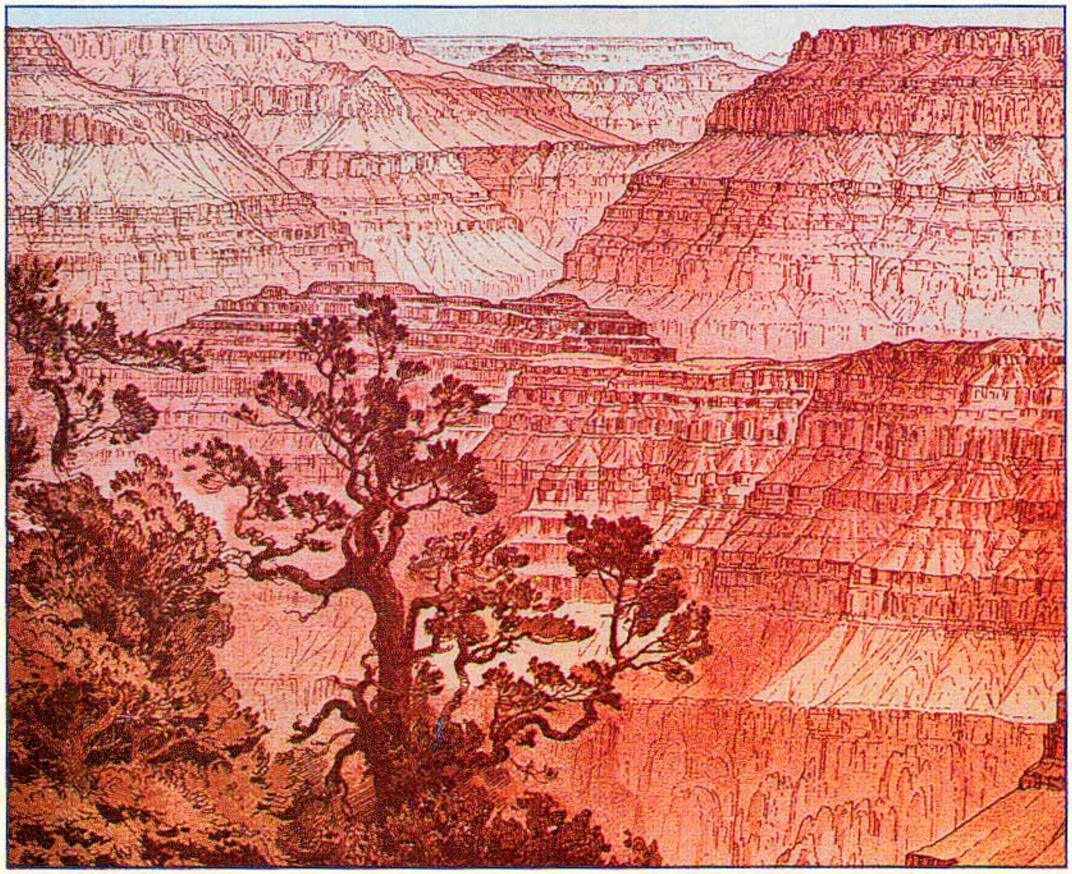
Teacher Feature GEOLOGIC TIME

The earth is 4.5 billion years old!

(give or take a million years)



Chromolithoghraph of the grand Canyon, by William Henry Holmes, 1982.

The earth is very old—4 1/2 billion years or more. This vast span of time, called geologic time by earth scientists, is difficult to comprehend in the familiar time units of months and years, or even centuries. How then do scientists reckon geologic time, and why do they believe the earth is so old?

The evidence for an ancient earth is concealed in the rocks that form the earth's crust and surface. The rocks are not all the same age—or even nearly so—but, like the pages in a long and complicated history, they record the earth-shaping events and life of the past. The record, however, is incomplete. Many pages, especially in the early parts, are missing and many others are tattered, torn, and difficult to decipher. But enough of the pages are preserved to reward the reader with accounts that certify that the earth is billions of years old.

The Relative Time Scale

At the close of the 18th century, careful studies by scientists showed that rocks had diverse origins. Some rock layers, containing clearly identifiable fossil remains of fish and other forms of aquatic animal and plant life, originally formed in the ocean. Other layers, consisting of sand grains cleaned by the pounding surf, formed as beach deposits that marked the shorelines of ancient seas. Certain layers are in the form of sand bars and gravel banks—rock debris spread over the land by streams. Some rocks were once lava flows or beds of cinders and ash thrown out of ancient volcanoes; others are portions of large masses of once-molten rock that cooled very slowly far beneath the earth's surface. Other rocks were transformed by such intense heat and pressure during the heaving and buckling of the earth's crust in periods of mountain building, that their original features were obliterated.

