Fossils: evidence of past life

Remains or traces of prehistoric life

Petrified

Petrified

Formed by replacement

Cell material is removed and replaced with mineral matter

Mold

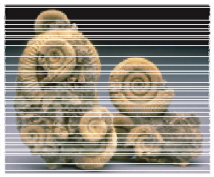
Shell or other structure is buried and then dissolved by underground water

http://www.ammonoid.com/Manning.html

Shape is preserved in the surrounding sediment

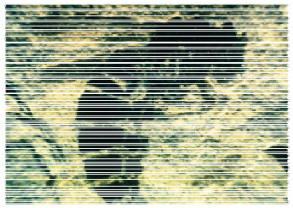
Cast

Hollow space of a mold is filled with mineral matter



Carbonization

Organic matter becomes a thin residue of carbon. This is a 'compression' of the original organism



Impression

Replica of the fossil's surface preserved in fine-grained sediment

http://www.lfbuffalo.org/exhibitions/map/t/

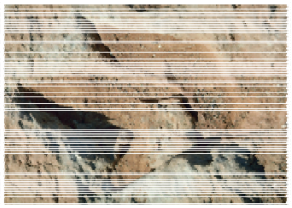
Preservation in amber

Indirect Evidence Includes

- Tracks
- Burrows
- Coprolites
  - fossil dung and stomach contents
- Gastroliths
  - stomach stones used to grind food by some extinct reptiles

Tracks

Dinosaur footprint in fine-grained limestone near Tuba City, Arizona.



Types of fossils

- Petrified
- Formed by replacement
- Mold
- Cast
- Carbonization
- Impression
- Preservation in amber
- Indirect evidence

Conditions favoring preservation

- Rapid burial
- Possession of hard parts

Fossils and correlation

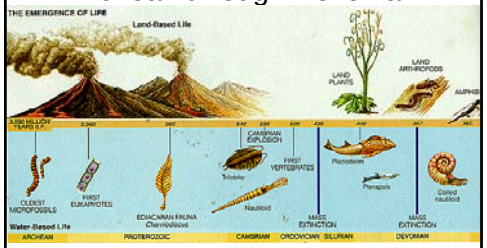
- Principle of faunal succession
- Index fossils

Principle of faunal succession

http://www.lfbuffalo.org/exhibitions/map/a/

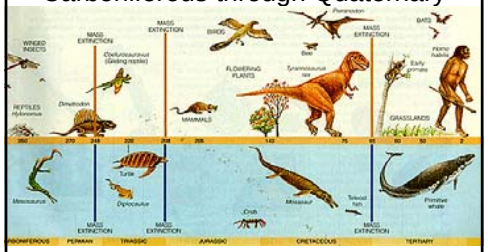
- Proposed by William Smith – late 1700s
- Fossil organisms succeed one another in a definite and determinable order, therefore any geologic time interval can be recognized by its fossil content

