Geologic Time: Big Ideas

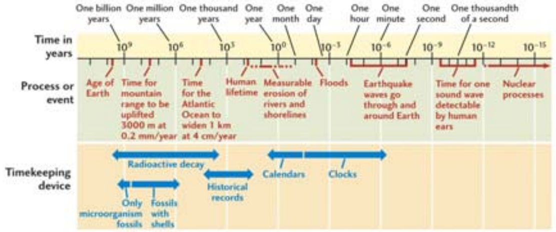
- Fossils document the presence of life early in Earth's history and the subsequent evolution of life over billions of years
- As an outcome of dynamic Earth processes, life has adapted through evolution to new, diverse, and ever-changing niches
- Understanding geologic processes active in the modern world is crucial to interpreting Earth's past
- Earth's rocks and other materials provide a record of its history

Trilobites

Geologic Time

A major difference between geologists and most other scientists is their concept of time.

A "long" time may not be important unless it is greater than 1 million years



Two Ways to Date Geologic Events

- relative dating (fossils, structure, cross-cutting relationships): how old a rock is compared to surrounding rocks
- absolute dating (isotopic, tree rings, etc.): actual number of years since the rock was formed

Which is older? How do you know?

http://stevengharms.com

Steno's Laws

Nicholas Steno (1669)

- Principle of Superposition
- Principle of Original Horizontality

These laws apply to both sedimentary and volcanic rocks.

Principle of Superposition

In a sequence of undisturbed layered rocks, the oldest rocks are on the bottom

Fig. 8.4

Principle of Original Horizontality

Layered strata are deposited horizontal or nearly horizontal to the Earth's surface.

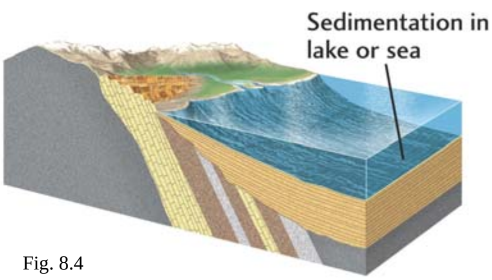


Fig. 8.4

Paleontology

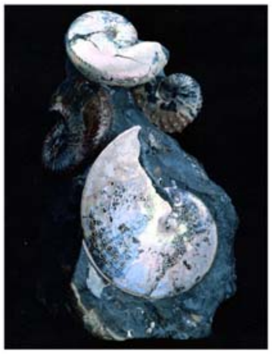
- The study of life in the past based on the fossil of plants and animals.

Fossil: **evidence of past life**

- Fossils that are preserved in sedimentary rocks are used to determine:
  1) relative age
  2) the environment of deposition

Ammonite Fossils

Petrified Forest

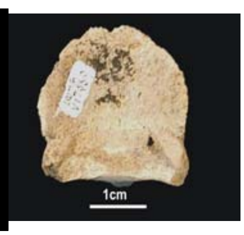


Grotzinger et al., 2007

Foraminifera, or 'forams' as they are often called, are small marine creatures that build a delicate house (called 'test') from chalk. The pyramids of Egypt are made of stone containing these creatures.

http://www.microscopy-uk.org.uk/mag/indexmag.html?http://www.microscopy-uk.org.uk/mag/artmar00/forwim.html

Louisiana Fossils



Horse hoof. A. Dorsal view, B. Ventral view.

The prepared palate of mastodon

Correlation, Relative Age Dating, and Environment of Deposition

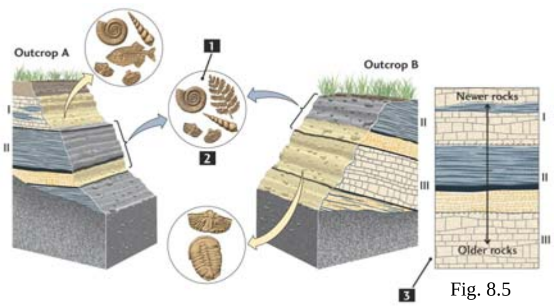


Fig. 8.5

Palynology

Study of organic-walled palynomorphs including pollen, spores, dinoflagellate cysts together with organic matter and kerogen

AASP Webpage

Archeology and Paleoecology

Q: How did Easter Islanders move and erect giant statues?
Why did their society collapse?

Archeology and Paleoecology

A: The island was once covered by giant palm trees which were used as sleds and levers. Deforestation destroyed their society.

