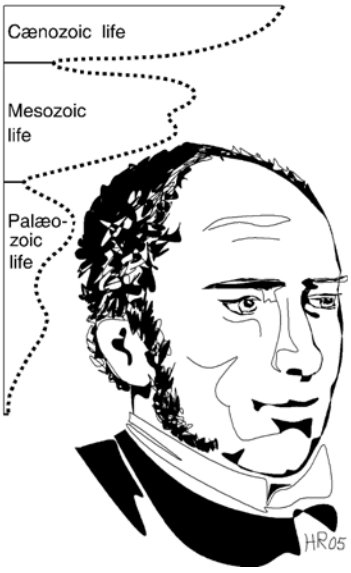
c22 Eons and Eras < major extinctions, Precambrian unconformities >

> It is important in correlation to discriminate between what is correlated (rocks, fossils, surfaces, time), what is demonstrated (physical continuity, similarity, difference), and what is inferred (kinds of similarity or difference). —Preston Ercelle Cloud (1912-1991), *Adventures in Earth History*.[1]

By 1840, the revolution of using fossils, and not lithological appearance, for defining and ordering systems in England was essentially complete. Grossly incomplete, however, was that sedimentary strata older than Precambrian were thought not to exist. (The then known systems of sedimentary strata, collectively of the Phanerozoic Eon, named in 1930, are now known to have accumulated during the *last ninth* of geologic time.) Periods are durations of time that rock systems make real. For worldwide correlations, attention necessarily turns to fossils. Only the Carboniferous System survived the revisions and still designates the period. To establish periods rather than systems had become the rage. Many were proposed. The Permian Period was named by Murchison in 1841 for fossiliferous sequence in the far-off Russian province of Perm.[2] Some others survive locally, as in America where near-equivalents of the Upper and Lower Carboniferous of the standard modern geologic column were named respectively the Pennsylvanian Period (for coal-bearing rocks in Pennsylvania) by **Henry Shaler Williams** (1847-1918) in 1891,[3] and the Mississippian Period (for rocks exposed in the upper Mississippi River drainage basin) by Alexander Winchell (1824-1891) in 1870.[4]

In England & Wales, fossils had been used, beginning in 1815, to successfully subdivide the Wernerian formations: Alluvial, Flötz, and Transition. That those broad subdivisions were reliable time-units was noted to be false by William Phillips (1773-1828) by 1818.[5] Recognition of the periods showed that Werner's formations had different ages in different parts of Europe. The refutation of Werner's universal formations as meaningful time-units had involved their subdivision. What was gained was the recognition of periods. As these were many more than the three Werner formations that they replaced, William Smith's nephew, **John Phillips** (1800-1874)—orphaned at age seven, raised and trained in stratigraphical geology by his uncle William Smith, was Keeper, Yorkshire Philosophical Society museum, 1825-40, Assistant secretary, British Association for the Advancement of Science, 1832-62, Professor of geology, King's College, London, 1834-40, elected FRS, 1834, Palaeontologist, Geological Survey of Great Britain, 1840-4, Deputy reader in geology, Oxford University, 1853, and Professor of geology there, 1860-74 (when tippled after dinner he broke his crown in a fall down stone stairs at All Souls)—beginning in 1838,[6] decided that by first grouping periods to reveal true gross fossil differences, these "larger units" could then (by the fossil counting method that Lyell had used to subdivide the Alluvial—although problematic and later abandoned as "lumpers" and "splitters" could never agree on percentages of extant and extinct species)[7] be subdivided for *regional* correlations on "statistics" of differences of "fossil assemblages" and not on "characteristic" fossils (that his uncle William Smith had used) which are best used for *local* correlations.



