THE PROCESS OF PALEONTOLOGY

PALEONTOLOGY

Paleontology is not just the study of dinosaurs. Paleontology encompasses the study of many different types of ancient life forms including both invertebrates and vertebrates.

THE PROCESS OF PALEONTOLOGY

Lots of people dream of becoming a paleontologist, but may not truly understand what the job entails. How do we really excavate fossils? How do we transport them? How are the labeled? Stored? Studied?

STEPS IN THE PALEONTOLOGICAL PROCESS

1. SOMEONE DISCOVERS A FOSSIL.

Video: Finding Fossils

Rock Layers

Dinosaur fossils are found in sedimentary rocks (rocks made of sediment deposited in layers). Rock layers formed at different times throughout history. To figure out where to hunt for dinosaur fossils, paleontologists have to find sedimentary rocks that formed at the time when the non-avian dinosaurs lived and died.

Geologic Maps

Paleontologists use geologic maps to locate these places in Montana. Geologic maps show what type and age of rock are found at the Earth's surface. Paleontologists locate sedimentary rocks from the Mesozoic Era (the time when non-avian dinosaurs lived) on a geologic map, and go to those areas to hunt for fossils.

Prospecting

Prospecting is a term that paleontologists use that means "hunting for fossils". Once they have permission to search in an area that could contain fossils, they hike around looking for fossil fragments on the ground. The best way to prospect is to carefully look along the base of a hill. Bits of fossil tend to weather (erode) out of the rock and roll downhill. When a fossil fragment is found the prospector searches uphill above the find to see if there is a larger fossil.

Video: Prospecting for Dinosaur Fossils

Identifying Fossils

Broken pieces of fossils and rocks often look very similar. It takes a trained eye and lots of practice to tell the difference. Some of the features that paleontologists use to identify fossils are shape, color and texture.

Video: Identifying Fossils

Video: Concretions

Shape

If you stumbled across a T.rex skull, you probably would not have a hard time identifying it as a fossil. However, fossils are often broken and only small fragments are found while prospecting. Paleontologists take anatomy (the study of animal structure) classes in which they observe many different kinds of bones. They become familiar with the shapes of bones—so much so that they can often recognize the shape of a curve or a knob even if it has been worn down or broken.

Texture

Many different kinds of textures can be found on fossils and a person who spends a lot of time working with fossils learns what these are and recognizes them. Some fossils have a smooth and shiny surface compared to rocks. Some have a striated (lined) texture. Some look like they are full of little holes. What makes a fossil stand out is how its texture is different than the texture of the rocks around it.

Color

Rocks and fossils can both be a variety of colors—reds, browns, grays, blacks, etc. Often, fossils take on the color of the rock in which they were buried making them more difficult to identify. Occasionally, fossils stand out because of their color. For example, this fossilized dinosaur egg shell found at the Egg Mountain dig site near Choteau, Montana stands out because it is darker than the surrounding rocks.

2. IF THE PERSON IS A PALEONTOLOGIST THEY DECIDE WHETHER OR NOT THEY ARE GOING TO EXCAVATE THE FOSSIL.

3. IF THE PERSON IS NOT A PALEONTOLOGIST, THEY SHOULD NOT TAKE THE FOSSIL—BUT LET A PALEONTOLOGIST KNOW WHAT THEY FOUND (DIGITAL PICTURES) AND EXACTLY WHERE THEY FOUND IT (GPS COORDINATES).

4. THE PROPER PERMITS OR PERMISSION MUST BE ACQUIRED FOR EXCAVATION AND COLLECTION ON THE LAND WHERE THE FOSSIL WAS FOUND (TECHNICALLY SHOULD HAVE BEEN DONE BEFORE ANY FOSSIL HUNTING).

Permits

All land is owned by someone. It might belong to a private citizen or a government agency like the Forest Service or Bureau of Land Management (BLM). Paleontologists (or anyone else) must seek permission from the landowner before hunting for fossils. They find out who owns the land and apply for a permit.