Archean through Devonian



http://rst.gsfc.nasa.gov/Sect2/Sect2_1b.html

Carboniferous through Quaternary



http://rst.gsfc.nasa.gov/Sect2/Sect2_1b.html

Cambrian Marine Life

http://www.handprint.com/PS/GEO/geoevo.html

Trilobite

http://www.ststephens.it/biology/fossils.html

Ordovician Invertebrates

http://www.handprint.com/PS/GEO/geoevo.html

Crinoid—

http://www.lsa.umich.edu/exhibitmuseum/exhibits/temporary_exhibits/

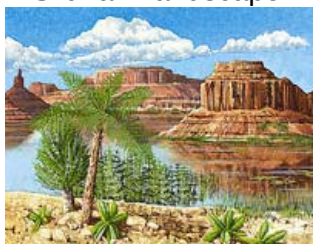
Ordovician sea floor

http://www.uwsp.edu/geo/faculty/hefferan/Geol106/CLASS6/MAIN%20PAGE.htm

- Silurian Reef

http://hoopermuseum.earthsci.carleton.ca/camex/1rpaleoreef.html

Silurian Landscape



http://www.nasa.gov/worldbook/earth_worldbook.html

Devonian Sea

http://www.handprint.com/PS/GEO/geoevo.html

Mid Paleozoic

FIGURE 6.10 – The Paleozoic Age saw many forms of life flourishing on planet Earth. In this artist's conception, some life ekes out a sparse living—mostly in the sea, such as the trilobites and sponges on the ocean floor and the jellyfish-like creatures nearer the ocean surface. Yet, as suggested by this painting, simple life forms were beginning to make their way onto the land. (Smithsonian)

http://www.tufts.edu/as/wright_center/cosmic_evolution/docs/text/text_bio_4.html

Late Paleozoic

FIGURE 6.12 – This painting captures a scene toward the late-Paleozoic. Life had diversified and become more robust—as depicted here both by the variety of (now extinct) fish and also by an increased presence of plants on the land. (Smithsonian)

http://www.tufts.edu/as/wright_center/cosmic_evolution/docs/text/text_bio_4.html

Carboniferous Fern Forests

http://www.handprint.com/PS/GEO/geoevo.html

Permian Sea

http://www.handprint.com/PS/GEO/geoevo.html

Permian Reptiles

http://www.handprint.com/PS/GEO/geoevo.html

Permian Extinction

- Link to hypotheses of the Permian Extinction http://en.wikipedia.org/wiki/Permian_extinction
- 80-95% of marine species died out
- 70%+ of terrestrial vertebrates
- Largest extinction episode in geologic record

Geologic time scale

- Divides geologic history into units
- Originally created using changes in organisms representing that time interval

Subdivisions

- Eons
  - –Eras
    - Periods
      - –Epochs

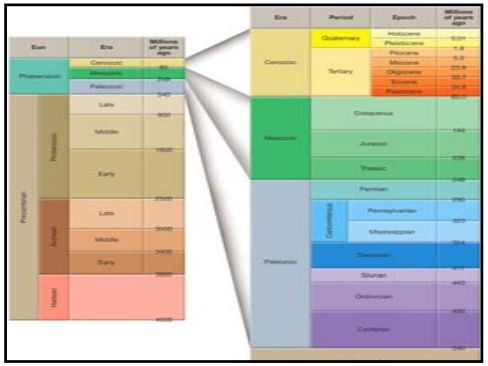
Eon

Greatest expanse of time: 4 eons

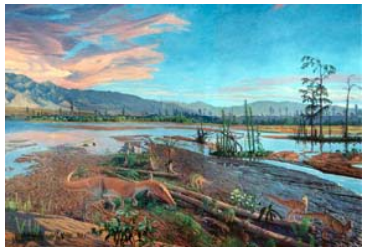
- Phanerozoic ("visible life") – the most recent eon: started 543 Ma
- Proterozoic: 2500 – 543 Ma
- Archean: 3800 – 2500 Ma
- Hadean – oldest eon 4500–3800 Ma

Eras of the Phanerozoic eon

- Cenozoic ("recent life"): 65 Ma – now
- Mesozoic ("middle life"): 248 – 65 Ma
- Paleozoic ("ancient life"): 543 – 248 Ma



Mesozoic

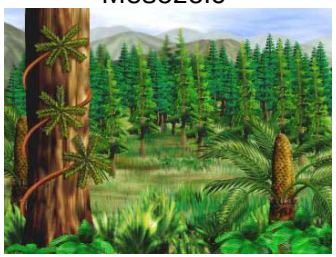


http://geography.berkeley.edu/ProgramCourses/CoursePagesFA2002/Geog40/Geog40.Week7.html

Mesozoic

http://serc.carleton.edu/introgeo/earthhistory/dinosaur.html

Mesozoic



http://geography.berkeley.edu/ProgramCourses/CoursePagesFA2002/Geog40/Geog40.Week7.html

