

EDUCATOR RESOURCE GUIDE



Arizona Museum of Natural History
53 N Macdonald Street
Mesa, AZ 85201
Group booking line 480-644-3553



GOALS FOR VISIT

G

To help understand the history of life on earth through the study of fossils.

Students Will Understand:

U

Essential Questions

Q

that fossils are a record of past life forms.
what a fossil is.

What can we learn from fossils?
What should a student do if they find a fossil?

Students Will Know:

K

Vocabulary:

V

the difference between a body fossil and a trace fossil.
that not all fossils are dinosaur.

body fossil	matrix
bone bed	paleontologist
excavation	paleontology
fossil	trace fossil
fossil jacket	trackway
in-situ	

Learning Plan

L

Make an Imprint Fossil
Chocolate Chip Cookie Excavation

Please see our Dinosaur Educator Resource Guide for additional information and activities.

State Standards Met in Packet

SS

Science

Science

Science

Science

Science

Strand 1, all grades
Concepts 1, 2, 3

Strand 2, all grades
Concept 1

Strand 4
Concept 1
P.O. 1 Kindergarten
P.O. 2 4th grade
P.O. 3 1st grade
P.O. 1 5th grade

Strand 4
Concept 2
P.O. 2 3rd grade

Concept 4
P.O. 3 3rd grade

Strand 6
Concept 1
P.O. 4 3rd grade
P.O. 5 3rd grade

Arizona Science Standards for Paleo Dig Pit

Strand 1 Inquiry Process all grades

Concept 1 Observations, Questions and Hypotheses

Concept 2 Scientific Testing

Concept 3 Analyses and Conclusions

Strand 2 History and Science of Nature all grades

Concept 1 History of Science as Human Endeavors (careers in science)

Strand 4 Life Science

Concept 1 Structure and Function in Living Systems

PO 1 Kindergarten *Distinguish between living and nonliving things*

PO 2 4th grade *Classify animals by identifiable group characteristics: vertebrates/invertebrates*

PO 3 1st grade *Identify observable similarities and differences (e.g. number of legs, body coverings, size) between/among different groups of animals*

PO 1 5th grade *Identify the functions and parts of the skeletal systems*

Concept 2 Life Cycles

PO 2 3rd grade *Explain how growth, death and decay are part of the plant life cycle*

Concept 4 Diversity, Adaptation and Behavior

PO 3 3rd grade *Cite examples of how a species inability to adapt to changing conditions in the ecosystems led to the extinction of that species*

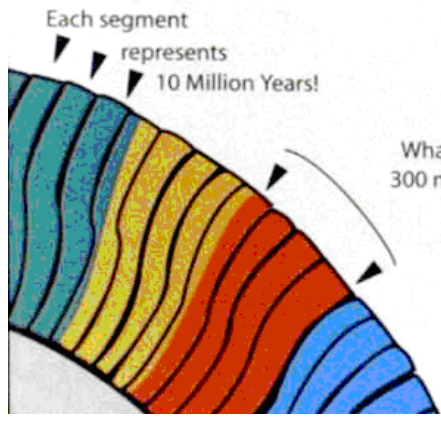
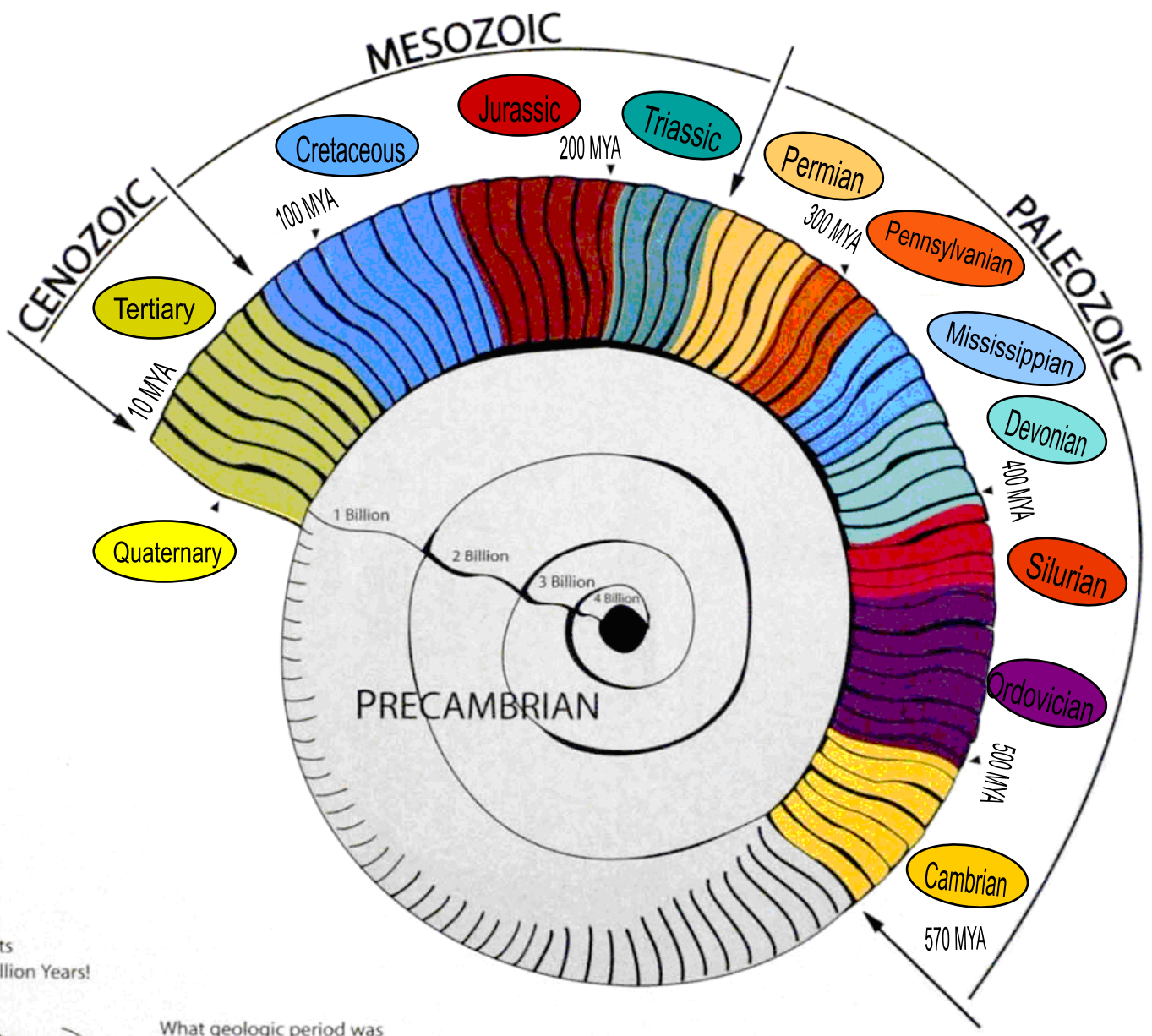
Strand 6 Earth and Space Science

