us to determine which species lived when and where, what their environment was like, and what their food preferences may have been.

4. Wind or water (like rain and floods) deposit sand and mud that covers the body of the Plesiosaur. Almost all fossils are preserved in sedimentary rock which forms when layers of sediment such as clay, mud, silt and sand pile up. These layers of sediments are compressed and hardened over millions of years. These types of sediments are deposited on land and in rivers, lakes and oceans.

5. Over time, the earth changes. Rivers, lakes and oceans dry up and sometimes become deserts. Sand, mud, and the bones buried within, have harden into rocks. The bones are fossilized. Weathering and erosion exposes the bones of the fossilized Plesiosaur skeleton. Fossils can be exposed after they have spent millions of years beneath the earth’s surface. Paleontologists collect and study fossils to understand what life on earth was like millions of years ago.
STEPS TO FOSSILIZATION! - PART 2
Raymond M. Alf Museum of Paleontology

Color and cut out the four pictures of the plesiosaur, Liopleurodon. Study Steps to Fossilization-Part 1 and use what you learn about how fossils are formed to decide which picture happened first, second, third and fourth. Glue the pictures in the correct order from first to last on the numbered squares.

1. First
2. Second
3. Third
4. Fourth
Great Impressions!

This activity allows your class to make impressions of objects using a method that is very similar to the way that fossil impressions are created. Fossil impressions or molds are imprints of the original animal or plant parts that preserve the shape and details of the original material. They are made of the surrounding matrix (e.g. sand or mud). Sometimes the original object is also preserved. Other times it may dissolve completely, leaving only a cavity that retains the shape of the original in the rock. The cavity is known as a natural mold. When natural molds are filled in by minerals carried in ground water, a natural cast is formed.

MATERIALS:
- Plaster of Paris
- Water
- Container and utensils to mix plaster
- Paper trays or paper or Styrofoam bowls
- Petroleum jelly
- Leaves or other objects such as shells, bones, keys, etc.
- “Great Impressions!” handout to accompany imprint

PROCEDURES:
1) As per package instructions, prepare a mixture of Plaster of Paris and water.

2) Pour the mixture into the paper containers. Tap the side of each container lightly to release trapped air bubbles. When the mixture just begins to set, place a leaf on the surface of the plaster (with the tip of the stem sticking up) and have the students gently press down evenly across the leaf. Allow the plaster to almost harden completely (the plaster should not move when the container is tipped from side to side) and then remove the leaf by pulling it slowly up by its stem. Allow the plaster to fully harden.

3) If you are using an object other than a leaf, lightly cover the surface of the object with petroleum jelly before pressing the object into the plaster. Allow the plaster to harden. After the plaster has hardened, remove the object.

MODIFICATIONS/EXTENSIONS:
1) Press a sugar cube into the plaster. After the plaster has hardened, run water over the sugar cube until the sugar has dissolved. You are left with a natural mold where the sugar cube was.
2) To make a “natural cast”, lightly coat the entire surface of the plaster mold with petroleum jelly. Prepare a second Plaster of Paris mixture. Pour a fresh layer of plaster on the petroleum-jellied surface. When the second layer has hardened, carefully remove it. This second layer has formed a cast and is a replica of the original object.
3) For younger groups, modeling clay or play dough may be used instead of plaster.
Plants and animals can be fossilized in a number of different ways. Often the actual organisms or hard parts of the organisms get preserved (like petrified wood or bugs trapped in amber). Sometimes the organisms are preserved as impressions. In this case, the actual plant or animal parts are not preserved but their shape and details are left as marks or imprints in the mud or sand they were touching. Leaves are among the most common fossils preserved as impressions.
Who Makes It Into The Fossil Record?

It's not easy to make it into the fossil record! Animals that have hard parts have a better chance of making it into the fossil record. After death, the remains of an animal must be buried by sediments like mud or sand. Where an organism lives or dies is also important as to whether or not it gets preserved as a fossil. Marine animals like the ones below, get buried more typically than land animals. Read about the characteristics of each organism on your reference sheets and think about whether or not they have a good chance of being preserved as fossils.