Between 1785 and 1800, James Hutton and William Smith advanced the concept of geologic time and strengthened the belief in an ancient world. Hutton, a Scottish geologist, first proposed the fundamental principle used to classify rocks according to their relative ages. He concluded, after studying rocks at many outcrops, that each layer represented a specific interval of geologic time. The bottom layer was deposited first and was, therefore, the oldest; each succeeding layer was younger.

Today, such a proposal seems elementary, but nearly 200 years ago, it was a major breakthrough in scientific reasoning. It established a rational basis for relative time measurements. However, unlike tree-ring dating—in which each ring is a measure of 1 year's growth—no precise rate of deposition can be determined for most of the rock layers. Therefore, the length of geologic time represented by any given layer is usually unknown or, at best, a matter of opinion.

William "Strata" Smith, a civil engineer and surveyor, was well acquainted with areas in southern England where "limestone and shales are layered like slices of bread and butter." His hobby of collecting and cataloging fossil shells from these rocks led to the discovery that certain layers contained fossils unlike those in other layers. Using these key or index fossils as markers, Smith could identify a particular layer of rock wherever it was exposed. Because fossils actually record the slow but progres-

Relative Time Scale

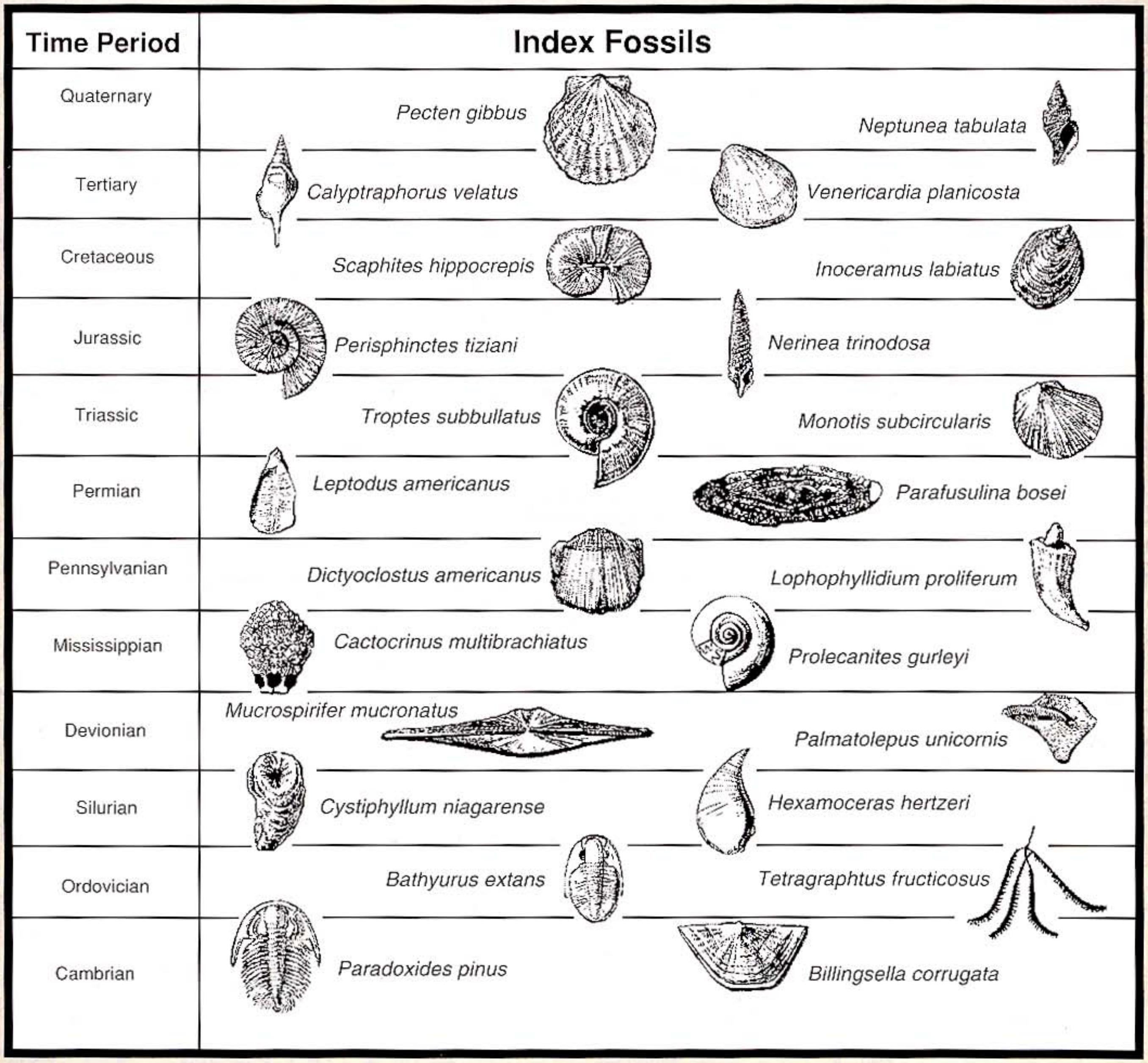
CENOZOIC ERA Age of Recent Life	Quaternary Period Tertiary Period	Originally geologic eras were named Primary, Secondary, Tertiary, and Quaternary. The first two names are no longer used; Tertiary and Quaternary are still used, but they are period designations.
MESOZOIC ERA Age of Medieval Life	Cretaceous Period	Derived from the Latin word for chalk (*creta*) and first applied to extensive deposits that form white cliffs along the English Channel.
	Jurassic Period	Named for the Jura Mountains between France and Switzerland where rocks of this age were first studied.
	Triassic Period	Taken from the Latin word *trias* in recognition of the threefold character of these European rocks.
PALEOZOIC ERA Age of Ancient Life	Permian Period	Named after the province of Perm, U.S.S.R. where these rocks were first studied.
	Pennsylvanian Period	Named for Pennsylvania where these rocks have produced a lot of coal.
	Mississippian Period	Named for the Mississippi River Valley where these rocks are well exposed.
	Devonian Period	Named after Devonshire, England where these rocks were first studied.
	Silurian Period Ordovician Period	Named after Celtic tribes, the Silures and the Ordovices, that lived in Wales during the Roman Conquest.
	Cambrian Period	Taken from the Roman name for Wales (Cambria) where rocks containing the earliest evidence of complex forms of life were first studied.
PRECAMBRIAN	— — — — — —	The time between the birth of the planet and the appearance of complex forms of life. More than 80 percent of the earth's estimated 4 1/2 billion years falls within this era.

