Week 4 Ch 8 PPT

EAPS 10000 Y01
Online Course
Planet Earth
Prof. Lawrence Braile

Welcome to the EAPS 10000 Y01 online course ***Planet Earth*** *(also known as EAPS 100)!*

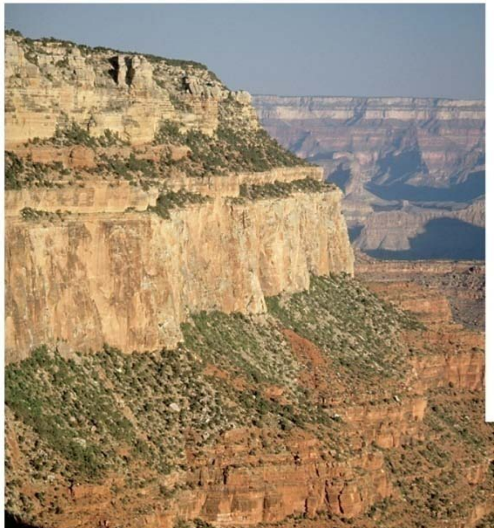
Professor Lawrence Braile
Dept. of Earth, Atmospheric, and Planetary Sciences
2271 HAMP (CIVL), Purdue University
braile@purdue.edu, (765) 494-5979

PURDUE UNIVERSITY

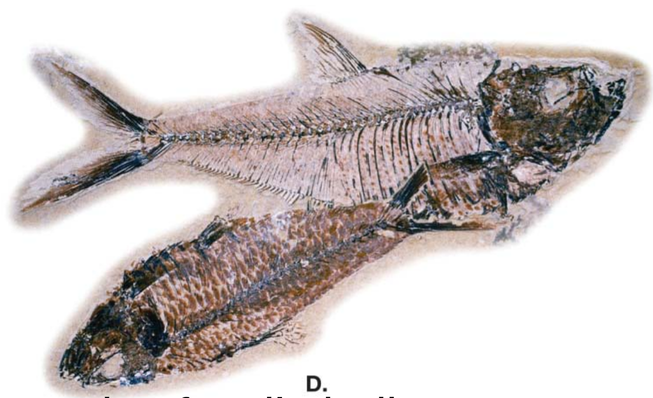
Earth Atmospheric Planetary Sciences

EAPS 10000 Y01 – Planet Earth (online course)
Week 4, Chapter 8 (pages 270-293, text)

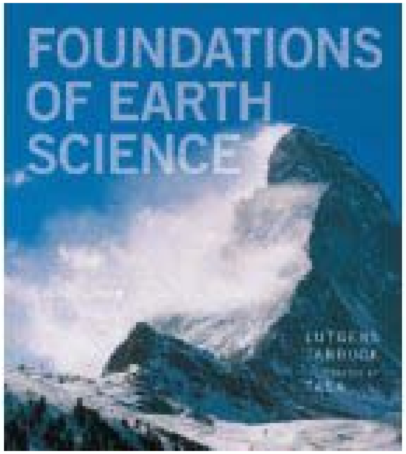
Week	Chapter	Assigned Pages	Major Concepts	Important Terms
4	**8 – Geologic Time**	270 – 293	Relative dating, absolute dating, correlation, fossils, radiometric dating, geologic time scale	Superposition, horizontality, cross-cutting relationships, unconformity, radioactivity, half-life, Precambrian, Paleozoic, Mesozoic, Cenozoic



For sedimentary rocks, superposition means older rocks are below younger rocks.



Index fossils indicate age.



EAPS 10000 Y01 – *Planet Earth* (online course)
Week 4, Chapter 8 (pages 270-293)

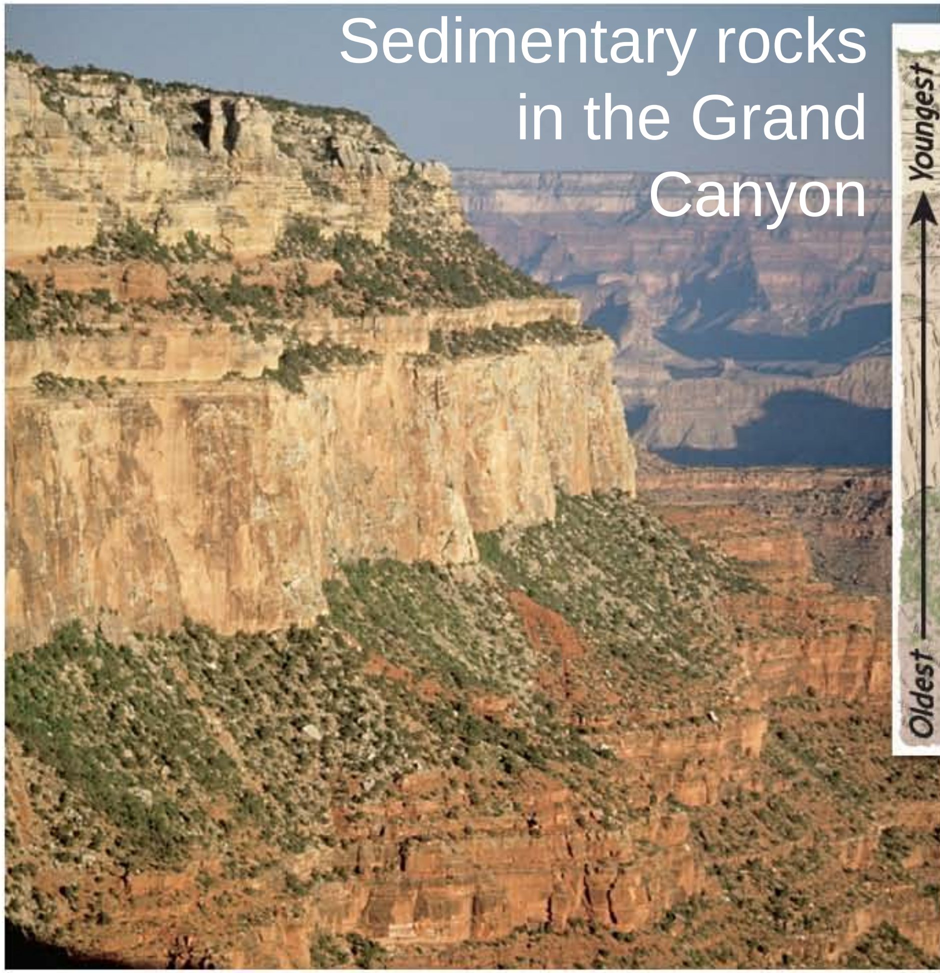
When you have finished reading Chapter 8 and viewing the PowerPoint file for Chapter 8, take the quiz (Quiz7; be sure to read the Syllabus for more information on quizzes). You can use your book, notes, etc. during the quiz.

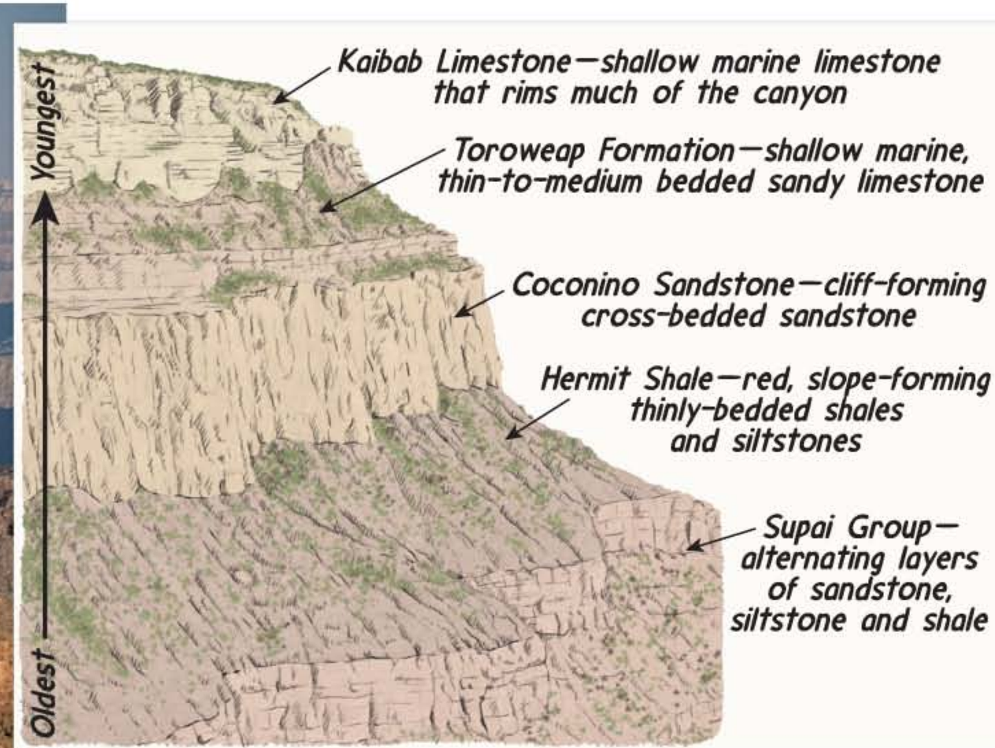
The PPT files (converted to PDF files) are best viewed with the Full Screen view in browsers.

Please open the Week 4 folder (in Weekly PowerPoints) and view the two radioactive decay/geologic dating animations. Select the animation (swf files) and click Play. You can listen to the audio narration and/or select Show Text.

The following slides illustrate some of the important concepts and topics of Chapter 8 (we're more than half way through the book!)

Superposition of sedimentary layers – we observe that sedimentary layers (and therefore sedimentary rocks) are deposited on the Earth's surface on top of older rock units.