How different would the "preservable community" look from the community of animals in this picture? Which animals would probably not be preserved?
Who Makes It Into The Fossil Record?

Read about the characteristics of each organism on this page. Would these animals have a good chance of being preserved as fossils? Remember, after death the soft parts of animals may rot or be eaten, leaving only the hard parts. Animals that have hard parts have a better chance of being preserved or fossilizing.

**Fish** are the earliest known vertebrates; animals with backbones. The first fish and the first vertebrates appeared in the Cambrian Period about 510 million years ago. Fish breathe using gills; water goes in through their mouths and out through their gills which take oxygen from the water. Fish eat plants and other organisms.

The **Snail** builds one strong hard shell around most of its body. It carries this shell with it as it moves around in the ocean or in tidal pools looking for food. Snails can also hide within their shells. Most marine snails eat algae off the rocks.

**Sharks** are vertebrate fish with a full cartilaginous skeleton. Cartilage is a strong, flexible substance that is not hard like bone (people have cartilage in their noses and ears). Because cartilage does not fossilize well, shark fossils are rare. Shark teeth are very hard and fossilize well, so most fossil evidence of early sharks is from fossilized teeth. Sharks have existed for over 350 million years, evolving over 100 million years before the dinosaurs. Sharks are apex predators - organisms at the top of their underwater food chain.

Like clams, **Mussels** are soft-bodied animals that grow two hard shells around the outside of their bodies. Mussels attach themselves to the rocks with thick strong threads. After mussels die, their soft parts decay and only the two shells are left behind. Mussels are filter feeders; they feed on plankton and other microscopic sea creatures which are free-floating in seawater.

The **Sea Anemone** are carnivorous invertebrates that have a ring of stinging tentacles around the central hole which is its mouth. It attaches itself to the rocks and puffs itself up with water. During a low tide when the anemone is exposed to air, it folds its tentacles inward and shrinks to keep moist. The sea anemone eats small fish and shrimp by injecting venom that paralyzes their prey so the anemone can move it to its mouth for digestion.

The **Starfish (Sea Star)** has a hard skeleton made up of many tiny pieces surrounded by soft parts. The body falls apart when the soft parts decay after death. Starfish move around on their tube feet that have little suction cups on the ends. Sea stars are successful scavengers and predators. Some attack mollusks, like mussels and oysters, which don’t move, and some feed on dead fish or other carrion. Others take in organisms from seawater.
Read about the characteristics of each organism on this page. Would these animals have a good chance of being preserved as fossils? Remember, after death the soft parts of animals may rot or be eaten, leaving only the hard parts. Animals that have hard parts have a better chance of being preserved or fossilizing.

**Dolphins** are highly intelligent cetacean mammals closely related to whales and porpoises. Dolphins evolved about 11 million years ago. They are carnivores, mostly eating fish and squid. Dolphins live in social groups of five to several hundred. They use echolocation to find prey and often hunt together by surrounding a school of fish, trapping them and taking turns swimming through the school and catching fish.

The **Squid** is an invertebrate marine cephalopod similar to the octopus. Squid have eight arms and two tentacles arranged in pairs. Squid are carnivores eating various types of small fish, crabs, and shrimp.

The **Octopus** is considered the most intelligent of all invertebrates. They are carnivores that prey on crabs, crayfish, and mollusks, and will sometimes use their ink to disorient their victims before attacking. It has eight long limbs protruding from a globe-shaped head (or mantle). When threatened, the octopus has camouflage abilities.

**Jellyfish** are invertebrate carnivores that have tiny stinging cells in their tentacles to stun or paralyze their prey before they eat them. They eat fish, shrimp, crabs and tiny plants. There are many types of jellyfish in the ocean. Inside their bell-shaped body is an opening that is its mouth. Jellyfish squirt water from their mouths to propel themselves forward.

**Green Sea Turtles** are reptiles and they are one of the few species so ancient that they watched the dinosaurs evolve and become extinct. Green sea turtles feed on crabs, jellyfish, and other creatures as juveniles. As adults they become herbivores, primarily eating sea grasses and algae. Weighing up to 700 pounds, green turtles are among the largest hard shell sea turtles in the world.