Concept 1 Properties of Earth Science

PO 4 3rd grade *Describe fossils as a record of past life forms*

PO 5 3rd grade *Describe how fossils are formed*

Telling Geologic Time



What geologic period was 300 million years ago (MYA)?



Geologic Time Scale

EON	ERA	PERIOD	EPOCH	MILLIONS OF YRS AGO	MAJOR BIOLOGICAL EVENTS	
P H A N E R O Z O I C	C E N O Z O I C	Quaternary	Holocene	.01	Rise of civilization and agriculture. Extinction of large mammals in northern hemisphere.	
			Pleistocene	1.8	Modern humans appear. Four major glaciations cause rapid shifts in ecological communities.	
		Tertiary	Neogene	Pliocene	5	Extensive radiation of flowering plants and mammals. First hominids appear.
				Miocene	23	Coevolution of insects and flowering plants. Dogs and bears appear.
		Paleogene	Oligocene	38	Worldwide tropical rainforests. Pigs, cats, and rhinos appear. Dominance of snails and bivalves in the oceans.	
			Eocene	54	Early mammals abundant. Rodents, primitive whales and grasses appear.	
			Paleocene	65	Early placental mammals appear; first primates; modern birds.	
		M E S O Z O I C	Cretaceous		146	Marsupials, ants, bees, butterflies, flowering plants appear. Mass extinction of most large animals and many plants.
	Jurassic			208	Dinosaurs and gymnosperms dominate the land; feathered dinosaurs and birds appear. Radiation of marine reptiles.	
	Triassic			245	Origin of mammals, dinosaurs and true flies. Less diverse marine fauna.	
	P A L E O Z O I C	Permian		286	Gymnosperms, amphibians dominant. Beetles, stoneflies appear. Major extinction of 95% of marine species and 50% of all animal families.	
		Carboniferous	Pennsylvanian	325	First reptiles, cockroaches and mayflies appear. Extensive coal swamp forests. Sponge reefs.	
			Missippian	360	Echinoderms, bryozoans dominant in oceans. Early winged insects. First coal swamp forests.	
		Devonian		410	First amphibians. Extensive radiation of fish, land plants. Many corals, brachiopods and echinoderms.	
		Silurian		440	First spiders, scorpions, centipedes, early insects, vascular plants, jawed fish and large reefs appear.	
		Ordovician		505	First land plants, primitive fungi, sea weed appear. Diverse marine life: corals, molluscs, bivalves, echinoderms, etc.	
		Cambrian		543	Rise of all major animal groups. Metazoan life abundant; trilobites dominant. First fish. No known terrestrial life.	
	PROTEROZOIC EON				570	Origin of multicelled organisms. First sponges, colonial algae and soft-bodied invertebrates.
	ARCHEAN EON				2,500	Oxygen levels rise as a result of photosynthetic organisms. First eukaryotes (single-celled algae): 1.4 billion years old. Earliest life, anaerobic prokaryotes (bacteria, archaeans) originate 3.5 billion years ago.
	HADEAN EON				3,800-4,600	No life known. Cooling and solidifying of Earth's crust.

The Paleo Dig Pit has been designed as an idealized, high-density bone bed for *in-situ* excavation. The Dig Pit fossil beds are ‘time and spatially compressed’ in that the fossils you will find here did not live together in the same place or at the same time. They were chosen for their variety of shapes and sizes. Students will experience the excitement of uncovering fossils and will learn how paleontologists handle fossils.

The bone beds found and excavated by paleontologists rarely look like this. More often than not, the fossils have been broken up by natural processes that can happen before, during or after fossilization.

It is a spectacular but very rare occasion to find a complete, fully articulated skeleton. The density of the fossils and variety depends upon the original environment of deposition and the diversity of the plants and animals in the community.