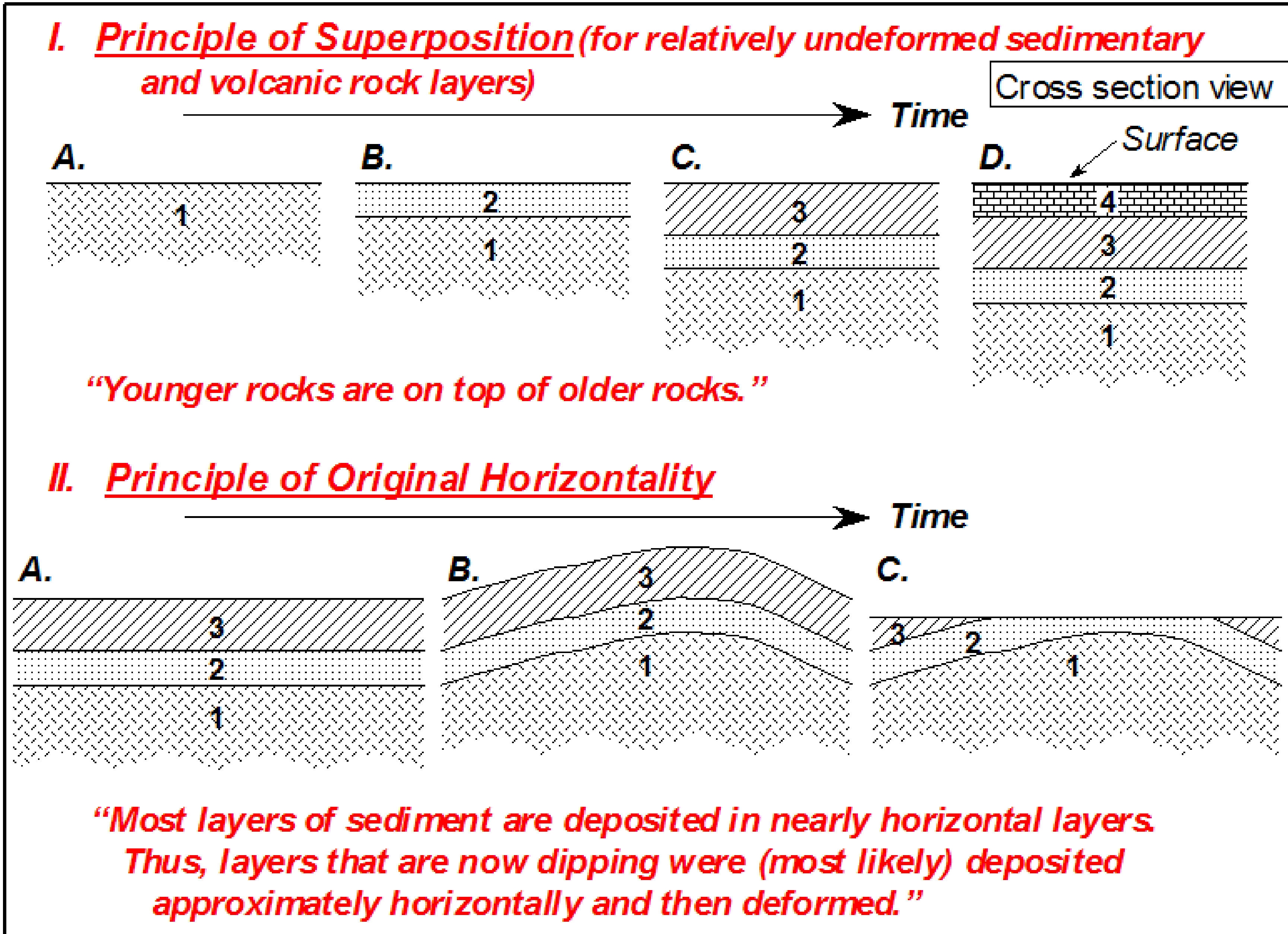


Geologist's Sketch

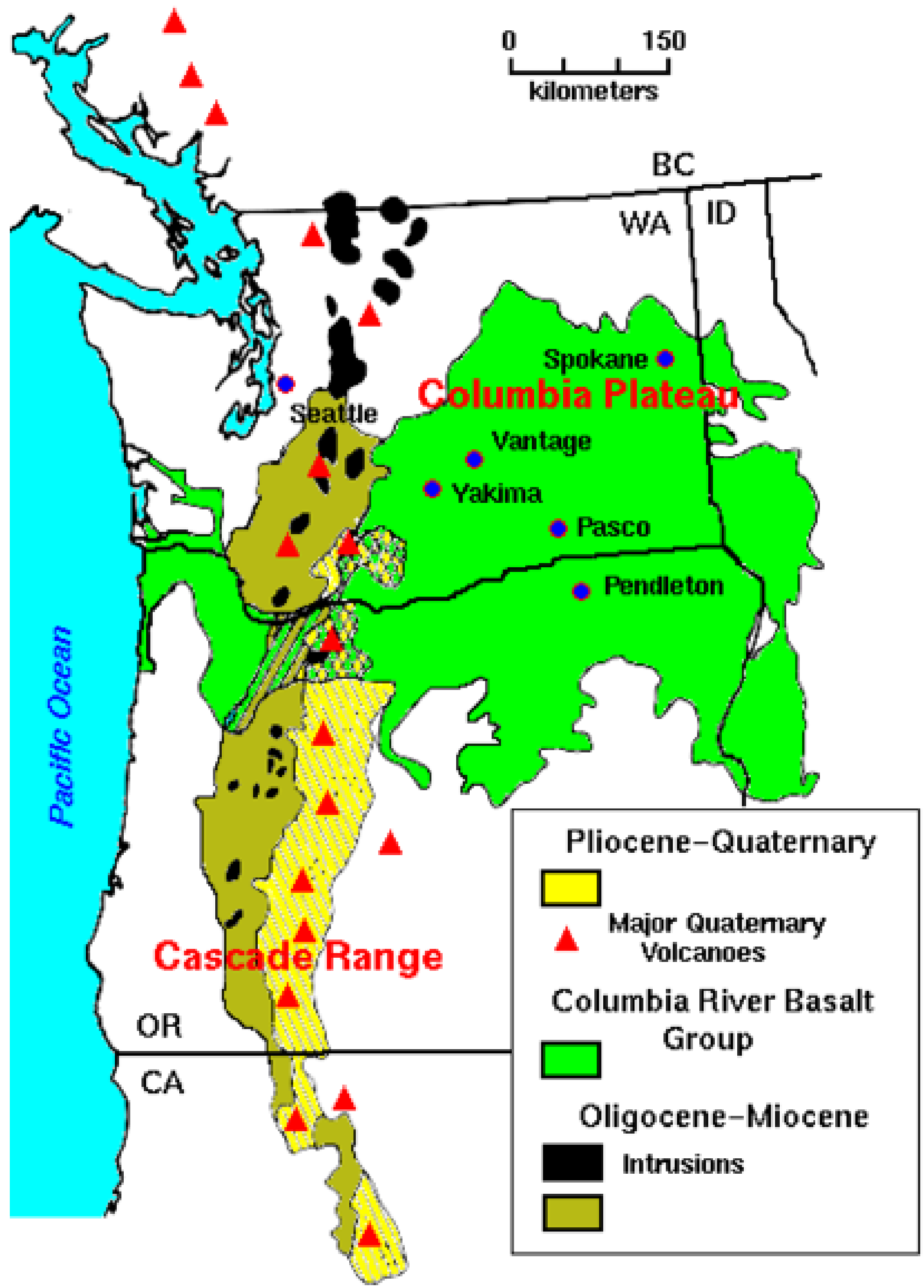
So, when we see stacks of sed. Rocks the youngest are on top and the oldest are below.

Figure 8.2, text.

Illustration of the principles of **superposition** and **original horizontality**.



Example of **superposition**, in this case for volcanic rocks (deposited on the surface) – The Columbia river basalt flows (~16 million years old). These flows erupted from fissures in SE Washington, formed “lava lakes” which cooled quickly, and are now visible (largely because of erosion by the Columbia river) as a stack of layers. Drilling and geophysical studies have shown that the layers total as much as 5 km. (See photo of Columbia river basalts in next slide.) Understanding these rock exposures is also an excellent example of **uniformitarianism** (see pages 272-273, text).

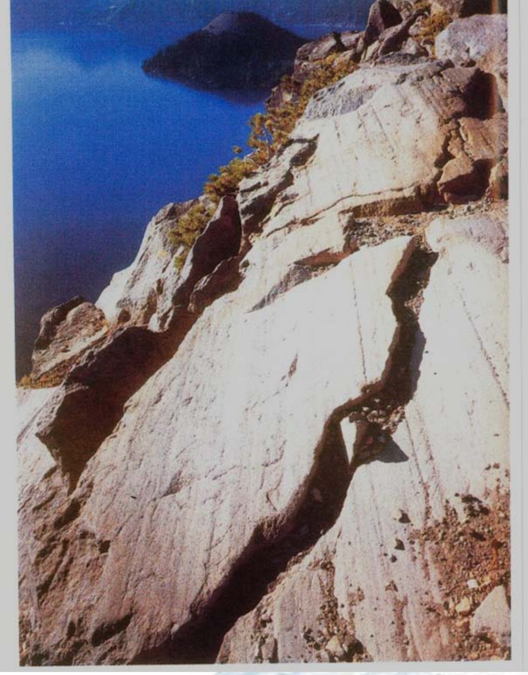


Note layers of basalt lava, erupted on the surface, so youngest above and oldest below.

Uniformitarianism (uniformity; two views):

- *1. "The present is the key to the past"*
- *2. Earth is shaped by slow, continuous processes acting over geologic time*
- Analogous to: "Laws of physics are constant"
- By studying modern geologic processes, we can *infer* past events when we *observe* the results (evidence) of those processes displayed in the geologic record - - examples: volcanic deposits, sediments in shape of delta, offset of layers by faulting due to an earthquake, etc.

Glaciations (ice ages, as discussed in Chapter 4 of the text) are excellent examples of uniformitarianism as evidence (such as morraines, drumlins, erratics, glacial till, and striations – some of these are illustrated on the next slide) has been used to infer the extensive distribution of glaciers in the past ~2 million years (see Figures 4.13, 4.14, 4.16, 4.17 and 4.22).