Unconformity: A buried surface of erosion

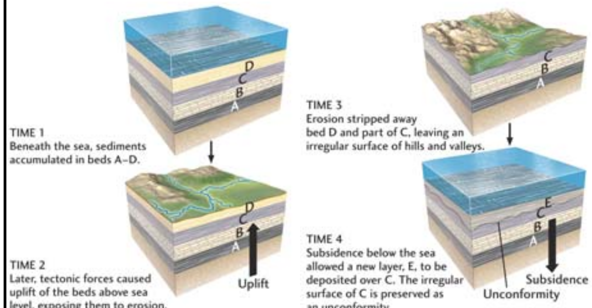


Fig. 8.6

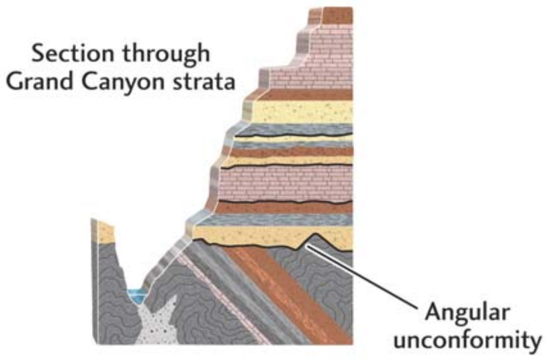


Fig. 8.7

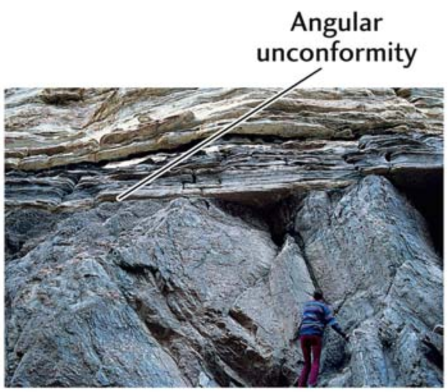
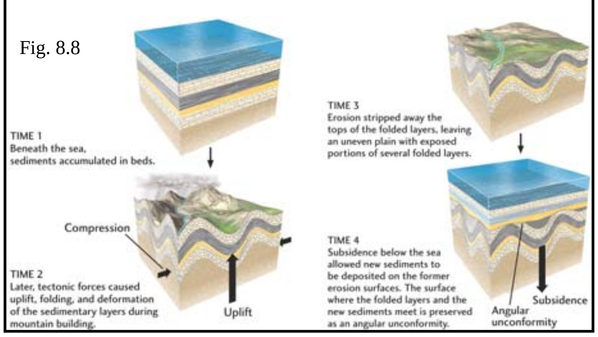


Fig. 8.7

Formation of Angular Unconformity

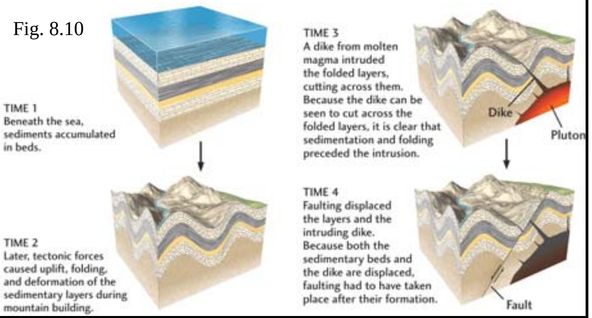
Fig. 8.8



Cross-cutting Relationships

- Geometry of rocks that allows geologists to place rock unit in relative chronological order.