5. ONCE PERMITS ARE GRANTED, A FIELD CREW (A GROUP OF PALEONTOLOGISTS, STUDENTS, AND VOLUNTEERS) GOES TO THE SITE OF THE FOSSIL.

Fossil Discovery

Just because a fossil is found doesn't necessarily mean it will be excavated. Many of the small fossil fragments found while prospecting never lead to larger fossil finds. If they do, paleontologists usually do excavate. However, in Montana the dig season is relatively short due to the weather (May-September at most) and limited time and resources mean that the most important fossils must take priority. At the Museum of the Rockies, fossils are usually excavated if more than three bones that appear to be from the same dinosaur are found together. Important fossils such as skulls, nests and eggs are always excavated.

6. THE FOSSIL AND SURROUNDING PROTECTIVE LAYER OF DIRT AND ROCK (MATRIX) IS CAREFULLY REMOVED FROM THE GROUND BY THE FIELD CREW.

A. The fossil is isolated.
B. The top of the fossil is covered with a field jacket.
C. The bottom of the fossil is excavated.
D. The fossil is turned over and covered with a field jacket.
E. The field jacket is carefully labeled.

Video: Fossil Jacketing and Excavation

Video: A Day at a Montana Dinosaur Dig 1

Video: A Day at a Montana Dinosaur Dig 2

Video: Dinosaur Diaries (TERRA)

Excavation means digging up something that is buried. Fossils are excavated from the ground for study and display in museums. Digging a bone out of the dirt may seem simple, but paleontologists (people who study fossils) are careful to preserve the fossil and learn from it as they excavate.

Taphonomy

"Taph" means burial in Greek, and "onomy" means to study. Taphonomy is the study of how a fossil was buried. To study what happened to an animal's body from the time it was buried until the time it was discovered, field crews carefully collect and record data about the arrangement of the fossil in the ground and the type and arrangement of the matrix and any other fossils around it.

For example, through careful taphonomic observations during the excavation of a Tenontosaurus (a small plant-eating dinosaur) skeleton paleontologists discovered eleven teeth from a type of meat-eating dinosaur called Deinonychus. Based on the number and placement of the Deinonychus teeth paleontologists hypothesized that more than one Deinonychus was feeding on the Tenontosaurus, and that Deinonychus likely hunted in packs.

Video: Taphonomy: Dinosaur Fossil Burial

Tools for Excavation

A variety of tools are used to unearth a fossil. Field crews use large tools like shovels and even jackhammers to remove the rock and dirt surrounding a fossil. As they get close to the bone they uses smaller tools like picks and rock hammers. Fossils that are crumbling are covered with special glues to help keep the pieces together.

Removing the Overburden

The first step in removing a fossil is to carefully remove the matrix (dirt and rock) that is covering the top of it. This may mean just dusting it off, or it could mean removing part of a mountainside!

Isolating the Fossil

Field crews (usually volunteers and students) carefully excavate around the edges of a fossil to isolate it on a pedestal of matrix below.

Plaster Cap

Field crew members cover the isolated fossil first with wet paper towels, and then with plaster coated burlap strips. The paper towels protect the fossil from the plaster. The plaster dries into a hard shell or jacket that protects the fossil.

Fossil Removal

With the top of the fossil safely inside the plaster cap, workers dig through the rest of the matrix underneath the fossil. They usually leave quite a bit of matrix that will be removed by preparators (workers who are skilled in cleaning fossils) back at the lab. The fossil is finally free from the ground and is rolled onto the side that has already been jacketed.

Jacketing

The second half of the plaster jacket is made to cover the exposed bottom of the fossil so that the entire specimen is encased in a hard shell of plaster for its trip back to the lab.

Labeling

Notes about the fossil's location and other information are sometimes sealed inside a plastic bag inside the jacket. Labels are written on the outside of the jacket.

7. THE FOSSIL IS TRANSPORTED FROM THE DIG SITE TO THE LAB.

Dino Wheel

At the end of the summer, all the excavated fossils (now in jackets) have to be transported from the remote field sites back to the lab. Depending on the size and weight of the jackets they may be carried or wheeled out by crew members.