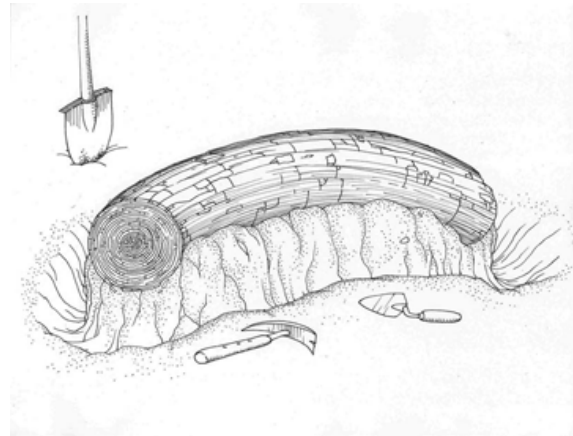
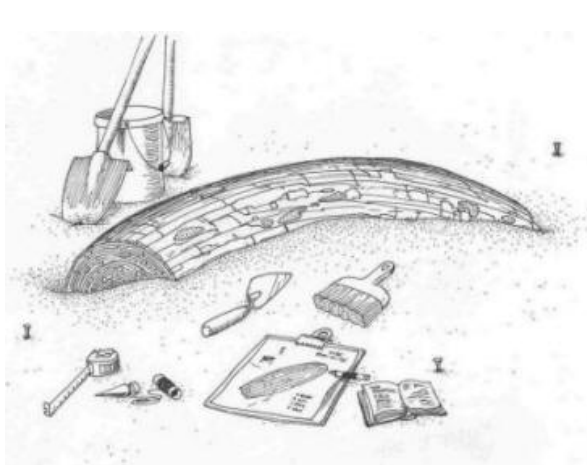
Ethics of Fossil Collecting

Animals that have a backbone are called vertebrates and fossils from these animals are rare. Vertebrate fossils discovered on public land such as national forests, Bureau of Land Management (BLM), state land, etc. are protected by law. Small quantities of invertebrate fossils (such as shells) and petrified wood may be collected legally from some public land such as the forest Service and BLM but not from state lands or national parks. Those on private land are the property of the land owner.

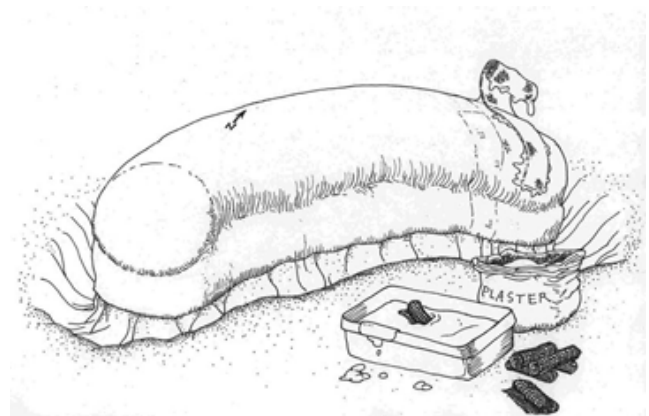
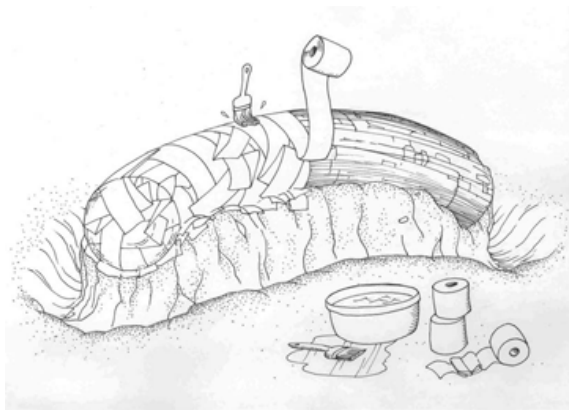
Fossils are very delicate and can be easily damaged without highly trained individuals doing the removal. The safest bet is to leave the fossils where you found them and contact a park ranger, university or a local natural history museum.

Field Procedures for Removing Fossils

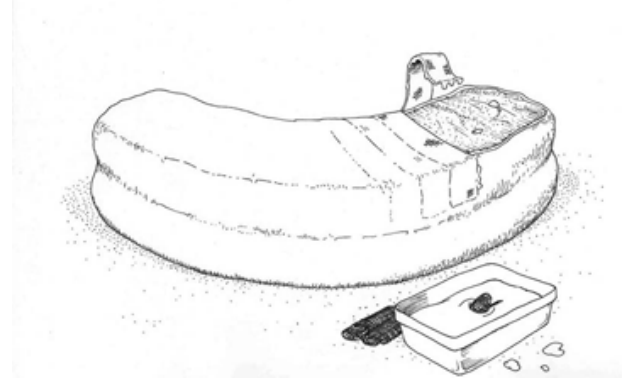
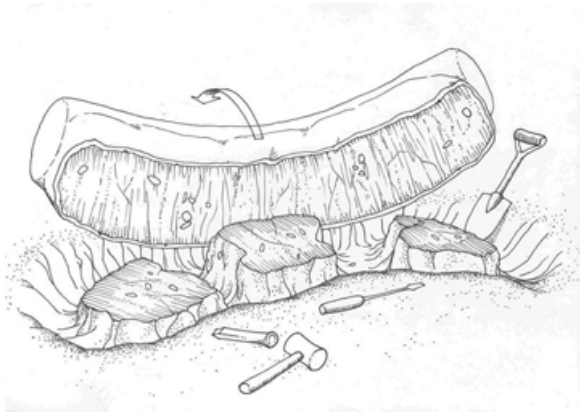
Usually a fossil is discovered because erosion has removed enough of the surrounding rock or soil to partially expose it. The paleontologist carefully uncovers more of the fossil using a variety of tools, revealing the extent of the fossil. As the fossil emerges, measurements and photographs are taken and a map is drawn. Paleontologists continue to expose the fossil, digging a trench around the fossil so that it sits on a pedestal of rock.