Striations
(scratches caused by glacier movement, Crater Lake, Oregon)

Drumlins
(streamlined hills)

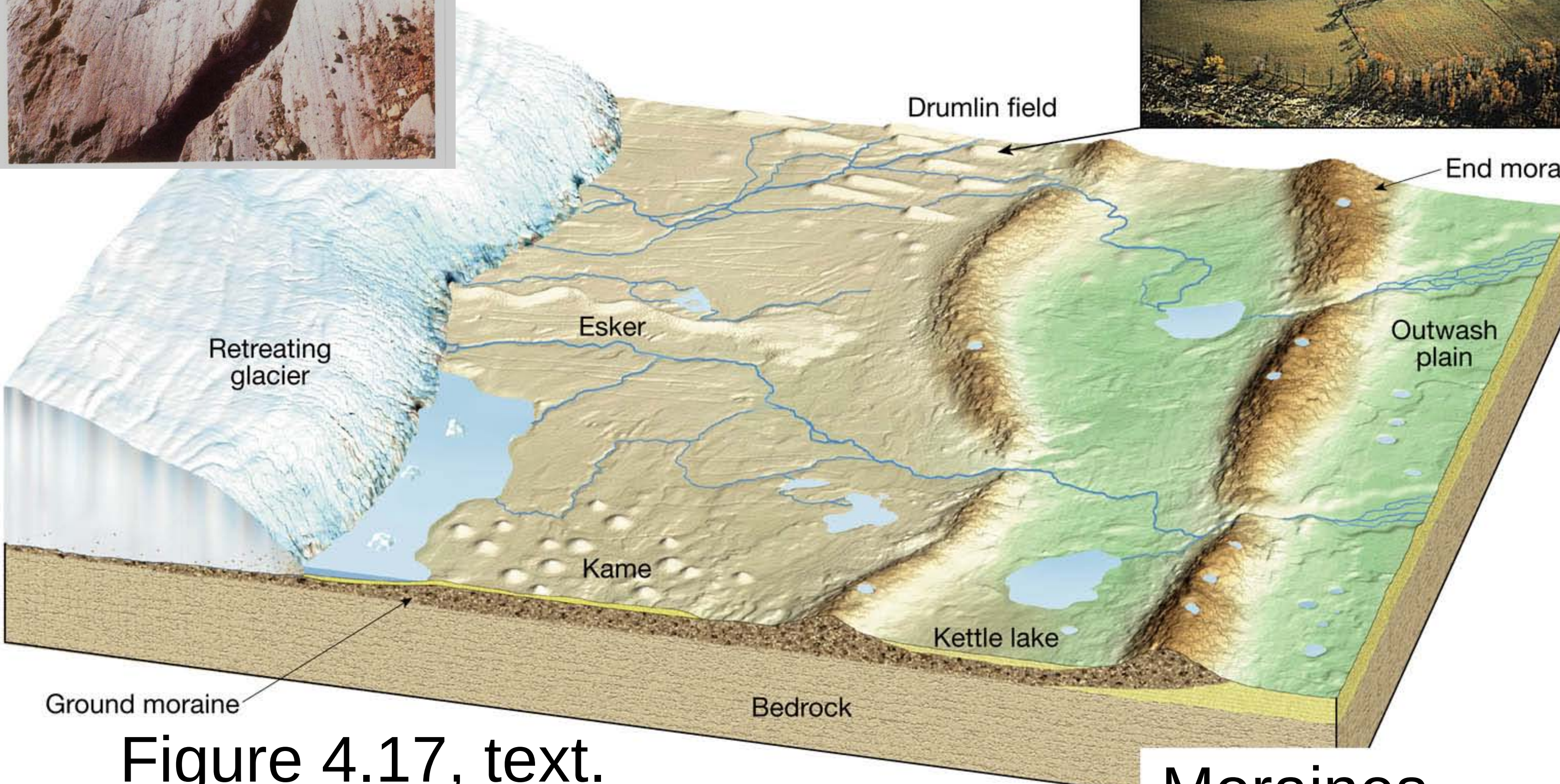


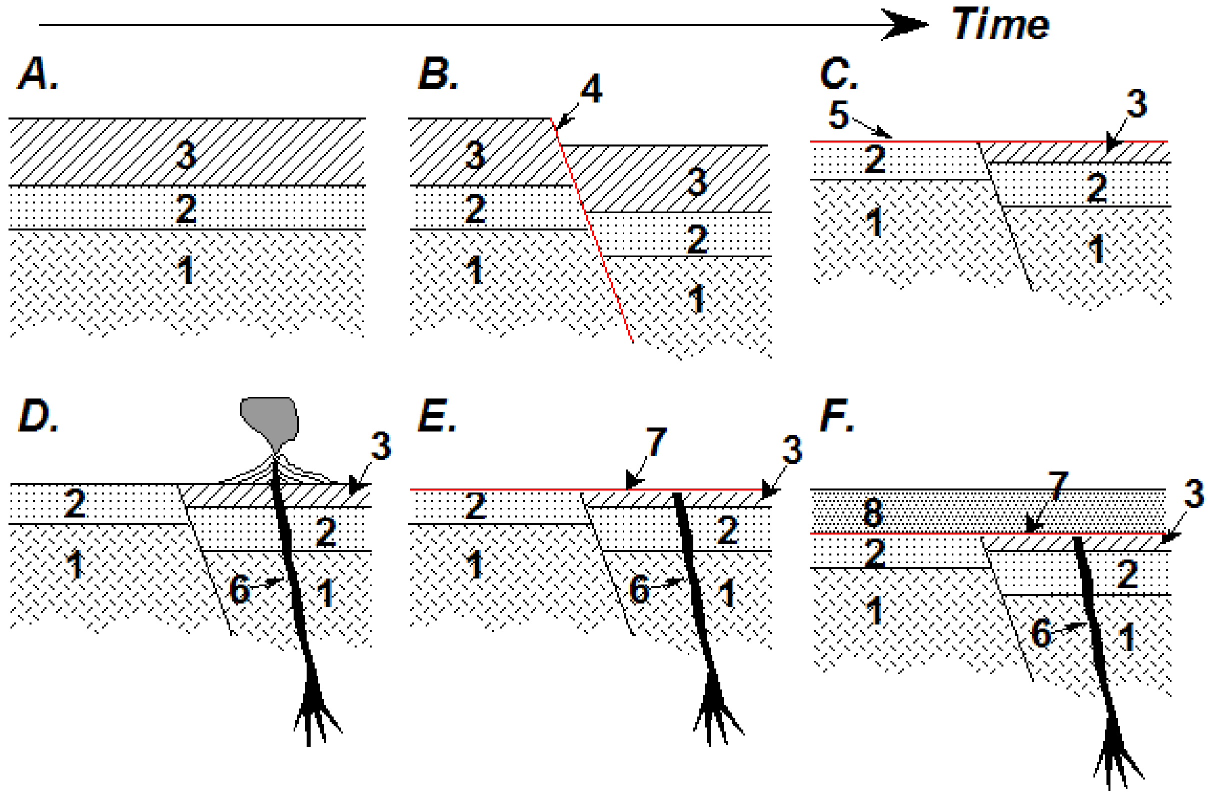
Figure 4.17, text.

Moraines

Illustration of the **cross-cutting relationships** and **unconformities**.

Superposition and cross-cutting relationships (also see Figure 8.12 in text) allow reconstruction of events A to E from the rock configurations shown in F.! Also note unconformity surface (7) in steps E and F.

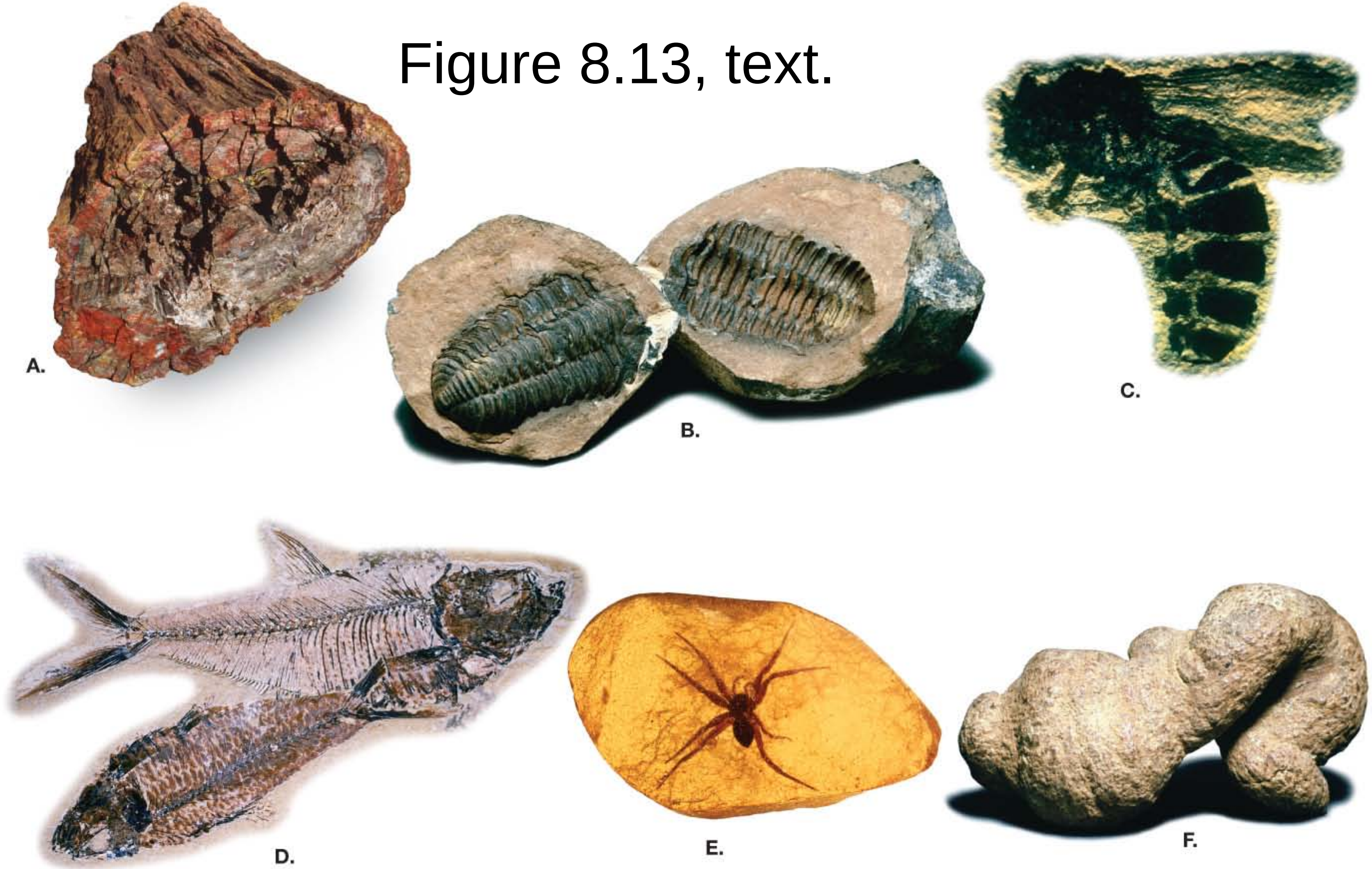
III. Cross-cutting relationships and Unconformities



"Rock units, structures or surfaces representing erosion and loss of continuous deposition (unconformities) that cut across layers (cross-cutting) are younger than the layers that are cut through."

