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## What are fossils?

- Mineralized or preserved remains
- Usually only hard parts (bones) preserved
- Paleontologists



40 my old fish

Fossil are mineralized or otherwise preserved remains. Any living thing can become a fossil. Sometime evidence of life, like footprints, can also be fossilized.

Fossil occur in a few different ways. But, they all require that the living thing be buried soon after it dies. This prevents bacteria and scavengers from eating the remains.

The picture is of a fossilized fish that is around 40 million years old. Since when we talk about fossils we are usually talking about really big spans of time, we abbreviate million year m.y.

Paleontology is the study of the history and development of life on Earth, including that of ancient plants and animals, based on the fossil record (evidence of their prehistoric existence as typically preserved in sedimentary rocks).

## Where can fossils form?

- Dry climates (now)
- Often former bodies of water
- Needs sediment



When we look for fossils, we look in places that have dry climates today. They did not always have to be dry though. The picture on the bottom is Badlands National Park in South Dakota. It is dry and mountainous. But, millions of years ago it was underwater. The picture on the right is a drawing of some of the creatures whose fossil remains have been found here.

Even though fossils are often found in dry climates today, many times those climates were underwater when the fossils were formed. This is partly due to the need for sediment, or some type of soil, to cover the remains very quickly. In bodies of water sediment is constantly filling in. But, sediment can come from other sources too.

## Where can fossils form? (cont.)

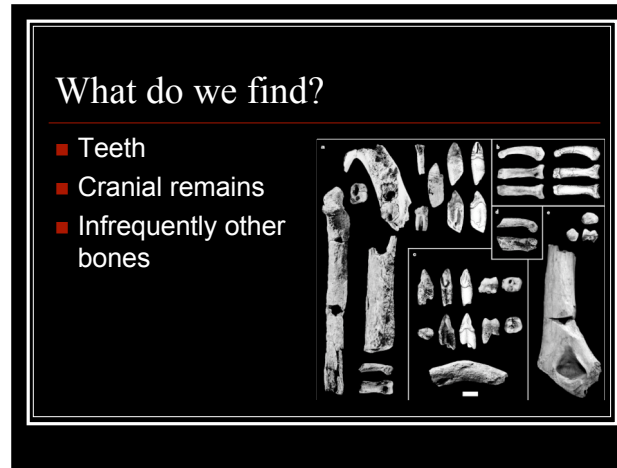


Here are some fossilized footprints from Laetoli, Tanzania, which is in Africa. The theory as to how they formed is that these two creatures on the right, were walking right before the volcano in the background exploded. When the volcano erupted, ash fell and filled in their footprints. Then they were uncovered by paleontologists, which are people who study the past through fossil remains.

You can probably guess how rare it is to find situations like this. Fossils are so rare that we can never hope to get a perfect picture of what the past was like.

*Australopithecus afarensis* is pictured here. It is an extinct creature. Much of what we find in the fossil record is not around anymore.

Caves are also good places for fossils to form.



Not only is fossilization rare, but it often does not preserve the entire individual. Most frequently we find teeth, since they are the hardest part of your body and no animals eat teeth.

Cranial remains (cranial is a fancy word for your skull) are the next most frequently found part of the body.

And then, sometimes you get really lucky and find other parts of the body. Even more infrequently, you may find a nearly complete skeleton.

## Extinct species



Here is an example of a site (place we dig) in the US. Example: Northwestern Nebraska, along the Niobrara river.

Twenty million years ago there was an ancient watering hole in the area, the ancestral Niobrara.

Many different kinds of animals roamed the floodplain, like the large moropus, primitive dogs, hippopotamus, and rhinoceroses.

It is believed that a drought caused many of these animals to die out.

## Extinct Species



When the rains finally came back, large numbers of their skeletons were covered with sediments, and eventually **petrified**.

This is what they look like as they are uncovered. (point out some skeletal features).