In 1840, J. Phillips formally proposed three *eras*: Cænozoic (new life: from Gk. *Kainos* recent, Gk. *zoon* animal) "The Age of Mammals" for when they were ascendant, Mesozoic (middle life) "The Age of Reptiles" (echoing Mantell's descriptor for the "Secondary" era) for when they were ascendant, and Palæozoic (old life) "The Age of Fishes" for when marine creatures were ascendant.[8]

A **plot of life's marine diversity** shown in Phillip's *Life on the Earth: Its Origin and Succession*, 1860, shows much extinction of life between eras but overall, life's diversity acceleratingly increases. When J. Phillips published in 1841 on his study of the Palaeozoic fossils of Devon, Cornwall and West Somerset, his Paleozoic consisted of three periods: Carboniferous, Devonian (?), and Silurian (Sedgwick doubted the existence of the Devonian and had—until 1852—given up on saving his "Cambrian" from being incorporated into Murchison's Lower Silurian).[9] Had the Ordovician been recognized, and the status of the Cambrian been restored—their time subtracted from the Silurian makes it the briefest of all the periods—and had the Permian been described, would Phillips have named two eras instead of the one he named the Palaeozoic in 1840? Even as late as 1860,[10] Phillips was steadfast in his and his late uncle's belief that the appearance of new species and discontinuities in the fossil record were evidence of separate creations,[11] these being "inscrutable" (thank you very much Darwin, and, by 1866, Lyell too) acts of God.[12]

What can be said of the eras? By definition, a geologic era is a geologic time-unit that includes two or more periods. The three eras that Phillips recognized were justified by him because life was overall different in each. That is so because the boundary between each is in fact a time of mass extinctions and it so happened that evolution had prepared organisms that were waiting for opportunities. That is *two* mass extinction events are emphasized: the one between the Cenozoic and the Mesozoic known as the K/T (Cretaceous/Tertiary) or in this book the E-K (Paleogene-Cretaceous)[13] boundary, and the one between the Mesozoic and the Paleozoic. However, in the time (541 million years) that the fossiliferous periods cover, those mass extinction events are but two of seven of like magnitude and are among many other lesser, but notable, ones.[14]

In short, the grouping of the periods into the eras and the designation of erathems (time-stratigraphic units of era duration in a locality, the suffix *-them* from Gk. *thema* meaning "something laid down") which was recognized in 1967 by the American Commission on Stratigraphic Nomenclature, is a convenience (*see* Topic *c23*). The preference is also to relegate to history, terms for geologic time divisions that are no longer meaningful. Early Paleozoic and before replace Primary), Late Paleozoic thru Mesozoic replaces Secondary, Paleogene and Neogene replace Tertiary as formal subdivisions of the Cenozoic. So now Quaternary appears anomalous, and for the same are proposed Anthropogene (often in use in the ex-USSR) or Pleistogene.[15]

Adjectives applied to subdivisions of chronostratigraphic (rock) units are: upper, middle, and lower, and equivalent subdivisions of geochronologic (time) units are (confusingly): late (for younger), middle, and early (for older)—so for time, where possible, use: upper, middle, and lower.

The Cretaceous Period is divided into Upper & Lower epochs. The Paleozoic erathem (as no middle sub-erathem is formally recognized) is divided into two sub-erathems: Upper Paleozoic (Permian, Carboniferous, & Devonian) and Lower Paleozoic (Silurian, Ordovician, & Cambrian).

For purposes of discussion, it is useful to have the continuum of geologic time broken into various durations that others agree to recognize. However, the era designations are historical artifacts with no significance other than they are. This is particularly so as Phillip's proposal, which has stuck, was made when opinions were widely divided over whether evidence in the fossil strata was for progression, and hence transmutation, or not. To decide, the replies to a circular letter from A. Hume to the leading men of science of the day (1845) were put in open forum, for free discussion, at the Liverpool Public Library. These "evidences," to which "it is surely unnecessary to add anything" decided nothing. James A. Secord in *Victorian Sensation* notes the remarks published in the *Liverpool Journal*, March, 1845, by a writer identified only as "A Mining Engineer" that "Hume's correspondents were split on geological progression; Murchison, Mantell, and James Bryce (an old Belfast friend of Hume's) defended a general picture of life's advance on Earth, while Lyell (yet to be persuaded differently as he would be by Darwin) undermined it, believing that all the major fossil groups extended back to the earliest strata. Known from the 'Age of Reptiles' strata, for example, is the Stonefield opossum, a tiny mammal jaw. Buckland's letter, moreover, was not really about general issues of progress but about specific instances of degeneration—claiming, for example, that very early reptiles were of a higher type than more recent ones."[16]

So extinctions were an accepted reality. But the fossil record was variously explained:

Creationist progressivists as Smith, Buckland, Sedgwick and Phillips, held that life's variety is under construction and distinctive assemblages have been harmonious in their variety of forms ("Fish first appear in the same strata as the first early invertebrates"—Buckland) created for changing conditions at Earth's surface.