Fig. 8.10



Likely Exam Question

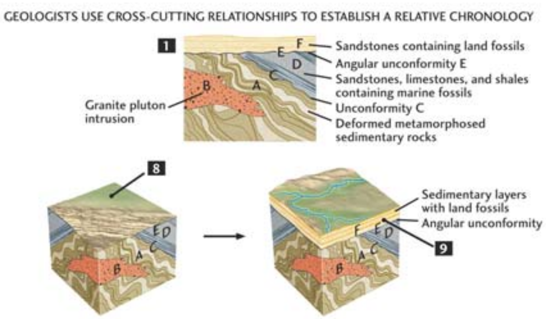
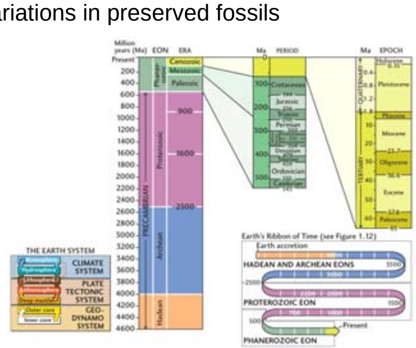
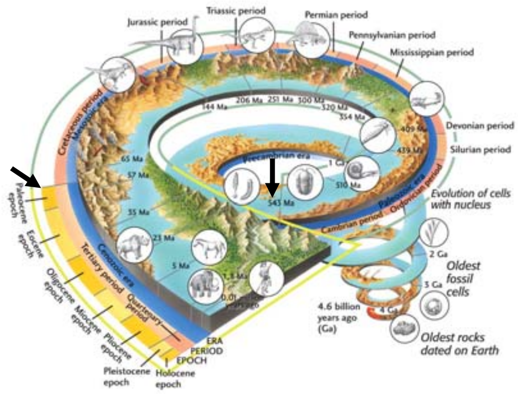


Fig. 8.10

The Geologic Timescale

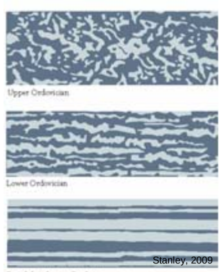
- Divisions in the worldwide stratigraphic column based on variations in preserved fossils





Cambrian Life: Burgess Shale

- Sediments indicate burrowers flourished



www.trilobites.info
burgess.ucalgaryblogs.ca
jdcalkins2001.wordpress.com/2007/12/
www.palaeos.com

Cambrian Life: Burgess Shale

Some of the diversity of the Burgess Shale biota is depicted in the drawing above by Sam Gonill and John Whorrall. Trilobites such as Olenoides serratus (1) were a minority among a diversity of arthropods such as Sidneyia (9), Waptia (17), Helmetia (13), Sanctacaris (18), Tegopelte (15), Naraoia (16), Leanchoilia (10), Canadaspis (12), Odaraia (19), Marrella (11), and Burgessia (14), as well as oddities such as Opabinia (24), Wiwaxia (26), Hallucigenia (20), and the giant predator, Anomalocaris (28).

KT Extinction

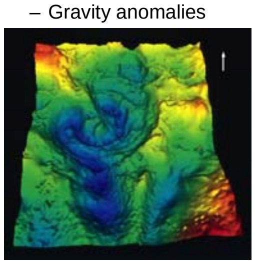
- Bolide Impact
  - Shock Wave
  - Tsunami
  - Heat/Fire
  - Dust into Atmosphere - Cooling

Cretaceous Mass Extinction

- Dinosaurs
- Ammonoids
- Mosasaurs and other marine reptiles
- Reductions in gymnosperms and angiosperms
- 90% calcareous nannoplanton and foraminifera went extinct

The Impact

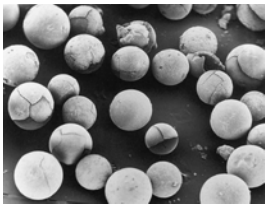
- Chicxulub Crater
  - Gravity anomalies



The Impact

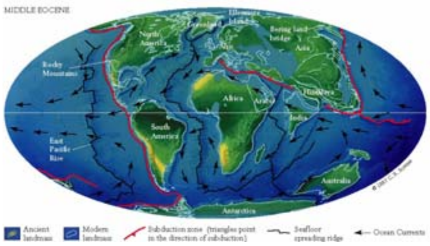
Iridium Layer

- Microspherules
  - Wyoming



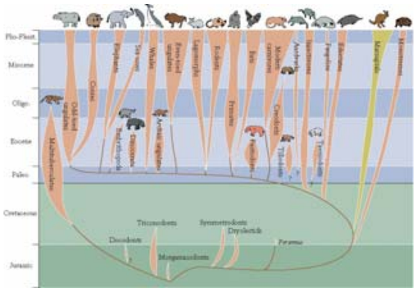
Paleogeography

- Continents were in modern configuration but closer together
- Early Paleogene
  - Warm climate
- Later cooled



Paleogene Life

- Mammals diversified
  - Most modern orders present by Early Eocene



Stanley, 2009

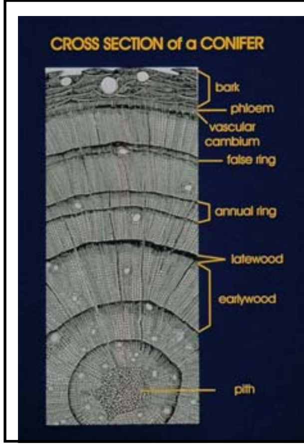
Absolute Geochronology

- Add numbers to the stratigraphic column based on fossils
- Based on the regular radioactive decay of some chemical elements

Dendrochronology or tree-ring dating

A method of scientific dating based on growth rings.