### Time - The Cenozoic Era

Period	Epoch	Years Ago
Quaternary	Holocene	10,000 bp
	Pleistocene	1.8 Mya
Neogene	Pliocene	5.0 Mya
	Miocene	24 Mya
Paleogene	Oligocene	37 Mya
	Eocene	58 Mya
	Paleocene	66 Mya

Let's talk about time period for just a moment. Since we talk about time on a such large scale, it is useful to have names for the different time periods.

We group time into eras, then periods, then epochs. So today, we are living in the cenozoic era, the quaternary period and the holocene epoch.

Nearly all fossils that we find are from this era. So it is typically more useful to talk about which epoch a fossil is from. You can see that the epochs are not divided on a set scale, rather they are divided by important events in the earth's history.

To get an idea of how long ago these epochs occurred, you can look at the years ago column in this chart.

MYA stands for million years ago and BP stands for before present. Since this is such large scale time, there is no point in giving it a year like how we currently measure them.

Big events - 65 mya dinosaurs extinct - likely through an impact event

Sometime late in the Miocene ~ 6-8 mya hominids start to develop

2 mya - drastic climate shift - makes Africa warmer and drier

10,000 bp - end of last ice age

primates

monkeys      apes

hominids



## How we find fossils

- Luck
- Educated guessing
- Patience



If you go looking for fossils you need luck to help you out. Fossils are very rare. Even though we have found a bunch of them, not many remains were fossilized. If you are pretty lucky you may find a couple of teeth, like in the lower picture. Teeth are the most common type of fossil to find since teeth are the hardest thing in your body. If you are incredibly lucky you may find more remains, like the picture on the right.

We know what type of areas preserve fossils the best, so we often start looking there or where people have found fossils in the past. Often, local people will find a fossil and then tell scientists who can then go and look at the area.

Finally you need patience. It takes a long time to find a fossil. Then it takes a long time to uncover it. And it takes a long time to figure out what you have found and then you still have to write-up and publish your results. This whole process takes years.

## How we find fossils & old stuff



Once you think you have a good place to find fossils, the first step is to lay out a grid, like in the top left picture. That way you will be able to record exactly where each item you find came from and how it was positioned in relation to other pieces you find. It is very important to know where you found each fossil and how it was positioned in relation to other fossils. Knowing this can help you tell if two fossils are related, and possibly if they come from the same time period.

Then you slowly remove each layer of soil, like in the bottom picture here. Going layer by layer in the soil is very important because soil layers are deposited slowly over time. So, if one fossil is found in one layer of soil and another fossil is found in a different layer of soil, it is fairly likely that they did not live at the same time.

If you find a large fossil you remove it, but sometimes it can be difficult to tell what is a fossil and what is not. So, you keep all the dirt that you remove and you run it through a screen, here on the right. That way you can look at each item that comes from the dirt and hopefully you find something.

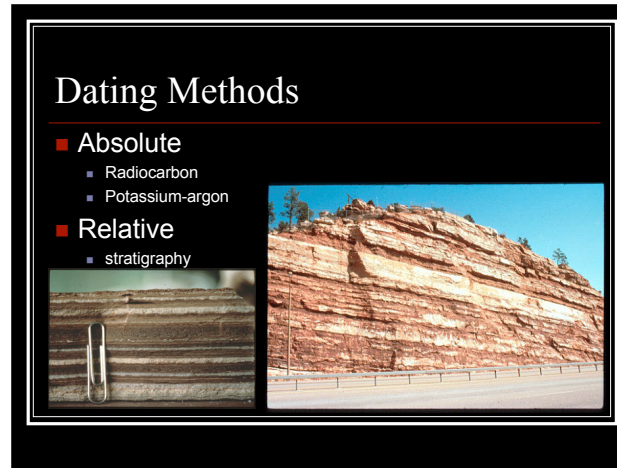
## Got remains? Now What?

- What is it?
- When did it live?
- What can we learn from it?



So, what do we actually do once we find some fossils? First you figure out what you have. And that can take years. Then you try and date it, or figure out when it lived. Finally, you study it and see what else you can learn from it.

