Fossils

What is a fossil?

A fossil is an impression, cast, original material or track of any animal or plant that is preserved in rock after the original organic material is transformed or removed.

A fossil may be:

- an original skeleton or shell;
- a mold or cast;
- material that has replaced the once living thing;
- traces such as footprints or worm tubes

CONDITIONS FOR FOSSILIZATION TO OCCUR

- Rapid burial to (a) avoid scavenging and (b) eliminate oxygen to prevent decay
- Possession of hard parts - bones, teeth, nails, shell or woody tissue

MODES OF PRESERVATION - PERMINERALIZATION

- Skeletal material can be quite porous. If the pores are filled in by foreign minerals that precipitate out of solution, the fossil is said to be permineralized.
- Petrified wood is an example of wood that has been permineralized by silica.

MODES OF PRESERVATION: PETRIFICATION

- Fossils in which the entire cellular structure of the organism is replaced by mineral matter

MODES OF PRESERVATION – MINERAL REPLACEMENT

- This occurs when skeletal material is replaced, molecule by molecule, with some alien material. This process occurs gradually over a long period of time as the original mineralogy dissolves away and a new mineral precipitates in its place. Examples include:
  - (1) Silicification - when calcium carbonate is replaced by silica, and
  - (2) Pyritization - when pyrite replaces calcium carbonate.

MODES OF PRESERVATION: CASTS & MOLDS

- Sometimes the original material is dissolved away, leaving a cavity in the rock which may later become filled with another material, such as a mineral.
  - The cavity is known as a mold
  - The internal filling is known as a cast

MODES OF PRESERVATION: IMPRINT

- Carbonization occurs when all organic volatiles are distilled away due to the effects of heat and/or pressure, leaving a carbon film remnant of the organism.
- This usually occurs with organisms rich in carbon that possess thin or no skeletal material.

MODES OF PRESERVATION: ACTUAL REMAINS

- Unaltered: Occasionally an organism's skeleton is preserved intact without any chemical alteration of the original mineralogy.
- This mode of preservation becomes increasingly rare for fossils of older ages.

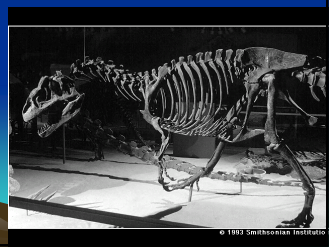
UNUSUAL MODES OF PRESERVATION

- Uncommon modes of preservation:
  - Encased in amber or copal – smaller animals, mainly insects, but sometimes lizards, frogs and birds
  - Mummification – rare process peculiar to desert areas
  - Freezing – animals, including humans and mammoths
  - Trapped in tar/asphalt

What are the fossil types?

- Body fossils – actual parts of an organism, unaltered or altered
  bones, shells, leaf imprints
- Trace fossils – evidence of life that is not a body fossil
  tracks, burrows, casts

Body fossils



Trace Fossils

What are the modes of fossil preservation for body fossils?

Unaltered

Original Material - original, unaltered material from the living organism
unaltered bone or shell

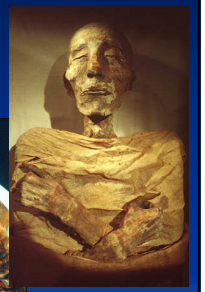
Encrustations or entombments –
material is trapped inside coating such as amber

What are the modes of fossil preservation for body fossils?

Unaltered

Mummification - quickly dried material

Refrigeration – material is trapped inside ice and tissue is preserved



What are the modes of fossil preservation?

- Altered

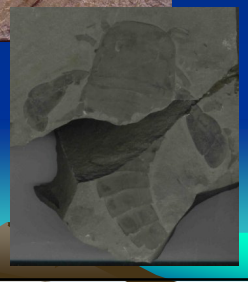
Permineralization – pores in tissue are filled by minerals

Replacement – replacement of tissue with minerals

What are the modes of fossil preservation for body fossils?