Mesozoic

FIGURE 6.13 — The Mesozoic Age saw a continued increase in the diversity of life forms especially among the land plants, and not least the first appearance of the mammals—all of which, however, were completely dominated by the dinosaurs.

http://www.tufts.edu/as/wright_center/cosmic_evolution/docs/text/text_bio_4.html

Archeopteryx

http://www.researchcasting.ca/sculpt%20miami.htm

Mesozoic Mammal

- Eomaia

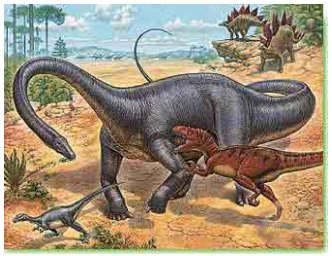
http://www.amnh.org/exhibitions/dinosaurs/diorama/

Mesozoic Mammal

- Repenomamus

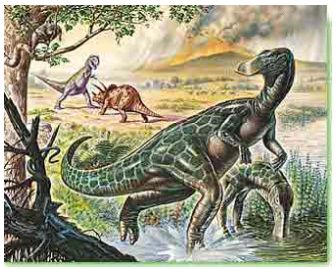
http://www.amnh.org/science/papers/mesozoic_mammal.php

Jurassic



http://www.worldbook.com/features/dinosaurs/html/world_mesozoic.html

Cretaceous

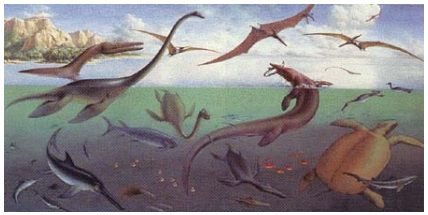


http://www.worldbook.com/features/dinosaurs/html/world_mesozoic.html

Mesozoic Sea

http://geography.berkeley.edu/ProgramCourses/CoursePagesFA2002/Geog40/Geog40.Week7.html

Mesozoic sea



http://www.uky.edu/AS/Geology/webdogs/time/mesozoic/mesozoic.htm

Cretaceous Extinction

- Perhaps 60% of species died
- Result of radical change in environment
- Perhaps Earth encountered a large meteorite—
  - 10 km in diameter
  - 90,000 km/hr
  - Equivalent to 100 megatons of TNT exploding

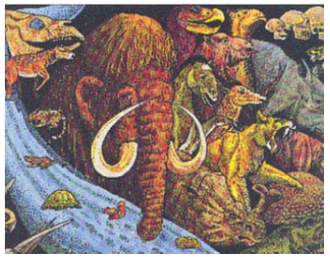
Cenozoic mammals

http://www.handprint.com/PS/GEO/geoevo.html

Cenozoic

http://www.handprint.com/PS/GEO/geoevo.html

Cenozoic



http://www.uky.edu/AS/Geology/webdogs/time/cenozoic/cenozoic.htm

Cenozoic

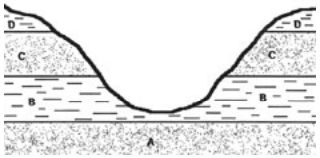
http://www.copyrightexpired.com/Heinrich_Harder/cenozoic.html

Relative dating

Placing rocks and events in proper sequence of formation

Deciphering Earth's history from clues in the rocks

Lateral Continuity



http://cse.cosm.sc.edu/hses/RelatDat/pages/lateral.htm

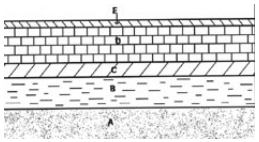
Principle of Original Horizontality

- Sediment is deposited horizontally

http://faculty.icc.edu/easc111lab/labs/labf/orig_horizontality.jpg

Principle of Superposition

- Oldest rock A
- Younger rocks above
- E is the youngest

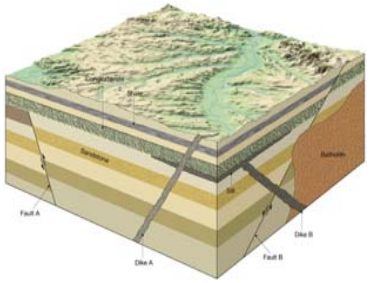


http://cse.cosm.sc.edu/hses/RelatDat/pages/superpos.htm

Principle of Cross-cutting Relationships

- Younger feature cuts through an older feature
  - Something must exist first to be cut by another thing
- The 'things' cutting may be 'things', such as igneous intrusions
- Or they may be events, like fault breaks, folding, or erosion periods