This is a baboon-like animal skull that lived around 2 mya.



There are two ways we date fossils. They are absolute and relative dating methods. Absolute methods are based on the remains themselves, while relative methods rely on information that does not come from the fossils.

Radiocarbon dating is based on the fact that all living things contain the element carbon. And that carbon breaks down at a slow pace, that we know. Half of the carbon in remains will be gone in around 5000 years. Then half of what is left will be gone in 5000 and so on. So, if we look at how much carbon is left in a remain, we can figure out around how long ago it died. But, carbon dating only works back to about 60,000 years ago. We have other methods that work basically the same way, but with other elements like potassium-argon, which dates rocks older than 100,000 years up to 5 my, that are able to date older material.

The way you get these results is that you take a very small sample from the remains and submit them to a lab. The lab will then process the sample and give you a date range. The date will be something like 20,000 +/- 5000. That means that the remains are from something that existed between 25,000 years ago and 15,000 years ago. So, these methods are not that precise, but they are still very good when we are talking about stuff that is really old.

Relative dating often is based on stratigraphy, which is the way layers in soil are deposited. The theory behind stratigraphic dating is that the layer on the bottom was deposited first, then the next layer and so on so that the top layer is the most recent. That way, if we find a fossil in one layer we can say that it is likely older than a fossil found a few layers above it. These pictures show some examples of very clear stratigraphic layers. But sometimes stratigraphy is not clear. Sometimes when fossils are found in caves or in other locations where something has happened, there is no clear stratigraphy because the soil has been churned up over time. This makes stratigraphic dating not as precise or reliable as absolute dating methods.

Even though we have some really good dating methods, we still have to make

## What can we learn?

- Morphology
- Behavior
- Living comparisons



The one thing that we can tell for sure is what the skeletons of these species looked like, which is called their morphology. Which is interesting, but doesn't really tell us that much about the species. We can take their morphological characteristics, so what features their skeleton has, and use that to infer behavior, which means make educated guesses about how they acted. For example, if we find the remains of a thing that looks somewhat like a tiger and has really big teeth, we can guess that it uses those teeth to hunt, much like a living tiger.

This is a really complete skeleton of a horse-like animal. It has lots of the same features that living horses do, so we can guess that it has a lot of the same behaviors as horses. Its legs and feet are made pretty much the same way as living horses. So we can guess that it lives on similar surfaces and moves in much the same way as horses.

## Teeth! - A Real-Life example



What I worked on recently was reconstructing the diets of extinct fossil primates. Specifically fossil baboon-like monkeys. (show tooth cast). On the right is a picture of a living baboon. What I did was to look at the teeth of these fossil baboons under a microscope. When you eat food, you don't even know it, but the food leaves little microscopic marks. So I look at the teeth under a microscope and try and figure out what the baboons ate based on the types of marks that are left on the teeth.

The reason that I wanted to know what types of food they ate is because the food that is available says something about the climate. These particular baboons lived in Southern Africa around 2 mya. This is really important because we think two things were happening back then. The first is that the climate was changing. The second is that a lot of hominid, or human like creatures were living in this area around this time. So, if we understand how the baboons dealt with the climate change, we may be able to guess at how the hominids dealt with the climate change.

## South African Stratigraphy

- Complex
- Can't date



Remember how I showed you those pictures earlier about stratigraphy and there were really nice, clear layers? That is the opposite of what is in South Africa. Most of the sites in South Africa are caves. As caves form and time passes, the caves tend to fall in on themselves, such that the stratigraphy gets messed up. Which means that what is on the bottom may or may not be older than what is on top.

And, since fossil teeth are what we find, we can't use any of our absolute dating methods on them. So, it is very hard to date them. What we end up doing is comparing what we find to other similar baboons in other parts of Africa. We have to assume that since they are very similar, they lived at roughly the same time.

## Summary

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- Fossils and other remains can tell us a lot about the history of the Earth and the creatures that inhabit it.
- But, they are hard to find and complex to study.



Questions?

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