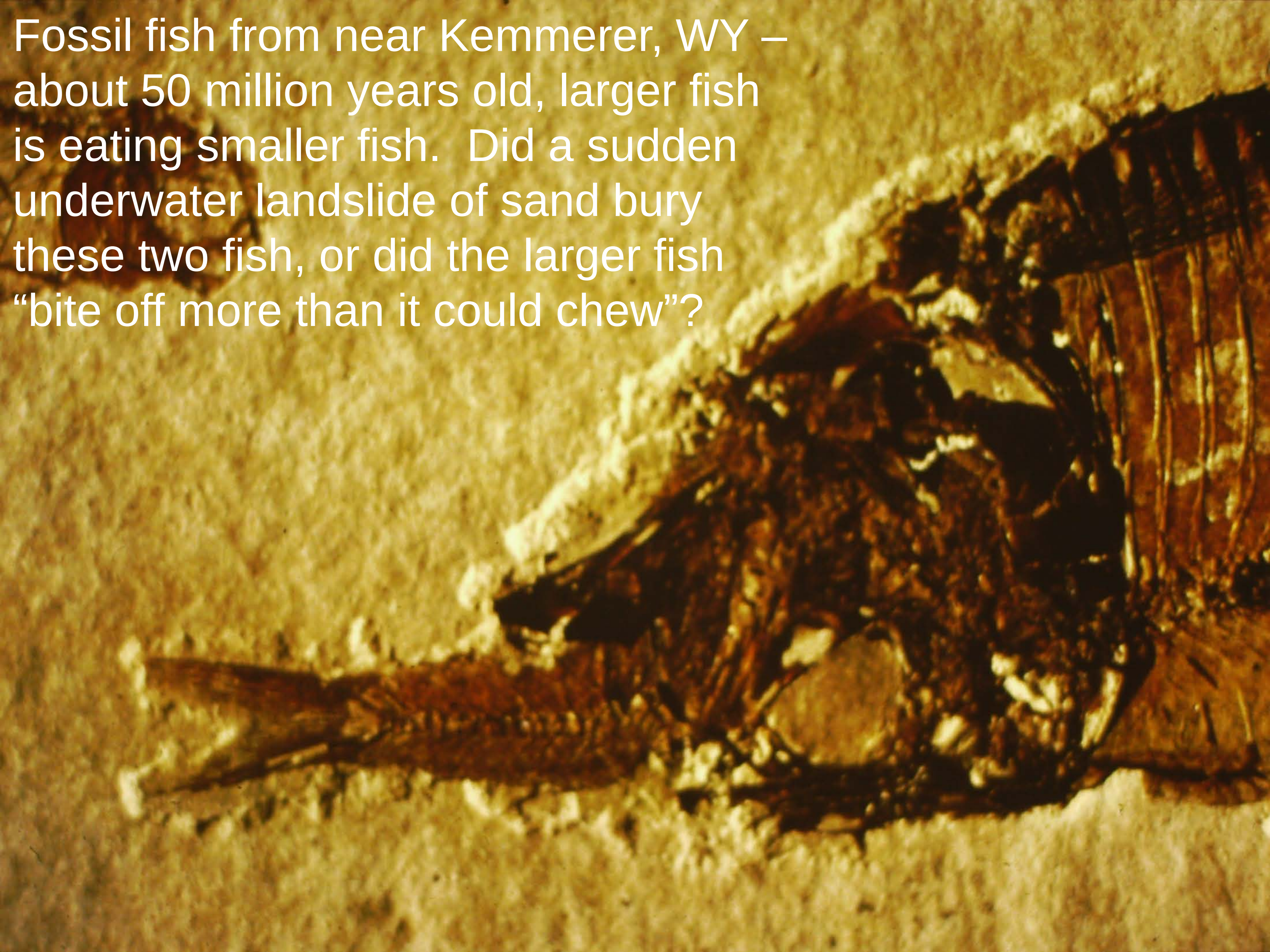
"An unconformity is a surface that represents a break in the rock record, caused by erosion or non-deposition."

Figure 8.13, text.



Some fossils are *index fossils* (widespread, distinctive, limited age range) and provide accurate age information for geologic units.

Fossil fish from near Kemmerer, WY – about 50 million years old, larger fish is eating smaller fish. Did a sudden underwater landslide of sand bury these two fish, or did the larger fish "bite off more than it could chew"?



Overlapping age ranges of fossils provides for age determination of sedimentary units and correlation of layers between widely spaced exposures.

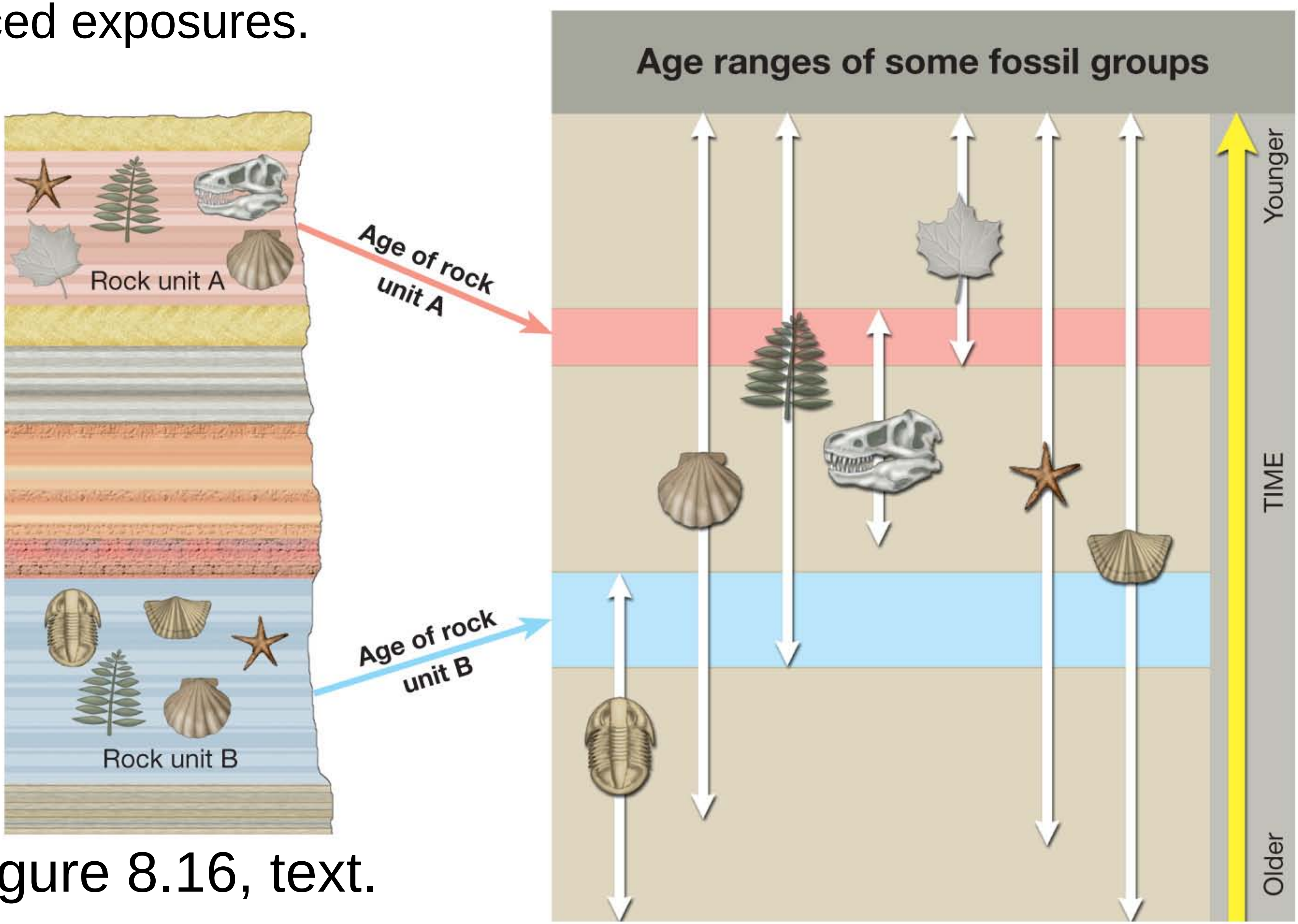


Figure 8.16, text.

Radiometric Dating – A method for determining the absolute age of material using the Carbon-14 (^{14}C) method (for organic material) or other radioactive isotopes (such as ^{40}K, ^{238}U, ^{87}Rb, and others) for rocks. The method uses the property of **half-life** which is controlled by the rate of spontaneous decay (***rate of decay***) of a radioactive isotope. The rate of decay can be simply measured in laboratory experiments.

Half Life – The **time** it takes for ***half*** of the radioactive isotope to decay (to the daughter product). The half life of Carbon-14 (^{14}C) is ~5700 years. The production of ^{14}C by natural processes on Earth is illustrated in Figure 8.20.

Radiometric Dating – See pages 284-287 in textbook for discussion of the radiometric dating method and radioactive isotopes. Some radioactive isotopes that are commonly used in age dating are shown in Table 8.1. Figure 8.19 illustrates radioactive decay (similar to the slides and discussion below). We will use the carbon-14 method for a tree to illustrate the method and the meaning of half life.