During this process the fossil is covered with a protective plaster jacket. This consists of a layer of moistened tissue paper to act as a barrier between the fossil and the plaster, then burlap dipped in plaster is wrapped around the fossil. When dry, the plaster hardens into a shell that protects the fossil during transport.

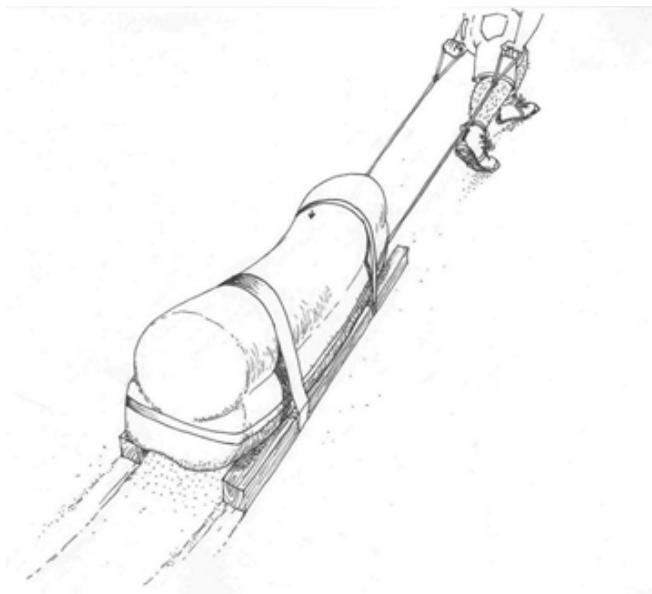


The plaster-jacketed-protected fossil is then carefully removed from its pedestal by carefully undermining and then flipping the fossil over. This is the most difficult moment of the process. The underside of the fossil is then encased in the plaster jacket following the steps above and readied for transport.



Transporting the Fossil

If done properly, the plaster jacket encapsulates the relatively fragile fossil, protecting it within some of its original surrounding rock or **matrix**. The fossil is then moved in whatever way it can be moved. This might include manually dragging, transporting in a truck, or even lifting with a helicopter.



Processing Fossils in the Lab

In many ways, working on fossils in the lab resembles archaeological (the study of past humans and the artifacts they left behind) field work on a small scale. The plaster jacket is opened and the preparators carefully begin to remove the rock and/or dirt from the fossil. As they work, they record the positions and orientations of the fossils they encounter before removing them from the jacket. Sometimes the fossil is not removed from the remaining portion of the jacket and is left there permanently.

The process of cleaning and stabilizing the fossils is called preparation. Fossil preparation must be tailored to the needs of the parent institution, so it is almost always different for every specimen. The fossils themselves can be in very different states of preservation and the surrounding rock or dirt, the matrix, can vary widely in hardness and density as well requiring a wide variety of tools and methods. Some of the tools used by preparators include small needles, small air-powered jackhammers, dental tools, acid, glues and consolidants, razor knives, hammers, very large to very small chisels, air scribes, bulb syringes and wooden tools such as tongue depressors and chopsticks.

Once the fossil is cleaned, put back together if necessary and stabilized, the paleontologist will decide what to do with it. Sometimes the real fossil is put on display or used in an exhibit, or it may be used for research. Often, a cast is made of the fossil and that is used for exhibitions and the real fossil is kept in the paleontology department's lab or vaults.



Arizona Museum of Natural History staff and paleo volunteers putting a plaster jacket on a tusk belonging to the mammoth found in Gilbert.



Paleontology volunteers working in the museum's fossil lab.

Fossils

Fossils are the remains or evidence of ancient life older than 10,000 years that have been preserved in rock or some other material such as permafrost or tar. Plants, animals and other organisms from past geological ages are represented in the fossil record. Paleontologists believe that only a small percentage of ancient organisms were fossilized. Nevertheless, the study of these fossils is the best way for scientists to learn about dinosaurs and other ancient creatures, although new frontiers of molecular research are greatly adding to our understanding of the evolution of many lineages.

There are two main types of fossils, **body fossils** and **trace fossils**. **Body fossils** are the direct physical remains of organisms, such as teeth, bones, claws, shells, wood, seeds, or leaves. **Trace fossils** are the indirect evidence of ancient activity (behavior), including tracks, trails, burrows, borings, footprints, coprolite, gastroliths (gizzard stones), and imprints of skin and plants. Scientists don't always agree on whether dinosaur eggs are body fossils or trace fossils. Some believe since the shell is something left behind it is a trace fossil while other argue that because the shell was a kind of body tissue it is a body fossil. The discovery of embryonic dinosaurs inside fossilized shells has added another dimension to the argument.

Usually only the hard parts of the body can be fossilized. The softer tissues almost always decompose before they can be fossilized. The teeth, bones, claws and shells will survive for a longer time, especially if they are buried quickly in mud, sand or silt. This protects these body parts from weather damage, rotting and scavengers.

Fun Fossil Fact: Fossils have been found on every continent, including Antarctica!