Helicopter

Really heavy fossils might have to be removed by helicopter.

8. THE FOSSIL MAY BE STORED IN ITS FIELD JACKET FOR A SHORT OR LONG TIME (UP TO MANY YEARS) DEPENDING UPON ITS SCIENTIFIC IMPORTANCE.

9. THE FIELD JACKET IS CUT OPEN USING A CAST CUTTING OR OTHER KIND OF SAW.

When fossils come in from field sites, they are still encased in matrix (dirt and rock) and a plaster field jacket. The jackets need to be opened, and the fossils cleaned, assembled, molded, cast and cataloged prior to study.

Opening the Jacket

All the fossils that come back to the lab after a field season are encased in labeled plaster jackets. Some of these fossils are stored in their jackets to be opened and prepped later. Others are opened right away.

Workers use a cast cutting saw (the same kind of saw that is used to remove casts for broken bones) to carefully cut all the way around the jacket. Then, the jacket is carefully pried open.

Video: Opening a Dinosaur Fossil Jacket

10. THE MATRIX (EXTRA DIRT AND ROCK AROUND THE FOSSIL) IS CAREFULLY REMOVED BY FOSSIL PREPARATORS (THIS CAN TAKE A SHORT OR LONG TIME).

Preparation (Cleaning)

Once the jacket is open, trained preparators begin to carefully remove the dirt and rock matrix surrounding the fossil. They work slowly and make notes about what they find. They use small tools such as dental picks, toothbrushes, and paintbrushes.

Sometimes, when the rock is very hard, preparators use a tool called an airscribe which is like a mini jackhammer.

Video: Dinosaur Fossil Preparation with Air Scribe

11. IF THE FOSSIL IS BROKEN, IT IS NOW PUT BACK TOGETHER.

Often, fossils are broken into tiny pieces and crumble as the matrix is removed. Preparators use special consolidants (glues) to keep the fossil intact.

Because fossils are often broken when we find them, there is need for assembly after the fossils are cleaned. Preparators work to put bones broken into many different pieces back together—like a three-dimensional puzzle.

12. THIS FOSSIL IS NOW CAREFULLY LABELED.

Cataloging

In a museum or other fossil collection, each fossil and replica is given a number so that it can be easily tracked and identified. At MOR, these numbers often start with the letters MOR, and end with a three to four digit number. Above, a drawer full of fossils in the MOR Paleo Collections.

13. A MOLD AND CAST ARE MADE FOR THE FOSSIL.

A mold is made of the fossil.

Molding

It is often necessary and important to make copies of fossils (called replicas or casts) using a molding and casting process. Casts provide exact copies of a unique and delicate fossil so that more people are able to study it. Molds are the shells from which casts are made. Molds are made from the original fossil. The fossil is coated with runny silicon, which hardens and retains the fossil's exact shape and fine details.

A resin cast (which is the exact size and shape of the original fossil) is poured from the mold.

Casting

A cast is an exact 3-D copy of a fossil made from pouring resin into a mold. Casts retain the same detail as the original fossil, but are much more durable. They can be used for study, display or educational purposes.

14. THIS FOSSIL MAY NOW BE PUT TOGETHER WITH OTHERS TO RECONSTRUCT THE DINOSAUR FROM WHICH IT CAME.

Reconstruction

Skeletons and skulls are made up of many different pieces. To see what an animal looked like, preparators have to put these bones back together

Sculpting

Most of the time, the fossil skeletons and skulls that paleontologists find are incomplete. To be able to see what the entire skull or skeleton might have looked like, paleontologists reconstruct missing pieces based on other similar specimens. Above, MOR preparator Michael Holland sculpts missing pieces of a T.rex skull.