Tree rings provide a record of local climate during the life of the tree



New growth rings are generated just under the bark (vascular cambium)

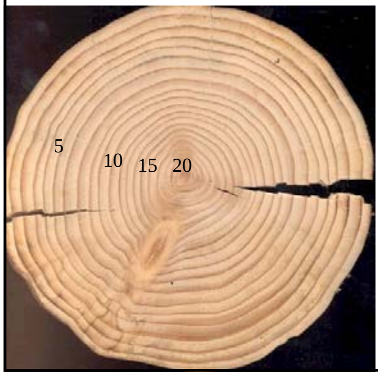
Each annual ring consists of earlywood and latewood

Earlywood thin walled, low in density and light in color

Latewood is thick walled and dark in color (less favorable growing conditions)

http://www.ncdc.noaa.gov/paleo/treering.html

Dating Trees



Counting the Rings gives the age of the tree

Variations in thickness of rings and variations in thickness of earlywood and latewood and color give information on climate (temperature and rainfall)

Changes in Climate

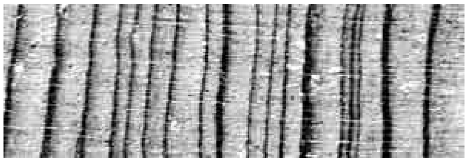
Douglas Fir from Arizona

550 mark is 550 AD

Note change in ring thickness from center to edge

http://web.utk.edu/~grissino/gallery.htm#Rings

Variations in Adjacent Rings Creates a Unique Pattern



variation in total ring width: a light and a dark band
variation in latewood width: just the dark bands
variation in latewood density: darkness of dark band

UPC Bar Code

Dendrochronology

Geochronology

http://www.barcodesinc.com/generator/index.php

Isotopes

Atoms of elements with the same number of protons and varying numbers of neutrons

Examples:

^{235}U, ^{238}U ^{87}Sr, ^{86}Sr ^{14}C, ^{12}C

Isotopic Dating

- Radioactive elements (parents) decay to stable, non-radioactive elements (daughters)
- The rate at which this decay occurs is constant and known (does not depend on T, P, x)
- If we know the rate of decay and the amount present of parent and daughter we can calculate how long this reaction has been occurring.

Requirements for Isotopic Dating

- **Closed system**
- **decay rate constant**
- **Initial concentration of daughter is known (zero is best)**

Half-life: as the time required for half of radioactive element to decay

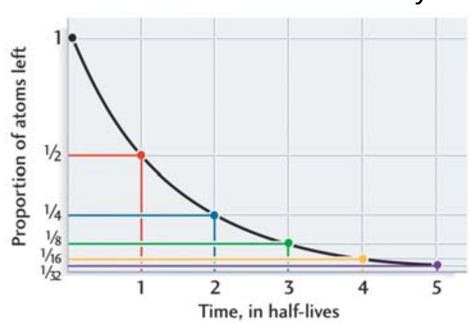


Fig. 10.14

Table 10.1 Major Radioactive Elements Used in Radiometric Dating

Isotopes: Parent	Isotopes: Daughter	Half-Life of Parent (years)	Effective Dating Range (years)	Minerals and Materials That Can Be Dated
Uranium-238	Lead-206	0.7 billion	10 million–4.6 billion	Zircon Apatite
Uranium-235	Lead-207	4.5 billion	10 million–4.6 billion	Zircon Apatite
Potassium-40	Argon-40	1.3 billion	50,000–4.6 billion	Muscovite Biotite Hornblende
Rubidium-87	Strontium-87	47 billion	10 million–4.6 billion	Muscovite Biotite Potassium feldspar
Carbon-14	Nitrogen-14	5730	100–70,000	Wood, charcoal, peat Bone and tissue Shell and other calcium carbonate Groundwater, ocean water, and glacier ice containing dissolved carbon dioxide