Fossils have the same shape as the original object, but their chemical makeup has usually been altered, reflecting the minerals that have replaced the organic material. Because fossils are rocks, they usually take on the color of their geological composition, rather than the color of the original matter.

Many of the fossils seen in museums are cast replicas of the original fossil. This is done for two main reasons. Many fossils, being rock, are often very heavy, fragile and therefore difficult to mount. A cast is much lighter and much easier to work with. Making a cast and using that for display allows the real fossil to be safely cared for and stored in the paleontologists' labs and vaults. Fossils should not be confused with **artifacts**, which are objects that were made by humans.

Fact or Fiction: Scientists can tell what color dinosaurs were by looking at their fossils.

Fiction: The soft tissues of the body usually decompose long before fossilization occurs. Fossil dinosaur skin is usually a trace fossil, made when the dinosaur's body is pressed into the ground and is not the actual skin that has become fossilized. Fossil dinosaur skin would still be the color of the rock it has become, although sometimes the pattern of the skin is preserved. There is no way to tell the color of skin from the fossils. Since no one has ever seen a real live dinosaur, scientist have only been able to hypothesize about the color of their skin. However, a recent feathered dinosaur fossil was shown to cells preserved in the feathers whose shapes indicate colors. It may be possible at some time in the future to determine the color of some dinosaurs.

Examples of Trace Fossils



Sauropod coprolite
Morrison Formation, Eastern Utah
www.hoopermuseum.org



Parallel teeth marks
(on fossil bone)
Courtesy Mesalands Community College



Footprint of a bipedal dinosaur
Image courtesy of Arizona Museum of Natural History



Dinosaur egg nest
Courtesy of the Arizona Museum of Natural History

Examples of Body Fossils



Petrified wood
www.unmuseum.org



Fish
Wikipedia.org



Mosasaur skull
2004, Michael Everhart



Brachiopod
www.uscmp.berkeley.edu



Fossilized *Apatosaurus* femur, Arizona Museum of Natural History

Dinosaur Egg Facts

Dinosaurs laid eggs like many modern animals, such as birds and most reptiles. Some dinosaurs laid their eggs in nests. Dinosaur eggs were laid in different patterns, including spiral, concentric circles, irregular clusters, arc, parallel rows and double rows. These eggs were hard shelled.

Over 200 dinosaur egg fossils have been found all over the world and on every continent, except Australia and possibly Antarctica. First identified in the 1920s, eggs have been found in such places as Mongolia, China, France, India, the United States (Montana and Utah), and Canada. Fossilized dinosaur embryos and hatchlings have been discovered recently as well.

Fact or fiction? Giant dinosaurs laid giant eggs.

Fiction: Dinosaurs may have grown into giants, but their eggs are relatively small. The largest dinosaur eggs were a little smaller than a basketball but most were much smaller.

The largest dinosaur egg found to date belonged to the *Hypselosaurus*. This egg was 1 foot long and 10 inches wide. An egg must be **permeable** (allow for an exchange of gases), so oxygen can enter the egg and carbon dioxide can exit. This is necessary for the developing embryo to survive. If an egg gets too large, the shell would be too thick to allow for this exchange of gases and the developing dinosaur embryo would suffocate. An eggshell may have as many as 17,000 tiny pores covering its surface that allow oxygen in and carbon dioxide out.

Fun Fact: The largest egg today belongs to the ostrich.

Paleontologists believe some dinosaurs, such as the **theropods**, may have been **altricial**. This means the animal needs intense parental care during incubation and for a period of time after hatching. Others, such as **sauropods**, may have been **precocial**. This means an animal can take care of itself immediately after hatching. However, there are tracks of sauropod herds that show the younger animals traveling in the center of the herd where they would be protected by the surrounding adults.

Dinosaur Nest



Courtesy of Arizona Museum of Natural History

Oviraptor Nest

Unknown theropod nest



Courtesy of The Black Hills Institute

Unknown theropod nest



Courtesy of Arizona Museum of Natural History

Troodon

Therizinosaurus

Camarasaurus



Image courtesy of Arizona Museum of Natural History

Tyrannosaurus bataar

Tyrannosaurus bataar, whose name means “alarming reptile hero”, roamed Mongolia during the Late Cretaceous and was a very close relative of the North American *T.rex*. It was older than the *Tyrannosaurs rex*, suggesting the genus originated in Asia and migrated to North America via the land bridge that joined the continents during the Cretaceous Period. There are a few slight differences between the *T. bataar* and the *T. rex*. The most notable ones are *T. bataar*’s smaller forearms and a relatively longer skull.

The first rather nondescript fossils of a tyrannosaurid were found in the Gobi Desert by the Sino-Swedish Paleontology Expeditions between 1927 and 1931. It wasn’t until after World War II that significantly diagnostic tyrannosaurid fossils were found in the Gobi Desert, including several nearly complete skulls and skeletons. No *T. bataar* fossils have been found outside of Asia.

The specimen in the dig pit was a juvenile, and when fully grown it may have been up to 40 feet long and weighed up to 6 tons. It was a carnivore, and likely ate anything it came across. Some aspects of its anatomy indicate it was possibly a scavenger, although the debate goes on as to whether the tyrannosaurids were scavengers or active predators.



Image courtesy of Arizona Museum of Natural History

Dinosaur Trackways

Trackways are the multiple fossilized footprints of an animal or groups of animals. For our purposes we will focus on dinosaur trackways. Dinosaur trackways can be found all over the world.