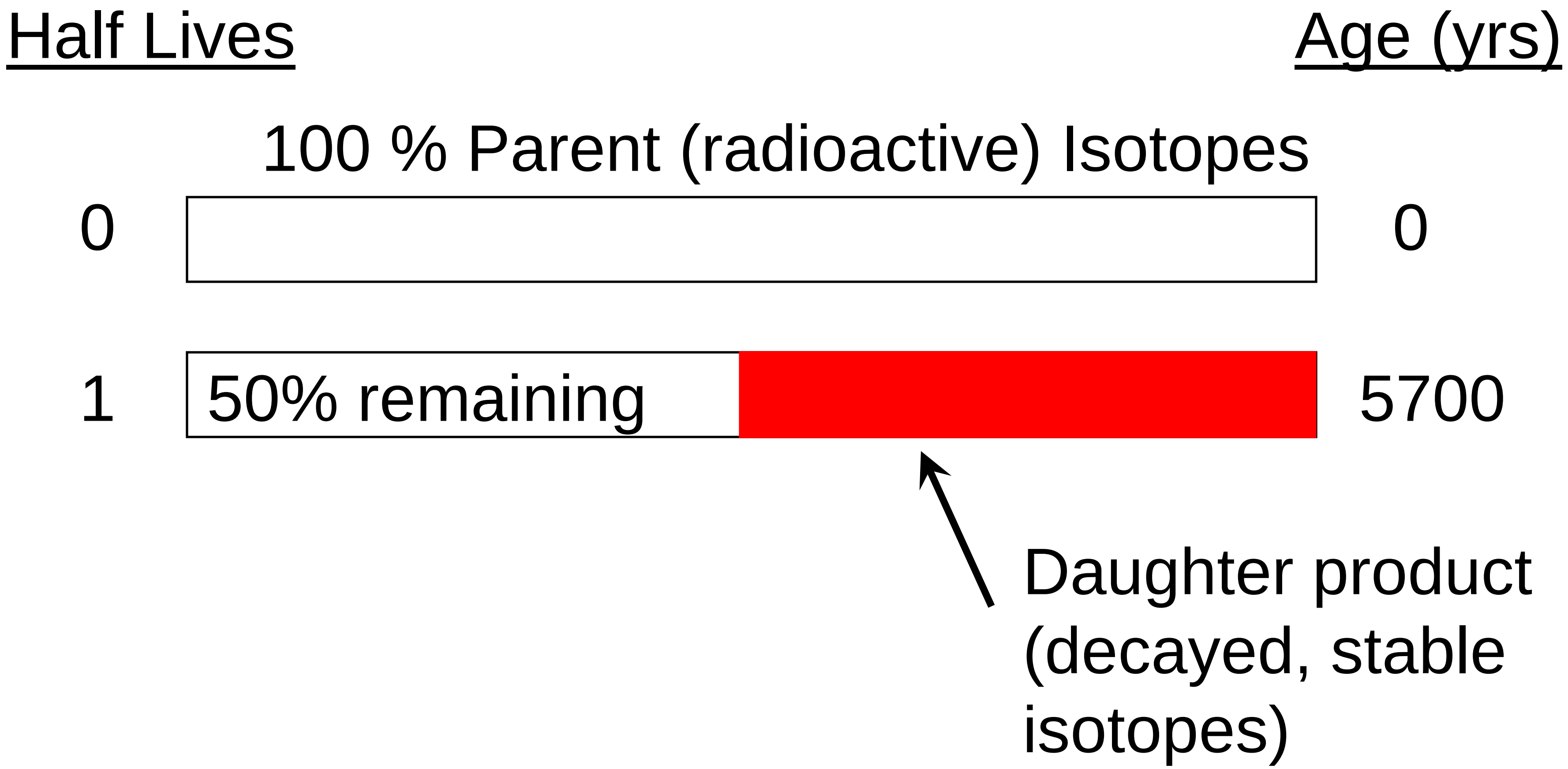
A living tree contains a small amount of ^{14}C (most of its carbon is the stable, not radioactive, form of carbon, ^{12}C). Because the live tree is interacting with its surroundings (water through the roots, transpiration in the leaves) the tree maintains an approximately constant amount of ^{14}C.

Illustration of the meaning of ***half life*** for a radioactive isotope (^{14}C parent, ^{14}N daughter product) with a half life of 5700 years

<u>Half Lives</u>		<u>Age (yrs)</u>
	100 % Parent (Radioactive) Isotopes	
0		0

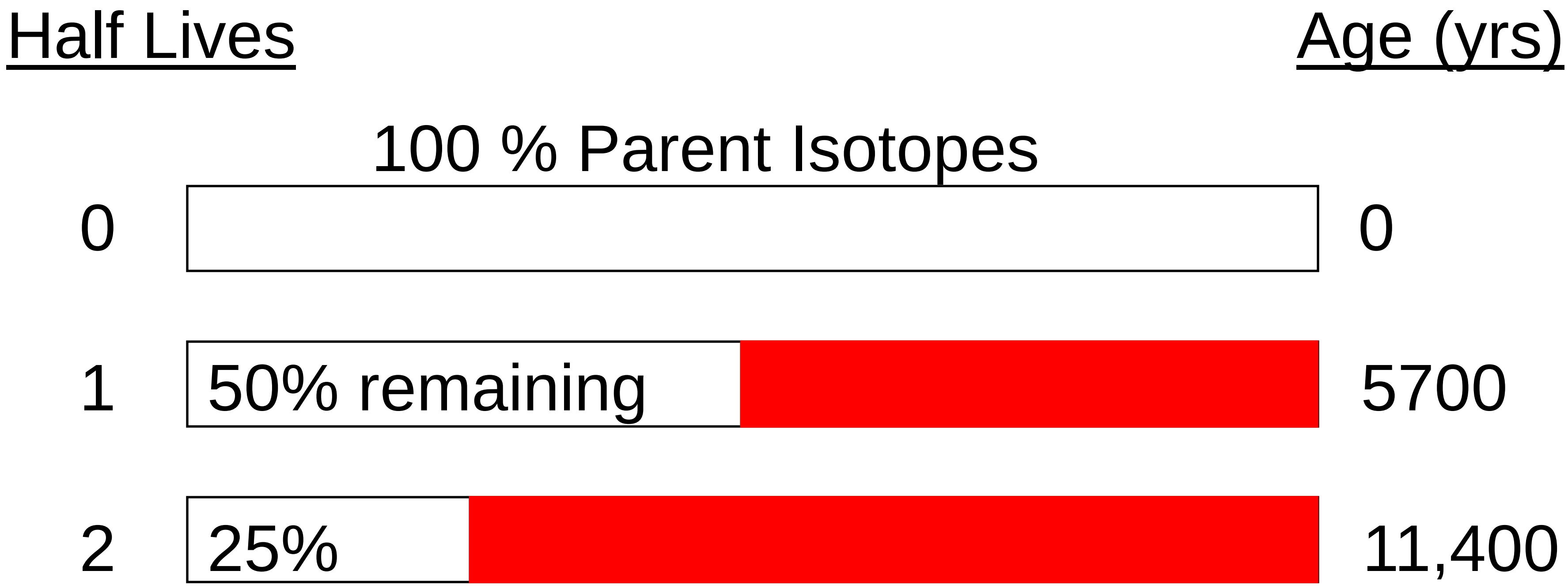
When the tree dies, falls down and is buried by sediments, it has a fixed amount of ^{14}C (we'll call it 100% for simplicity) and no longer interacts with its surroundings in the same way. This amount is shown by the partial bar graph above. Now the ^{14}C in the tree begins to radioactively decay and is not replenished from its surroundings.

Illustration of the meaning of ***half life*** for a radioactive isotope (^{14}C) with a half life of 5700 years



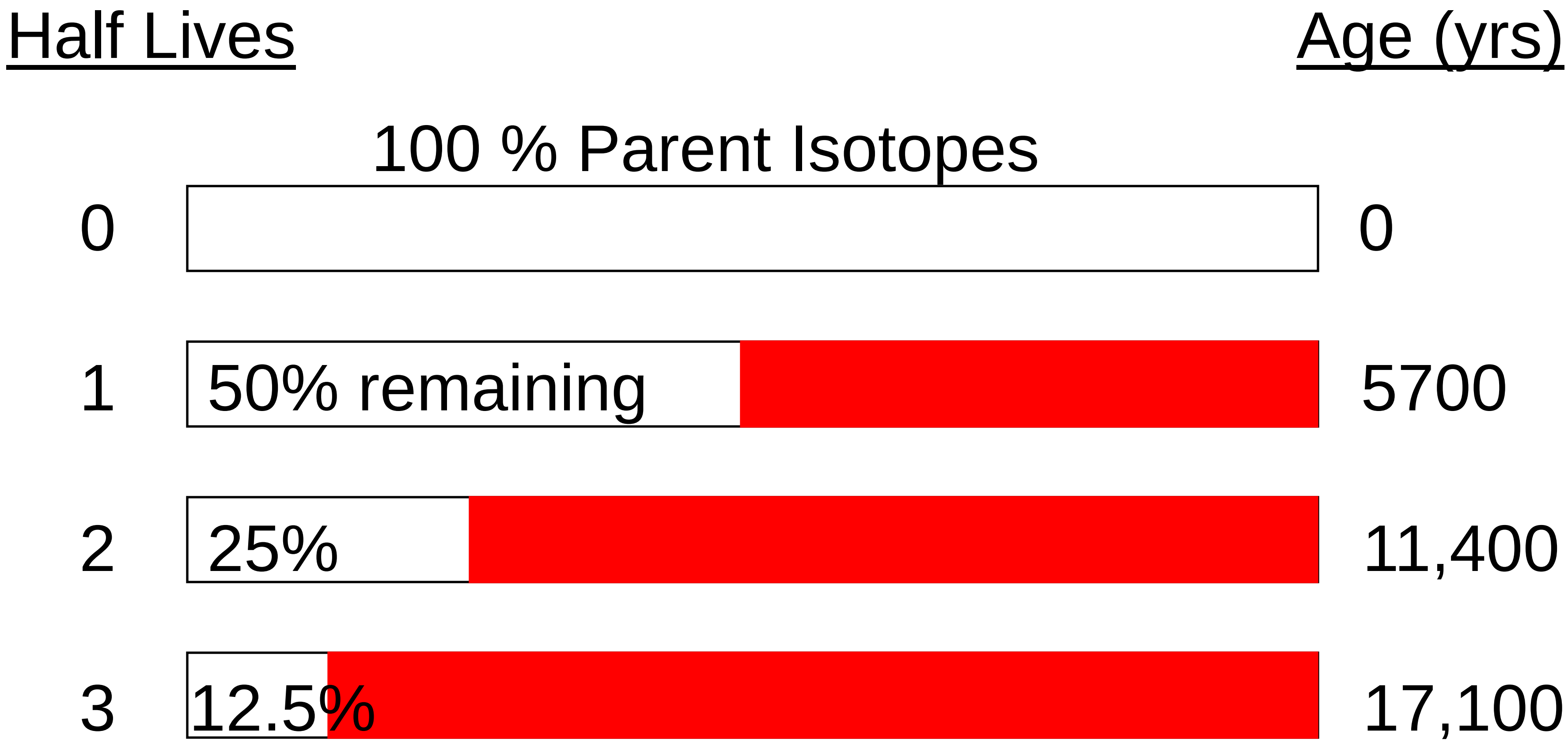
After one half life (~5700 years for ^{14}C), there is 50% of the original ^{14}C remaining.