This relative time scale is arranged in chronological order—the oldest division at the bottom, the youngest at the top.

sive development of life, scientists use them to identify rocks of the same age throughout the world.

From the results of studies on the origins of the various kinds of rocks (petrology), coupled with studies of rock layering (stratigraphy) and the evolution of life (paleontology), geologists reconstruct the sequence of events that has shaped the earth's surface. Their studies show, for example, that during a particular episode the land surface was raised in one part of the world to form high plateaus and mountain ranges. After the uplift of the land, the forces of erosion attacked the highlands and the eroded rock debris was transported and redeposited in the lowlands. During the same interval of time in another part of the world, the land surface subsided and was covered by the seas. With the sinking of the land surface, sediments were deposited on the ocean floor. The evidence for the pre-existence of ancient mountain ranges lies in the eroded rock debris. Proof of ancient seas is, in part, from the marine fossils that accumulated with the bottom sediments.

Material taken from Geologic Time *by William L. Newman, U.S. Geological Survey, 1996.*



Time Period	Index Fossils	
Quaternary	*Pecten gibbus*	*Neptunea tabulata*
Tertiary	*Calyptraphorus velatus*	*Venericardia planicosta*
Cretaceous	*Scaphites hippocrepis*	*Inoceramus labiatus*
Jurassic	*Perisphinctes tiziani*	*Nerinea trinodosa*
Triassic	*Troptes subbullatus*	*Monotis subcircularis*
Permian	*Leptodus americanus*	*Parafusulina bosei*
Pennsylvanian	*Dictyoclostus americanus*	*Lophophyllidium proliferum*
Mississippian	*Cactocrinus multibrachiatus*	*Prolecanites gurleyi*
Devionian	*Mucrospirifer mucronatus*	*Palmatolepus unicornis*
Silurian	*Cystiphyllum niagarense*	*Hexamoceras hertzeri*
Ordovician	*Bathyurus extans*	*Tetragraphtus fructicosus*
Cambrian	*Paradoxides pinus*	*Billingsella corrugata*

Keyed to the relative time scale are index fossils, the forms of life that existed during limited periods of geologic time. They are used as guides to the age of the rocks in which they are preserved.