Trackways were created as an animal walked in the soft sediment or sand along the shorelines of beaches, rivers, lakes, ponds and sometimes sand dunes. Since many of these sites were excellent sources of food and water with numerous plants for herbivores and plenty of prey for carnivores, they became the natural pathways for all sorts of animals.



Image courtesy of the American Museum of Natural History Special collections.

The footprints were almost immediately covered in sediment after the animal passed by, eventually becoming a fossil. This type of fossil is called a trace fossil. A trace fossil is evidence that a creature once walked, crawled, ran, hopped or burrowed across the land.

The largest dinosaur trackways are called megatracks where footprint-bearing rock can extend for up to a thousand miles. The trackways themselves do not extend for thousands of miles, but the rock units on which they are preserved may. There are several such sites in North America dating from the Jurassic and the Cretaceous. One such set of tracks dating from about 210 million years ago consists of more than a thousand well preserved dinosaur footprints and was found in a quarry in Virginia.

The trackway known as the Dinosaur Freeway extends along the Front Range of the Rocky Mountains from near Boulder, Colorado to eastern New Mexico. During the Cretaceous this area was a coastal plain with a wide shoreline, a good source of food and water.

These tracks are generally the traces of distinct footprints. Individual animals within the trackway can be identified by their own unique footprint. Although scientists have learned quite a bit from studying trackways, one thing they cannot tell is the exact species of dinosaur that made the track. They can only generally tell whether or not it is a **biped** or **quadruped** (walking on two feet or four) and if it was a **sauropod** or **theropod**. **Sauropods** were large, slow moving quadruped herbivores (such as *Apatosaurus*) and **theropods** were bipedal and predominantly carnivores such as *Tyrannosaurus rex*.

However, trackways can tell us much about the behavior, feeding habits, speed and how dinosaurs walked. For example, in the case of sauropods, trackways usually have the footprints of more than one animal going in the same direction. This indicates a herding behavior or a migration. Tracks often show younger animals were held in the center of the herd, most likely to protect them from predators. Sometimes the trackway will also have the footprints of large theropods, a possible indication of pack behavior in stalking large sauropods.

Trackways have proven that some dinosaurs walked and ran on four legs and others used two legs. Some walked in an erect fashion and walked by putting one foot directly in front of the other. Others either quickly ran or walked slowly, possibly indicating the animals were browsing, wading, trotting, running after prey or running from predators.

Scientists can also tell the relative speed of dinosaurs as they moved along trackways. By measuring the distance between the footprints and the size of the tracks it is possible to determine that some dinosaurs ran faster than originally thought. One thing trackways do not show are tail marks, which would indicate that the dinosaurs were dragging their tails behind them. It is because of this observation that scientists believe dinosaurs held their tails erect.

Paleontologists can also study the feeding habits of many dinosaurs from the trackways. Cretaceous period footprints of herbivorous dinosaurs have been found in an eastern Utah coal mine. These footprints are clustered around fossil tree trunks giving an indication of their foraging behavior. In another trackway from the Late Cretaceous of Bolivia a pack of theropods appear to have been actively stalking a herd of sauropods.

The first dinosaur footprints found in the United States were found in Connecticut in 1800. It was originally believed the footprints were made by giant birds.

Ammonite Fossil

Ammonites were mollusks that appeared in the early Devonian, about 410 million years ago and survived through the Cretaceous Period when they became extinct, about 65 million years ago. Ranging in size from about ½ inch to 7 feet, depending upon the species, they had no skeleton, but were protected by a hard shell made of calcium. Ammonite shells could be spiraled, curled upon themselves or straight. The name comes from “horns of Ammon”, a Greek god represented by a ram’s horn.

Found worldwide, ammonites lived in marine waters, likely preferring warm shallow waters. Fast moving predators, they ate a wide variety of things, including carrion, crabs and fish. Ammonites moved themselves by jet propulsion, expelling water through a funnel-like opening to propel themselves in the opposite direction like today’s octopus, squid, cuttlefish and nautilus. They likely caught their prey by silently stalking it, then rapidly extending their tentacles to grasp the target. Once caught the prey would be eaten by the powerful jaws located at the base of the tentacles, between the eyes. Ammonites, in turn, may have been prey for mosasaurs and other marine predators (including other ammonites).

Ammonites are very similar to the modern chambered nautilus.



Brachiopod fossil

A Brachiopod is a type of marine animal that entered the fossil record over 500 million years ago and was among the most common marine fossil in the Paleozoic Era. There were hundreds and hundreds of types of brachiopod. Although it looks a lot like a clam or oyster, and had a similar lifestyle, it is not related.

Brachiopods still exist, but their diversity is relatively low and they are found mostly in refugial environments. These are places with relatively low biotic competition and stable environments. The common name for one of the approximately 300 living species is “lamp shell” (genus *Lingula*).



Trilobites

Trilobites appeared over 500 million years ago in the Earth's ancient seas and were extinct before the dinosaurs even existed.

Trilobites were among the earliest of the hard-shelled animals called arthropods, an extremely diverse group of invertebrates (animals with no backbone) that also includes spiders, insects, barnacles, scorpions and lobsters.

Trilobite means three part body in Latin. A Trilobite's body had three sections, the Cephalon (head), the Thorax (segmented body) and Pygidium (tail). Trilobites were covered with a segmented exoskeleton and they could roll into a ball for protection. Some trilobite exoskeletons were covered with spines and bumps for additional protection. Trilobites shed their exoskeleton and developed new ones as they grew as do all modern arthropods.