Illustration of the meaning of ***half life*** for a radioactive isotope (^{14}C) with a half life of 5700 years



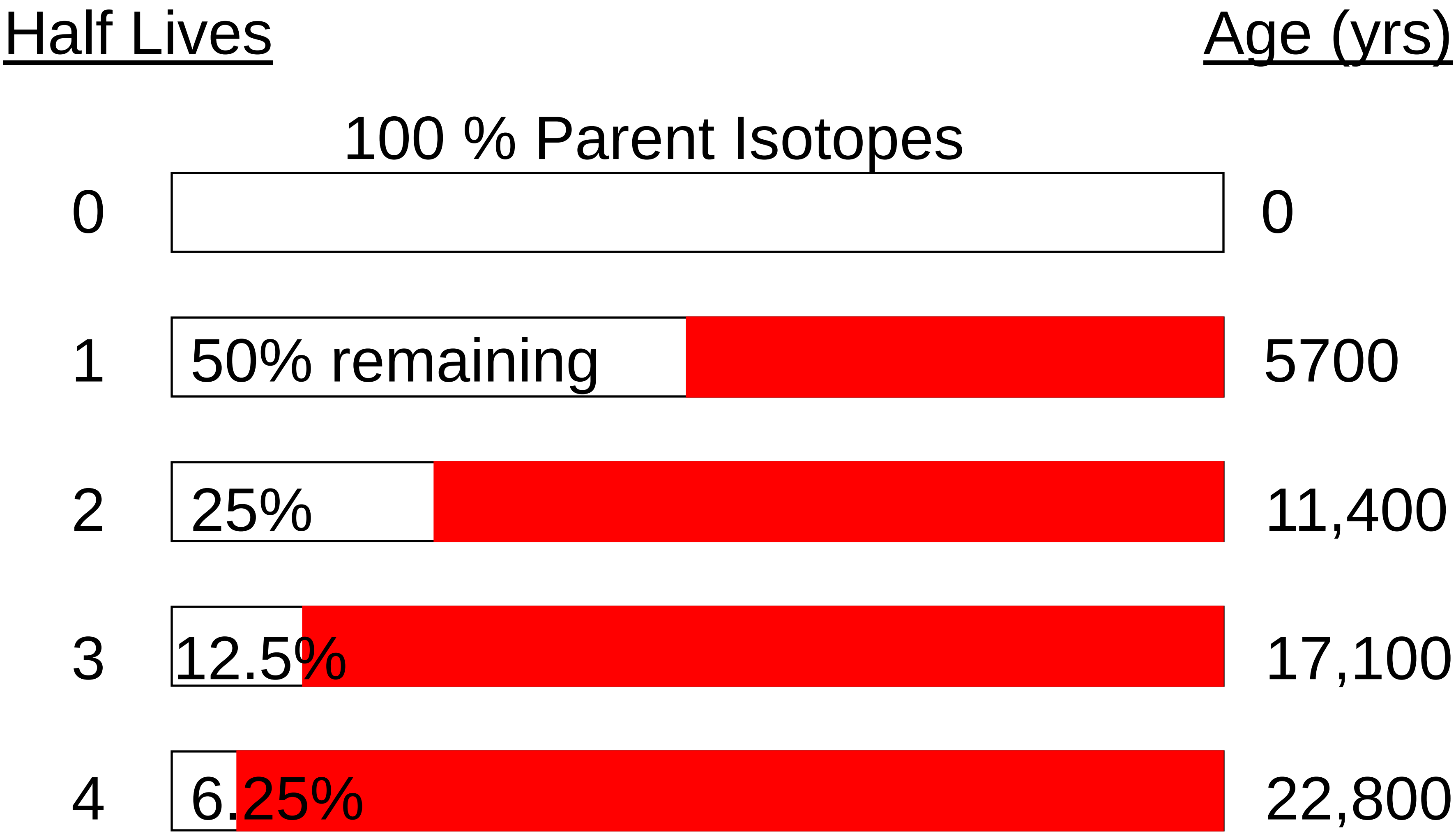
After two half lives (~11,400 years for ^{14}C), there is 25% of the original ^{14}C remaining. Because the number of ^{14}C isotopes has decreased, the number that decay in our sample in the second half life is less even though the rate of decay remains a constant.

Illustration of the meaning of ***half life*** for a radioactive isotope (^{14}C) with a half life of 5700 years



After three half lives, there is 12.5% of the original ^{14}C remaining.

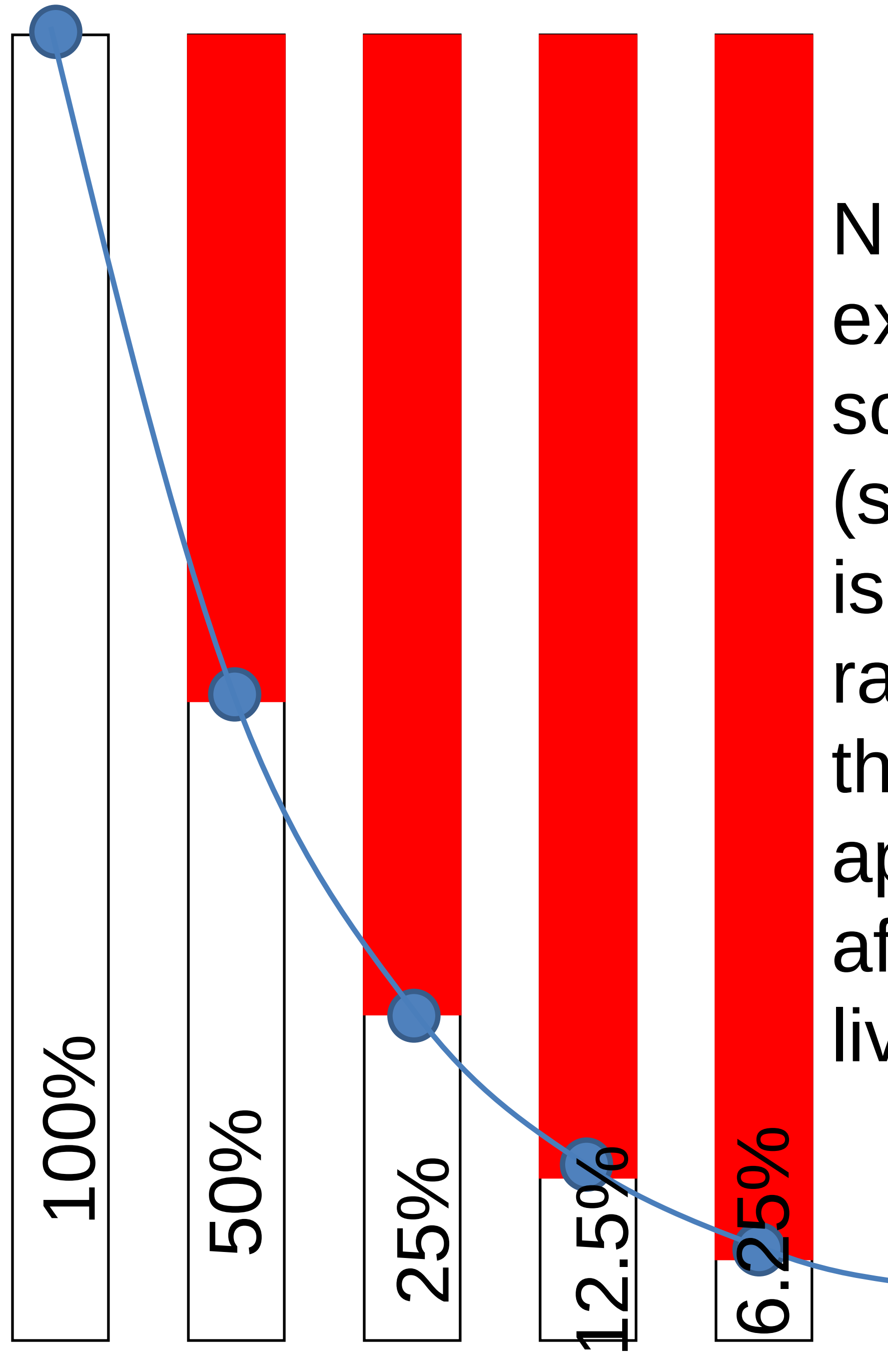
Illustration of the meaning of ***half life*** for a radioactive isotope (^{14}C) with a half life of 5700 years



After four half lives, there is only 6.25% of the original ^{14}C.