Cross-cutting relationships



Folding occurred after deposition

http://rst.gsfc.nasa.gov/Sect2/Sect2_6.html

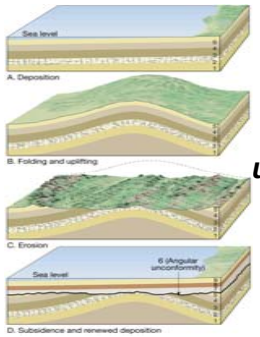
Unconformities

A break in the rock record

- Three types of unconformities
  - Angular unconformity –
  - Disconformity – strata on either side are parallel
  - Nonconformity

Angular Unconformity

- Tilted rocks are overlain by flat-lying rocks
- Remember the principle of original horizontality?

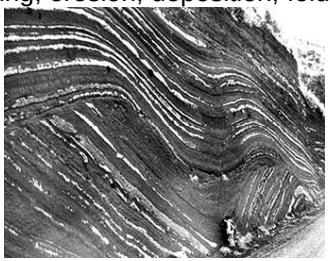


Formation of an angular unconformity

Simple angular unconformity

http://www.grisda.org/colorado/index.htm

Folding, erosion, deposition, folding

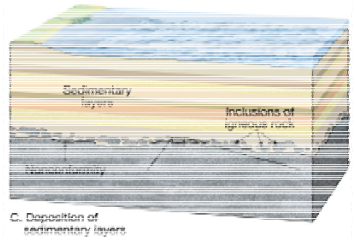


http://rst.gsfc.nasa.gov/Sect2/Sect2_6.html

Nonconformity

- Metamorphic or igneous rocks below
- Younger sedimentary rocks above

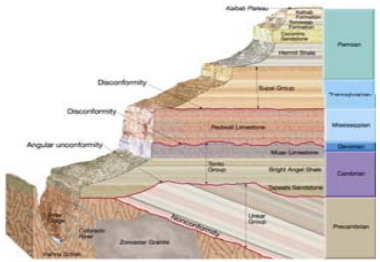
Nonconformity



Disconformity

- Gap in sedimentation that may have erosion also
- Represents an interval in geologic time without rock deposited
- Most difficult of the three unconformities to detect
- Strata on either side are parallel

Several unconformities are present in the Grand Canyon



Principles of Relative Dating

- Original Horizontality and Lateral Continuity
- Superposition of sedimentary layers
- Faunal Sucession
- Inclusions
- Crosscutting Relationships
- Unconformities

Leaves of History

http://wwp.greenwichmeantime.com/time-zone/usa/nevada/las-vegas/tourism/grand-canyon-tour-company/

http://www.city.tottori.lg.jp/geopark/en/geopark/index.html

The strata of the Grand Canyon has unconformity (missing interval), which is the age of the strata of the Northern Pennines of England: determined by faunal correlation

Absolute Geologic Time

- Radiometric Dating
- Igneous rocks contain potassium, uranium thorium and rubidium that are radioactive
- Careful measurement of ratios of these and their daughter products, or of the isotopes of them that are not radioactive can be used to calculate absolute ages

Absolute Ages

- Only possible for igneous rocks
- Need to have crosscutting relationships
- Can bracket age of sediments, geologic events like faulting, folding, erosion

Importance of radiometric dating

- Confirms the idea that geologic time is immense
- Rocks from several localities have been dated at more than 3 billion years
- Radiometric dating is a complex procedure that requires precise measurement