So far as we know, trilobites were the first group of animals in the animal kingdom to develop complex eyes. They were also one of the first to develop multiple legs for moving around.

Trilobites lived in marine waters. Some could swim, others burrowed or crawled around on the muddy ocean floors.

Trilobites died out at the end of the Permian Period about 250 million years ago.



Courtesy of www.savingadvice.com

Gingko biloba

Gingko biloba is the only surviving member of the ginkgo family, of the order Ginkgoales, part of a group of gymnosperms (naked seed). The genus *Gingko* was a group of highly unusual non-flowering plants dating back to the Permian Period, 270 million years ago.

Because of the lineage's long history, the *Gingko biloba* is considered a "living fossil" and is biologically the oldest known species of tree in the world. Although ginkoes existed throughout the time of the dinosaurs, they reached their greatest diversity during the Cretaceous Period. A link between the present and the remote past, it is possibly the most enduring species of living seed plant.



Image courtesy of www.xs4all.nl/~kwanten/history.htm

Fossils recognizably related to the modern *Gingko* have been found from as far back as the Permian Period, dating back 270 million years. *Gingko* fossils in the Jurassic show that the genus diversified and spread throughout Laurasia during the Middle Jurassic and Early Cretaceous. Laurasia was the ancient continental mass in the Northern Hemisphere that included North America, Europe and most of Asia. The *Gingko* began to decline in diversity throughout the rest of the Cretaceous Period and by the Paleocene Epoch only one species, *Gingko adiantoides*, was left in the Northern Hemisphere. By the end of the Pliocene Epoch *Gingko* fossils disappeared from the fossil record everywhere except a small area of central China where the modern species survived.



Image courtesy of <http://en.wikipedia.org>



Image courtesy of www.xs4all.nl/~kwanten/history.htm



Image courtesy of <http://upload.wikimedia.org>

Once common in North America and Europe and accustomed to a moderate climate, most species possibly died out during the last Ice Age with the lone surviving species, the *Ginkgo biloba*, living in China. The tree became known to Europeans in the 18th century and was soon reintroduced to the Western world. Reintroduced into the United States in 1784 the tree can now be found in virtually every American city.

The tree was able to survive over the millions of years because of its genetic tenacity and resistance to disease, pest and fire. *Ginkgo biloba* can grow to be over 100 feet tall. Trees over a 1,000 years old can be found at ancient temples in Japan and China. Individual trees can live to be 3,000 years and older.

The name *Ginkgo* comes from a phonetic pronunciation of a Japanese name for the tree. The species name *biloba* comes from the two distinct lobes typical of the tree's distinctive fan shaped leaves.



Image courtesy of <http://imagination.org>

Ferns

Ferns were among the first plants to appear on land. This ancient lineage of plants dates back to at least the Devonian Period, 350 million years ago. They are older than land animals and far older than the dinosaurs. Ferns were thriving on Earth for two hundred million years before the flowering plants evolved. The Carboniferous, also known as the Mississippian and Pennsylvanian Periods, 290 million years ago, was called the “Age of Ferns” because of the numerous fossils with fern like fossils found in the coal and rock from this era.

Ferns were among the most common plants during the Jurassic Period, 205 million years ago. Many of the current families and species did not appear until the Cretaceous, after flowering plants had come to dominate.

Ferns (Pteridopsida) belong to a group of about 12,000 species of plants. They have stems, leaves and roots but do not have either seeds or flowers. Ferns are vascular plants with well-developed internal vein structures that promote the flow of water and nutrients. Unlike the other vascular plants, the flowering plants and conifer, where the adult plant grows directly from the seed, ferns reproduce from spores and have an intermediate plant stage called **gametophyte**.

Fun Fact: A pteridologist is a specialist in the study of ferns.



Image courtesy of www.gardensoyvey.com



Image courtesy of www.boltonmuseums.org.uk

Conifers

Conifers were among the earliest of land plants. They belong to a group of plants called **gymnosperms** that were the dominant land plants in the age of dinosaurs. Gymnosperms are plants that produce seeds that are not enclosed within plant tissue. Conifers bear cones instead of fruit. Only flowering plants have fruit. Today's conifers include many familiar trees such as pine, spruce, firs, hemlock, cedar, yew, larch, cypress and monkey puzzle.

The earliest conifers in the fossil record date to Carboniferous Period, about 300 million years ago. They flourished in the hot and dry climate of the Triassic Period and were one of the major plants during that period. Conifers grew as both trees and shrubs. The fossilized trees found in the late Triassic layer of the Chinle Formation at Arizona's Petrified Forest are conifers.



Image courtesy of Ohio History Central



Image courtesy of northenrshade.com

Conifers could easily adapt to changing water conditions and forests of conifers, mainly sequoias and monkey puzzles, dominated the land in the slightly cooler and wetter Jurassic Period. Most of the modern families of conifers, such as the cypresses, redwoods, yews and junipers, evolved during the Jurassic. Conifers continued to rule the plant world into the Cretaceous Period.

Conifers can be large and are often the major plant life in some ecosystems. Since most conifers are evergreen, the leaves of many are long and thin with a needle like appearance, although some have scale-shaped, awl-shaped or flat

leaves. Most conifers also have distinctly scented resin that is secreted to protect the tree from insect infestation. This resin, when fossilized, becomes amber.

Fun Facts: The world's largest, tallest, thickest and oldest living things are all conifers. The oldest living tree is a Great Basin Bristlecone Pine that is thought to be 4,700 years old.