**Shore Crabs** are invertebrate carnivores with a hard shell or carapace. They use their strong claws to crack mussel shells and for fighting. They feed on worms, mollusks, small gastropods, small crabs, algae, carrion and almost anything else they can catch!
Who Makes It Into the Fossil Record?

Draw your own “preservable” tidepool and ocean community

Name ____________
WHO MADE THESE FOOTPRINTS? Ancient preserved footprints are trace fossils. Unlike body fossils, trace fossils are evidence of an animal's activity or behavior. Although it is often impossible to identify the trace maker, footprints and tracks can provide information about ancient animals that body fossils cannot. Only footprints tell us the shape and size of the fleshy pads of an animal's foot. Fossil footprints can provide information about the animal's gait, size, speed, posture, movement and even interactions with other animals. Paleontologists often look to the behavior and movements of modern animals in order to better understand the animals that made ancient fossil footprints and trackways.

1. __________
   Hint: You may have one of these animals in your home! Their claws are out all of the time.

2. __________
   Hint: This carnivore went extinct 66 million years ago.

3. __________
   Hint: You may have one of these animals in your home! Their claws are not out all of the time, they are retracted when they walk.

4. __________
   Hint: This animal crawls on eight legs.

5. __________
   Hint: This animal has wide spreading toes to keep it from sinking into loose sand.

6. __________
   Hint: You see them everyday - they are descendants of the dinosaurs!
LIMBS & LIFESTYLES

Limbs (arms & legs) can tell us a lot about an animal’s lifestyle - how and where it lived, what it ate and how it moved! Below are some of the different limbs of ancient animals (which reptile is still around today?). Think about how did each animal lived in its environment.

**Draw a line to match each animal with the correct limb. How did they each use their limbs?**

“Tetrapods” are limbed vertebrates - animals with a backbone, arms & legs. All tetrapods (including you!) have the same basic limb bones, but different groups have evolved very different anatomy from this common starting point.

**How are your limb bones similar or different from the limbs below?**

![Limbs and animals](image)

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WINGS AND THINGS!

Below are some of the different kinds of wings of flying animals. Match each animal with the correct wing. Compare the wings to each other and to the arm of the boy.

How are they similar?
How are they different?

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Prehistoric Neighbors?

Below is an Ice Age environment. Can you name the Ice Age animals that belong? Circle the animals that do not belong.
PALEO PUZZLE

Imagine that you are a paleontologist and have just uncovered the fossil bones (body fossil) and fossil footprint trackways (trace fossil) shown in this picture. Examine the clues in the picture to figure out what happened!

KEY

Camel footprint

Bear dog footprint (Amphicyon)

Describe what you think might have happened here:

_________________________________________________________________
_________________________________________________________________
_________________________________________________________________
_________________________________________________________________
_________________________________________________________________
_________________________________________________________________
IT'S ALL IN THE SMILE! Teeth tell a lot about an animal's lifestyle - if it is a carnivore (meat-eater) or herbivore (plant-eater). What do you think these dinosaurs ate and why?

Coelophysis
Camarasaurus
Centrosaurus
Allosaurus

Cut along dotted lines. Match the correct tooth shapes to the dinosaurs. Glue in place. Describe each dinosaur with the word "carnivore" or "herbivore" on the line provided.
HOW BIG WAS I?

The giant alligator skull at the Alf Museum is one of the largest of its kind ever found! It was found without the rest of the skeleton, but paleontologists can figure out how big the ancient animal was by comparing it to the size of modern alligators. Scientists have found that the total length (including the head) of a modern alligator’s body is about 12 times the length of the animal’s head.

Using the pictures and skull lengths of the modern alligator and the fossil alligator shown below, find the answers to how big the whole animals were! Write the skull length in the box and solve the multiplication problem to calculate the body sizes of the reptiles.

**Modern American Alligator**

\[
\square \text{ foot long skull } \times 12 = \square \text{ foot body length}
\]

**Fossil Alligator *Purussaurus***

\[
\square \text{ foot long skull } \times 12 = \square \text{ foot body length}
\]

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