Stochastic progressivists as Lyell and Murchison, held that life was initially in all its variety but that simpler forms, then more numerous, were displaced or went extinct in a scattershot way (*stochastic* means *random* and is from the Greek word for *aiming*) as conditions (the climate, the emergence and elevation of the land, and so on) changed and so more advanced forms become proportionately more numerous as younger strata are sampled. Bias is that more advanced forms (as say land mammals), by virtue the environments in which these lived, are not usually fossilized, and erosion has worked at all times to remove terrestrial (land) and continue marine accumulations. Geological progression and progressive development are not synonymous: often according to Murchison the "most elaborately formed and highly organized" forms were "the first created of their classes" and "every portion of geological evidence sustained the belief that each species was perfect in its kind when first called into being by the Creator."

Transmutationalist progressivists as Robert Chambers, the anonymous author of *Vestiges* (its narrative theme: "the universal gestation of nature," being that "animals are capable of being improved, through a succession of generations [in parallel lines through a predetermined sequence of stages within each family][17], by the constant presence of a meliorating agency"), and William Ewart Gladstone who opined that "the dust of the earth out of which Adam" had been created could have passed though many pre-Adamic forms, were for evolution of the more complex from the less complex.

All the above require the miraculous. The last threatens humankind's special status. In 1845, John Frederick William Herschel (1792-1871) could worriedly discount it as a "mere speculative law of development" (his telescope-making astronomer father, Friedrich Wilhelm Herschel (1738-1822) had cherished a belief that inside Sun and on Moon were intelligent creatures).[18] This would change when Darwin was heard from in 1859 and gave the same generalization explanatory power, namely: the origin of species and varieties though natural selection. In 1866, Lyell publicly declared for evolution but his prior dismissal of the notion was carried forward by such as the influential Acadian geologist John William Dawson (1820-1899)[19] (who also rejected Agassiz's explanation of moraines and the striated bedrock that underlay these, as evidence of an Ice Age—but for the good reason that the flow of ice sheets was then an unknown).[20] Geologic time spanning all the periods recognized by their fossil content accounts for the most recent ninth of geologic time (***Figure c22.1***). Time before, when the standard geologic column was first put together, was an unfathomable void to geologists.

Geologists who did come to map and study the seemingly unfossiliferous rocks of Precambrian age, organize these of the Azoic Era (J. Phillips's name for the "time of no life")[21] into a chronology on the observational criteria of lithology (Wernerian thinking) and angular unconformities. Two eons named for the Precambrian are: the Proterozoic (traces of life) named by Samuel Franklin Emmons in 1888 and the Archean (ancient) named by James Dwight Dana in 1872.[22] Only well into the last century did radiometric techniques allow a subdivision of these eons into eras of limited and local significance. The Precambrian time, called the *Cryptozoic* ("hidden life") Eon (name proposed by Charles Schuchert and Carl Owen Dunbar in 1933)[23] includes the Proterozoic Eon and the, older, Archean Eon. Earth, as part of the solar system, can be reasoned to have originated earlier. That time, for which there is no Earth rock record, is called the *Hadean* (after the ancient Greek god of the underworld) Eon. All time before is antemundane (occurring, or existing, before the creation of the world).❑

Eon	Era	Period	Epoch
Phanerozoic	Cenozoic	Pleistogene	Holocene
			Pleistocene
		Neogene	Pliocene
			Miocene
		Paleogene	Oligocene
			Eocene
			Paleocene
	Mesozoic	Cretaceous	
		Jurassic	
		Triassic	
	Paleozoic	Permian	
		Carboniferous	
		Devonian	
		Silurian	
		Ordovician	
		Cambrian	

Figure c22.1 **Phanerozoic Eon time subdivisions** (Gk. *phaneros*, visible or apparent, *zoion*, animal life) —name widely purported [24] to have been coined in 1930 by George Halcott Chadwick (1876-1953). All of geologic time before, physically recorded by Earth rock, is the Cryptozoic (Gk. for "hidden life") Eon. The geologic column is a triumph of Baconian "induction which takes experience apart and analyzes it, and forms necessary conclusions on the basis of appropriate exclusions and rejections."[25]