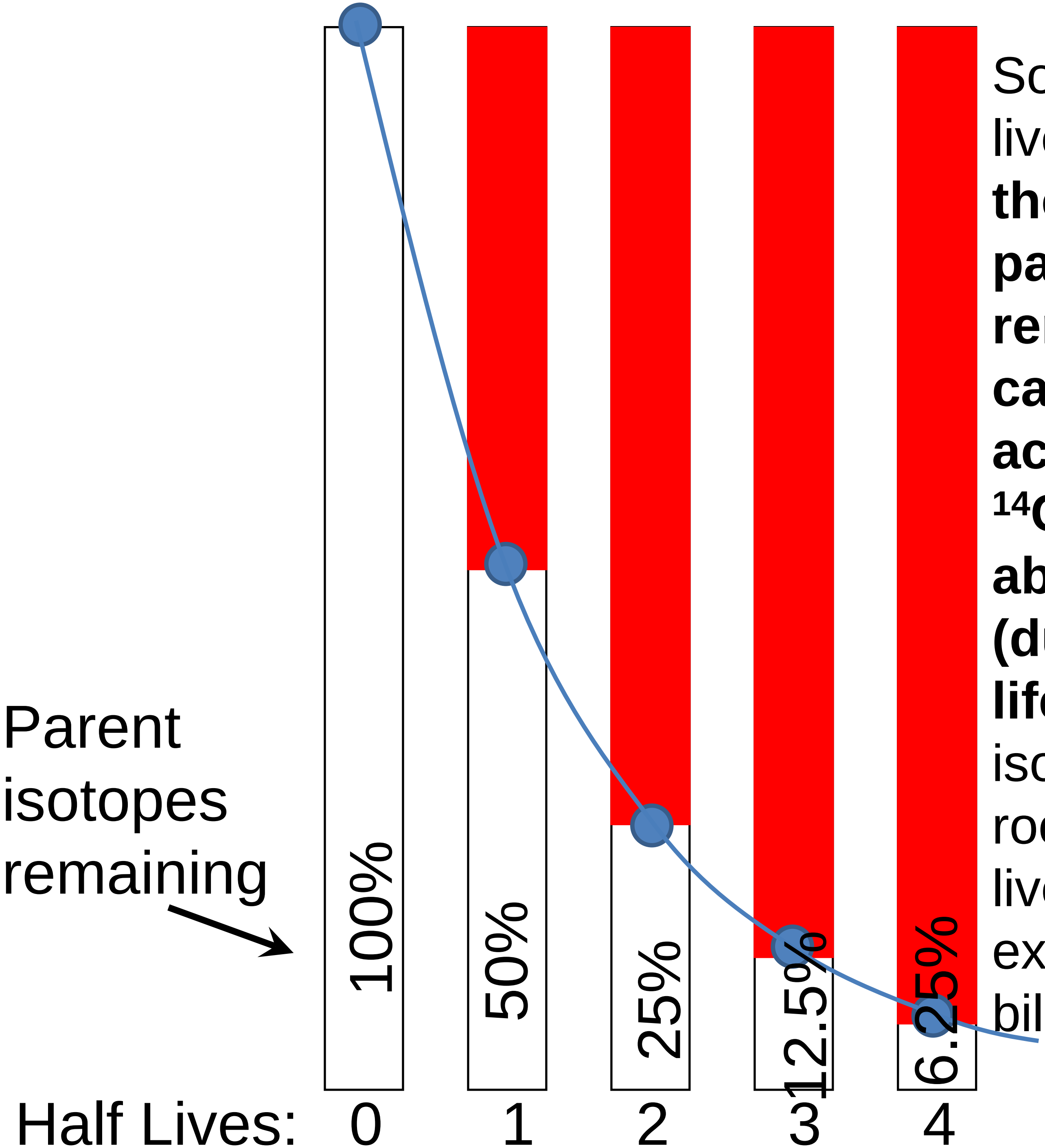
We turn this into a bar graph as shown here.

Parent isotopes remaining



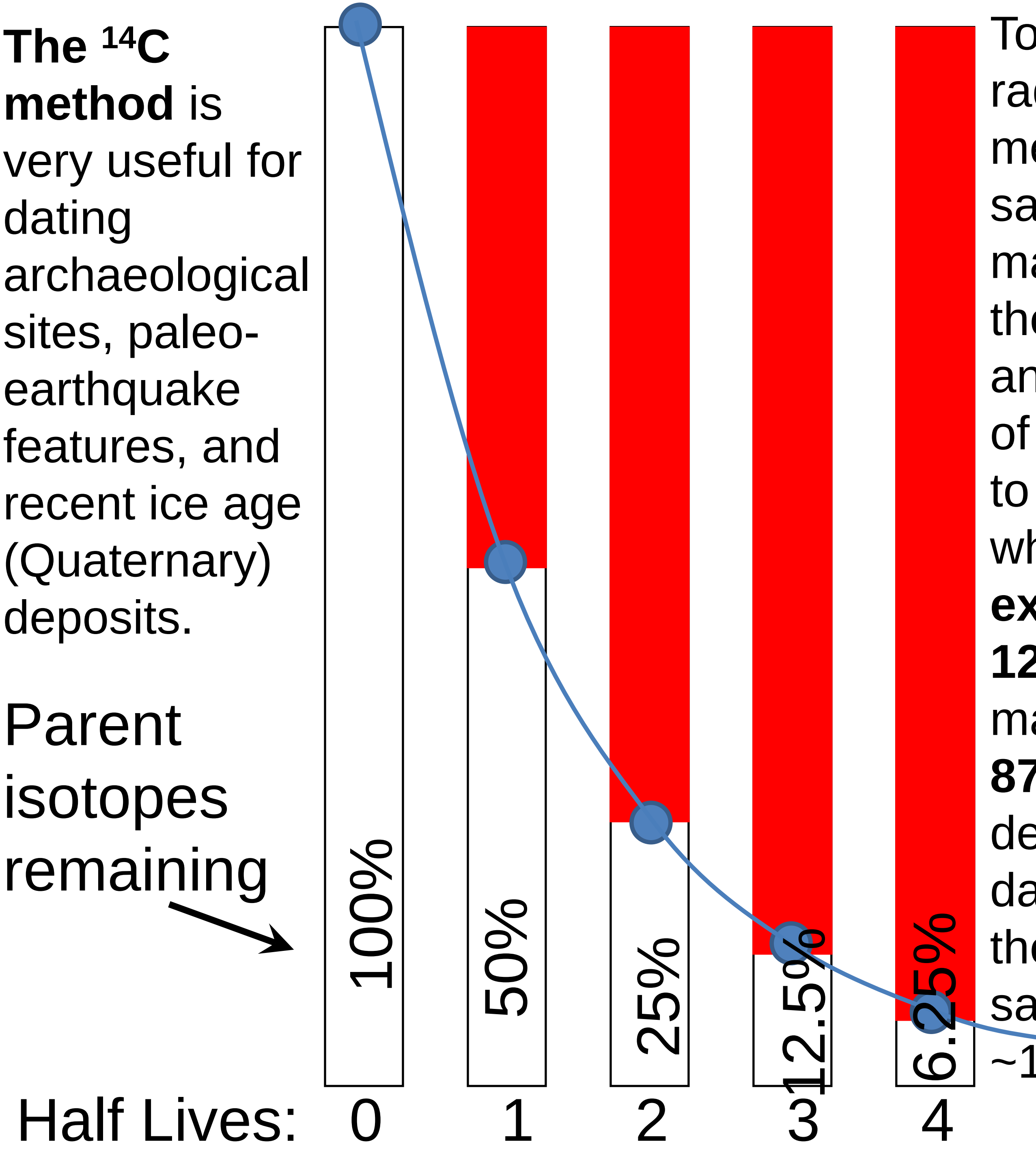
Half Lives: 0 1 2 3 4 Time →

Note that this is an exponential decay, so the % of parent (still radioactive) isotopes decreases rapidly with time, so the curve (blue line) approaches zero after many half lives.



So, after many half lives (say 10 to 15), **there is so little parent material remaining that it cannot be measured accurately**. **For the ^{14}C method, this is about 70,000 years (due to the short half life of ^{14}C).** For other isotopes (used for rocks, much longer half lives), age dating can extend back millions or billions of years.

The ^{14}C method is very useful for dating archaeological sites, paleo-earthquake features, and recent ice age (Quaternary) deposits.



To use the ^{14}C radiometric age dating method, we collect a sample of an organic material, such as part of the dead and buried tree, and measure the amount of ^{14}C remaining (relative to the amount it had when alive). **For example**, if there is **12.5%** of the ^{14}C parent material remaining (and **87.5%** of the ^{14}C has decayed into the daughter product ^{14}N), then the age of the sample is 3 half lives or ~17,100 years old.

Explanation of radioactive decay, half-life and radiometric age dating – see text for additional information.

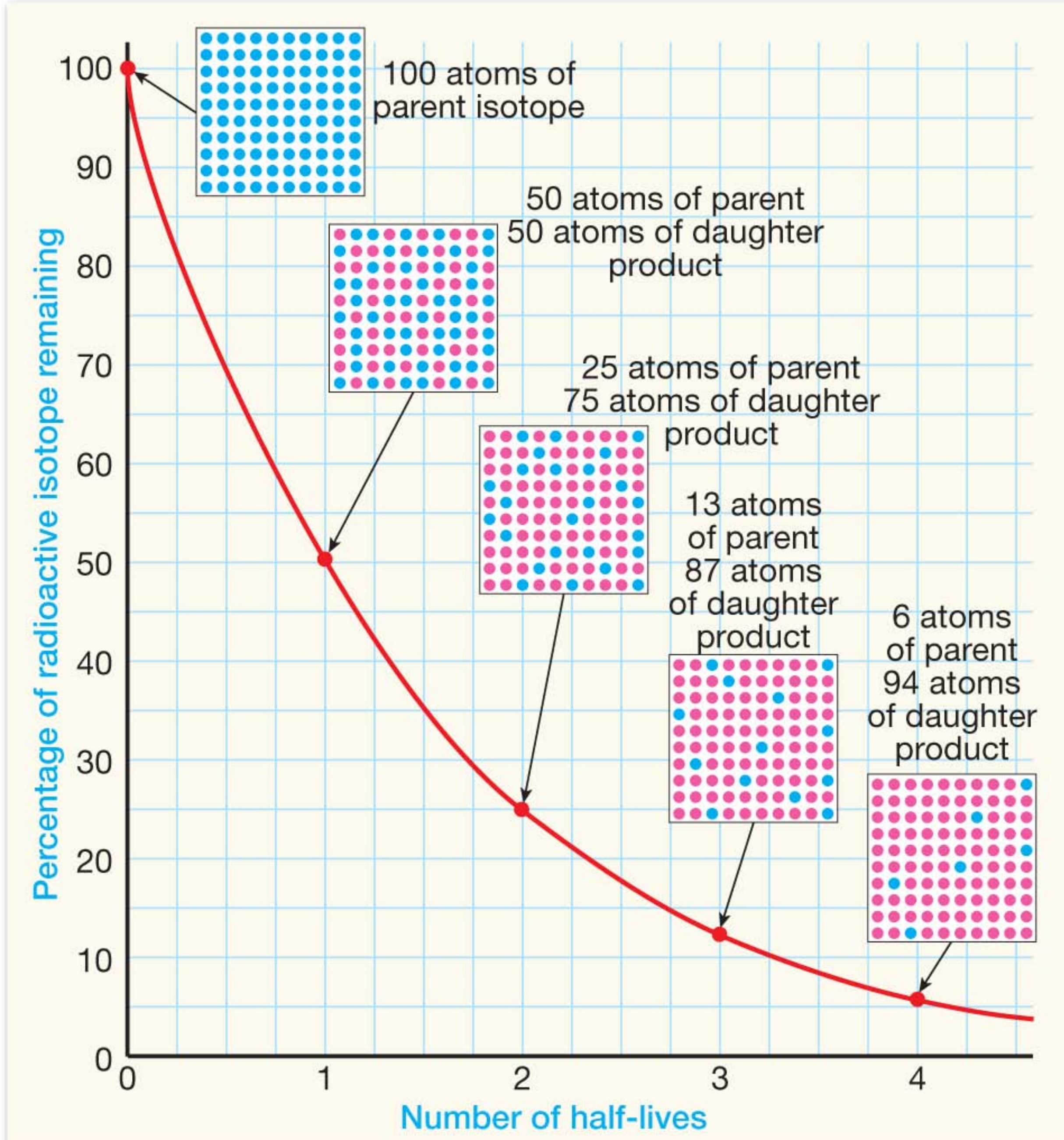


Figure 8.19, text.