15. OR, THIS FOSSIL MAY NOW BE STORED IN COLLECTIONS.

Video: Museum of the Rockies Collections

16. OR, THIS FOSSIL MAY NOW BE STUDIED BY PALEONTOLOGISTS AND STUDENTS. FOSSIL STUDY CAN INCLUDE:

A. Observing the fossil by itself
B. Observing the inside of the fossil through histology
C. Observing the fossil with an SEM microscope
D. Observing the fossil with CAT scan technology
E. Comparing the fossil to other similar or different fossils
F. Comparing the fossil to bones of modern animals

Dinosaur Research at the Museum of the Rockies

MOR's Paleontology Department is home to several world-class research laboratories where cutting-edge science is happening every day. PhD, graduate, and undergraduate students in the Paleo Department have access to research facilities second to none.

Bowman Fossil Preparation Laboratory

The Bowman Fossil Preparation Laboratory is located just before the entrance to the Dinosaurs under the Big Sky exhibit at the Museum of the Rockies. Behind the large glass wall of this lab visitors can watch trained volunteer preparators cleaning real dinosaur fossils. Current projects include femurs and vertebrae from sauropods (enormous long necked dinosaurs). The Bowman Fossil Prep Lab is operational most week days.

Fossil Preparation Laboratory

Fossil preparators are the people who very patiently remove bits of rock and sediment from the fossils once they are moved from the field into the museum. The finished specimens are prepared for both research and display purposes. Some fossils take just a few minutes to prepare, while others take several years. The preparation of most specimens requires the use of tools such as dental picks, and scrappers, while others require grinders and engravers. Some even require the use of sand-blasters, or have to be dipped in acid baths.

In addition to fossil preparation, the fossil preparators have other jobs such as molding and casting, and creating displays for the dinosaur hall. Some preparators even go to the field during the summer to help get the specimens out of the field, and back to the lab.

Paleo-Technology Laboratory

Paleo-Technology is both a laboratory and a program where we generate information to analyze form, function, and spatial relationships of everything from dinosaur bones and skeletons to geological outcrops. Using X-ray, and a variety of 3-Dimensional scanners we have the capability of analyzing specimens as small as individual teeth, or as large as the Museum of the Rockies building. Computerized tomographic (CAT-Scan) data is acquired from outside sources, particularly from the Bozeman Deaconess Hospital, and processed with special software.

We thank the Wiegand Foundation for support of the Paleo-Technology Program and Laboratory

Gabriel Lab for Cellular and Molecular Paleo

The Gabriel Laboratory, named for former graduate student Diane Gabriel, is the facility where bones are analyzed at the cellular and molecular levels. Histological slides produced in the Histology Preparation Lab, by Ellen Lamm, are studied to reveal information such as dinosaur growth, and physiology. Chemical analyses provide means to search for biomolecules such as proteins. We thank the Charlotte and Walter Kohler Charitable Trust for support of the Gabriel Laboratory.

Paleontology Field Program

The Museum of the Rockies Paleontology Field Program is the largest in the country, and is equipped to support 5 fully functional field camps. Large equipment includes 6 heavy duty trucks, 4 ATVs, 5 equipment trailers, 5 cook trailers, and 4 boats. Three of the camps can utilize high speed satellite internet. The program also has a satellite uplink station for broadcasting live feed from the field to the museum to be shown in the Mesozoic Media Center.

The Museum of the Rockies occasionally accepts applications for volunteers to work at our dinosaur dig sites. Volunteers must be between the ages of 16 and 60, and commit to at least 3 weeks of work. To learn more or submit a volunteer application, click here. We thank Nathan Myhrvold (Intellectual Ventures), and the Ameya Preserve for support of our field activities.

17. OR, THIS FOSSIL MAY NOW BE PLACED IN A CASE FOR DISPLAY IN A MUSEUM EXHIBIT.

18. **OR, THIS FOSSIL MAY UNDERGO A COMBINATION OF THE ABOVE STEPS**

DO YOU WANT TO LEARN MORE ABOUT PALEONTOLOGY?

- Visit the "Paleontology Portal" developed by the University of California Museum of Paleontology in collaboration with its Advisory Boards and funded by the National Science Foundation.

- Book: Digging up Dinosaurs, Jack Horner