- Altered

Carbonization – tissue material is decomposed or reduced to a film of carbon



More on trace fossils

- Mold – reproduction of the inside or outside surface of a living thing
- Cast – duplicate of the original organism; usually formed by replacement of inside of living thing

More on trace fossils

- Burrows or borings – Spaces dug out by living things and preserved as is or filled in

More on trace fossils

- Gastroliths – smooth stones from abdominal cavity of dinosaurs

- Coprolites – fossilized excrement; usually preserved by replacement

More on trace fossils

- Tracks – impressions of passage of living things

RELATIVE DATING

- The most basic concept used in relative dating is the law of superposition.
- Simply stated, each bed in a sequence of sedimentary rocks (or layered volcanic rocks) is younger than the bed below it and older than the bed above it.
- This law follows two basic assumptions: (1) the beds were originally deposited horizontally, and (2) the beds were not overturned after their deposition.

RELATIVE DATING

- The law of faunal succession states that groups of fossil animals and plants occur throughout the geologic record in a distinct and identifiable order.
- Following this law, sedimentary rocks can be "dated" by their characteristic fossil content.
- Particularly useful are index (zonal) fossils, geographically widespread fossils that evolved rapidly through time.

ABSOLUTE DATING

- **Carbon dating** uses the half-life of Carbon-14 to find the approximate age of certain objects that are 40,000 years old or younger.
- The ratio of normal carbon (carbon-12) to carbon-14 in the air and in all living things at any given time is nearly constant.
  - Maybe one in a trillion carbon atoms are carbon-14.
  - Carbon-14 decays by very weak beta decay to nitrogen-14 with a half-life of approximately 5,730 years.

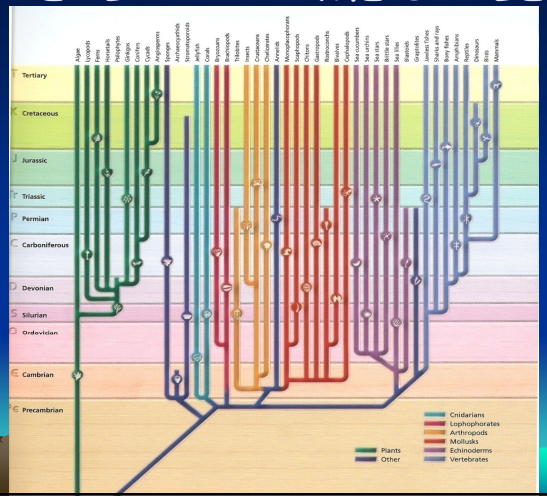
ABSOLUTE DATING

- Radioactive decay is the process by which a "parent" isotope changes into a "daughter" isotope.
- Rates of radioactive decay are constant and measured in terms of half-life, the time it takes half of a parent isotope to decay into a stable daughter isotope.

ABSOLUTE DATING

- Some rock-forming minerals contain naturally occurring radioactive isotopes with very long half-lives unaffected by chemical or physical conditions that exist after the rock is formed.
  - Half-lives of these isotopes and the parent-to-daughter ratio in a given rock sample can be measured
  - Then a relatively simple calculation yields the absolute (radiometric) date at which the parent began to decay, i.e., the age of the rock.

GEOLOGIC TIME SCALE



INDEX FOSSILS – CRITERIA

- An index or zonal fossil is any fossil that may be used for correlating and dating geologic strata found in different parts of the world.
- A perfect index fossil will satisfy all the following criteria:

INDEX FOSSILS – CRITERIA

- Short geologic range so the time between appearance and extinction is short. (Trilobites may be an exception. Their designation as index fossils is most likely based upon evolutional changes … vision, etc.)
- Widespread geographic range so it is found in many places around the globe
- Found in various rock types so it is not dependent upon a particular type of bottom sediment

INDEX FOSSILS – CRITERIA

- Must have hard parts that easily fossilize, either calcareous, siliceous, phosphatic or organic
- Must be extremely abundant so that it is likely to be found in even very small samples such as drill cores

INDEX FOSSILS – EXAMPLE

- Micro-organisms traveling the currents in the world's oceans (plankton) are excellent "index fossil" candidates