Geological Time Scale

Geological Time Scale – rock age originally described by name based on locations (i.e. *Cambria* and *Devon* in England) of distinctive layers that could be observed or correlated (see Figures 8.14 and 8.16, text) over long distances. After radiometric age dating was developed, absolute ages have been determined for the geologic time periods.

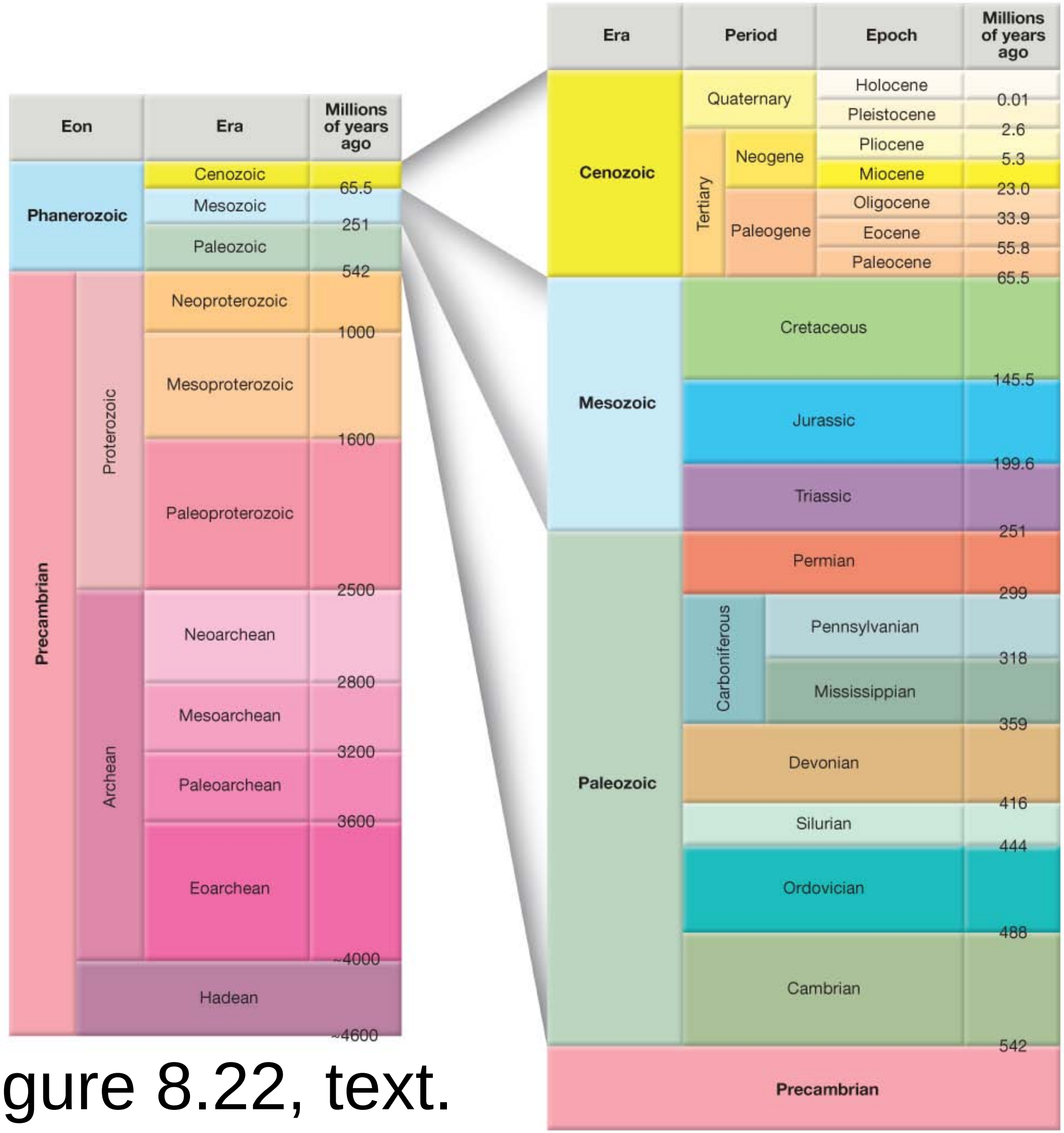


Figure 8.22, text.

Geological Time Scale

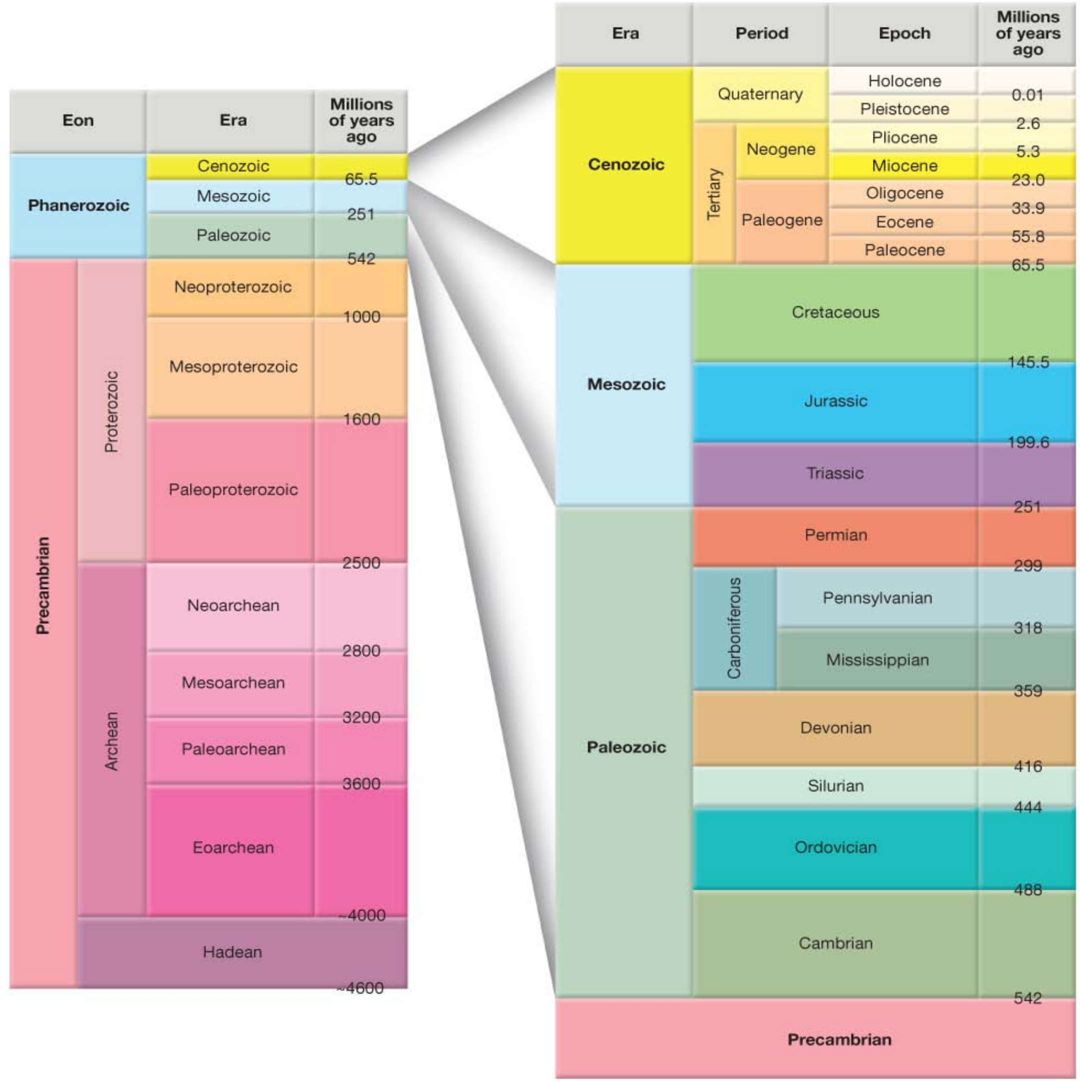
Geologic Time Scale – A simplified geologic time scale (useful for our purposes, and easy to remember) is:

Cenozoic ("young life")
0 to 65 mya*

Mesozoic ("middle life")
65 to 251 mya

Paleozoic ("old life")
251 to 542 mya

Precambrian**
542 to 4500 mya



* mya = millions of years ago

** Precambrian is the name used for the vast time period before the Cambrian which is the oldest major time unit of the Paleozoic

Figure 8.22, text

Please watch the animations: More information and illustrations of age dating concepts can be found in the following animations (developed by Pearson Prentice Hall for the Lutgens and Tarbuck textbook). To view, click on the following file names (swf files) in the **Week 4 folder** (the files will take several seconds to open; after the browser window opens, click on the PLAY button in the lower left hand corner; there is accompanying audio; the RelativeGeologicDating animation is less than 4 minutes in length; the RadioactiveDecay animation is about one and one half minutes long):

RelativeGeologicDating (similar to concepts in Figure 8.12, text)

RadioactiveDecay (similar to concepts in this PPT and Figure 8.19, text)