Today conifers are an important resource as a tree crop for pulp and timber. Their ability to grow in areas that are unsuitable for other crops is a plus. Since most conifers, although not all, are evergreens, they are also highly valued as landscape plants.

Petrified Wood

These are pieces of real wood that have turned into rock composed of siliceous minerals. One of the greatest concentrations of petrified wood in the world can be found in the Petrified Forest National Park in northeast Arizona. Logs as long as 200 feet and 10 feet in diameter have been found there.

The process of petrification needs three ingredients, wood, water and mud. After a tree fell to the ground and into a waterway, it was swept downstream with sediment and other debris. The stream traveled through a plain of lakes and swamps where the wood, debris and sediment was deposited along the way. Four hundred feet of sediment were deposited in what is now known as the Chinle Formation by rivers coming out of Mogollon Highland volcanic mountain range. As the logs were deposited they were buried with mud and other debris.

The mud that covered the logs was rich in volcanic ash, a key factor in the process of petrification. As the volcanic ash began to decompose it released chemicals into the water and mud. As the water seeped into the wood the chemicals from the volcanic ash reacted to the wood and formed into quartz crystals. As the crystals grew over time, the wood became encased in the crystals, which, over millions of years, turned the wood into stone.

One of the interesting things about petrified wood is how colorful it can be. It is not the wood that makes it so colorful, but the minerals in the groundwater. Quartz crystal is colorless, but when other minerals are added to the process the crystal becomes stained with color. Below are some common minerals found in the ground water and the related color hues.

Copper – green/blue
Cobalt – green/blue
Chromium – green/blue
Manganese - pink

Carbon - black
Iron Oxides – red, brown, yellow
Manganese Oxides - black
Silica – white, grey



Vocabulary Words

- Body fossil** The direct physical remains of organisms, such as teeth, bones, claws, shells, wood, seeds, and leaves.
- Bone Bed** A geological deposit than contains many fragments of fossil bones, teeth, and other fossilized materials.
- Excavation:** The process of removing a fossil from the ground.
- Fossils** The remains of or the evidence of ancient life older than 10,000 years preserved in rock or some other material, such as tar or permafrost.
- In-situ*** In its original or natural place or site. A fossil in the ground would be *In-situ*.
- Matrix** Any material that surrounds a fossil or fills the spaces between parts of fossils, but it is not considered part of the fossil. Matrix can be made up of rock, sand or dirt. It can even be other fossils such as shell fragments. Matrix is usually removed in order to expose the fossil, but some scientific questions require preservation of the matrix. The chocolate chip cookie analogy: If the chips are the fossils, the dough is the matrix.
- Paleontologist** The study of fossils and prehistoric life.
- Paleontology** A scientist who studies fossils and prehistoric life.
- Plaster jacket** A plaster casing made up of burlap and plaster which is put on a fossil in the field to stabilize it so it can be brought back to the lab. It is very similar to the plaster casts put on broken bones.
- Trace fossil** The indirect evidence of ancient activity (behavior), including tracks, trails, burrows, borings, footprints, coprolites, gastroliths (gizzard stones) and imprints of skin and plants.

Trackways The multiple fossilized footprints of dinosaurs or other ancient creatures.

Making An Imprint Fossil

Supplies:

“Stone” Dough Mix

½ cup of salt
1 cup of flour
½ cup of brewed coffee (cold)
1 cup of used coffee grounds
Measuring cups
Mixing spoon
Mixing bowls

“Fossils to Imprint”

Twigs
Leaves (stiff bay leaves work well)
Seashells
Chicken bones
Plastic dinosaur models for skin
texture or footprints

Procedure:

1. Measure salt, flour, coffee, and coffee grounds. Add each to the bowl and stir together until well mixed.
2. Turn this dough out onto a large sheet of waxed paper and knead until smooth.
3. Break off a piece large enough for the imprint you want to make, roll it into a ball, and use the heel of your hand to flatten it out.
4. Press the object you wish to make a fossil imprint of firmly into the dough. You can use more than one object if you like. Carefully remove the objects to leave the prints behind. Let your fake stone dry overnight and you will have an imitation fossil!

**** You could also use clay, Crayola Model Magic or plaster of paris or any other type of modeling material you wish.

Discussion Point

What you are doing is very much like the way real imprint fossils were created. Millions of years ago plants, bugs, or other animals left impressions in soft mud. This mud eventually dried and became rock.

Much of what we know about ancient, extinct plants and animals comes from such imprints since neither skin or feathers are likely to survive as actual fossils, the way bones do. This is how we know what the texture of dinosaur skin was and why scientist believe some dinosaurs may have had feathers.



Chocolate Chip Excavation

Excavation is the process of getting a fossil out of the ground. The work is often difficult and must be done with a great deal of skill and patience. The excavator needs be very careful not to damage any fossils which may be under or next to the fossil they are excavating.

Supplies:

Packaged chocolate chip cookies, not the soft, chewy version

Toothpicks

Paper Towels or paper plates to hold cookie

Pencil and paper

Procedure:

1. Give each student a cookie and a toothpick on a paper towel or plate.
2. Have the student trace an outline of the cookie. Then make a diagram of the visible chocolate chips on the outline of the cookie.
3. Tell the students they are paleontologists and using the toothpick they must excavate as many fossils (chips) from the matrix (cookie) in one piece as they can.
4. Give the students ten minutes to work on their dig site. See how many were successful in excavating whole chips from their cookie.

Vocabulary Words:

excavation

fossil

in-situ

matrix



