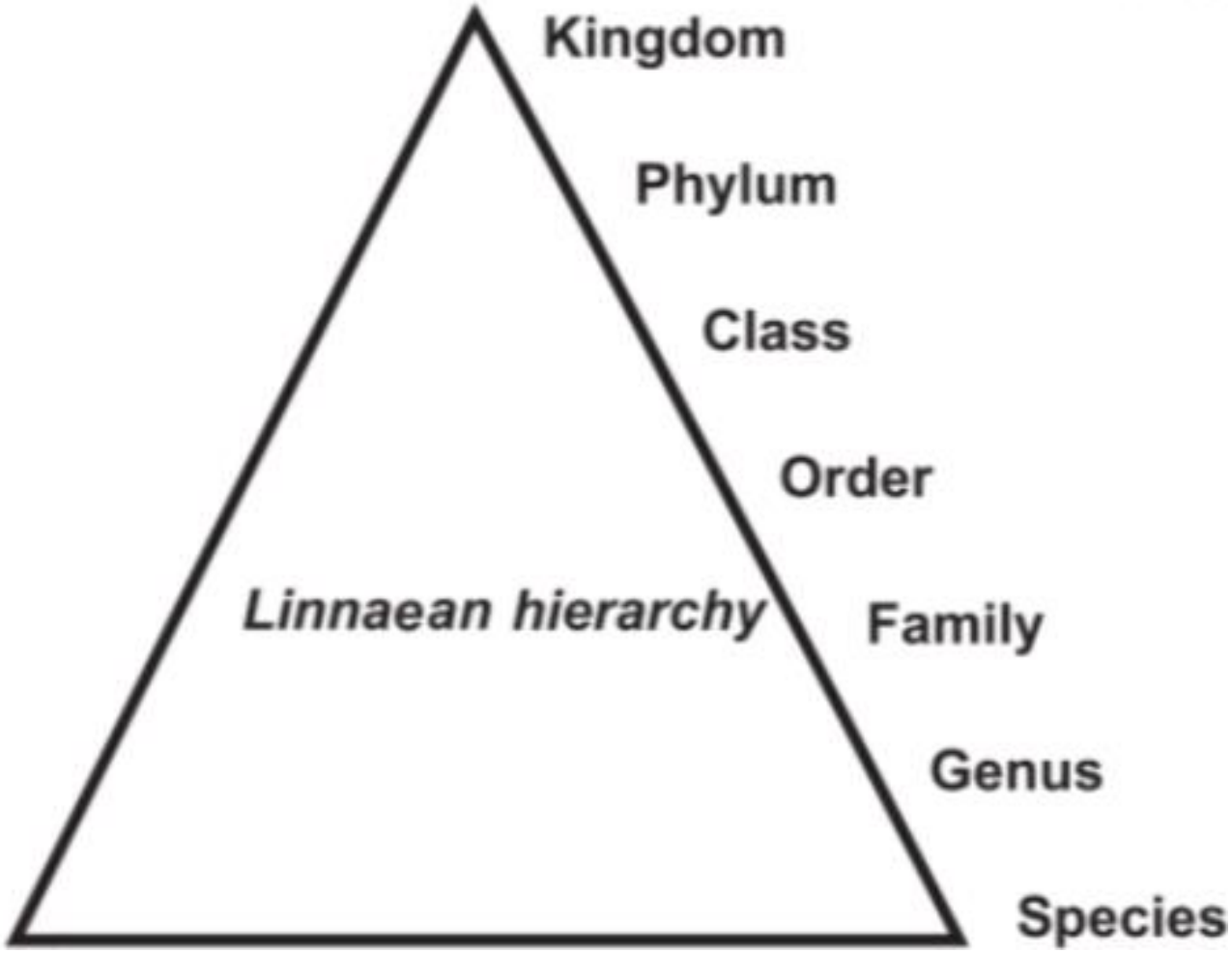
GGY 3030 LECTURE 3
BIOSTRATIGRAPHY

PRINCIPLES OF BIOSTRATIGRAPHY

- A ***biostratigraphic unit*** is a body of rock defined by its fossil content.
- The fundamental unit of biostratigraphy is the *biozone.*
- *Biozones* are units of stratigraphy that are defined by the zone fossils (usually species or subspecies) that they contain. In theory, they are independent of lithology
- Biozones are named from the characteristic or common taxon (or occasionally taxa) that defines the biozone.



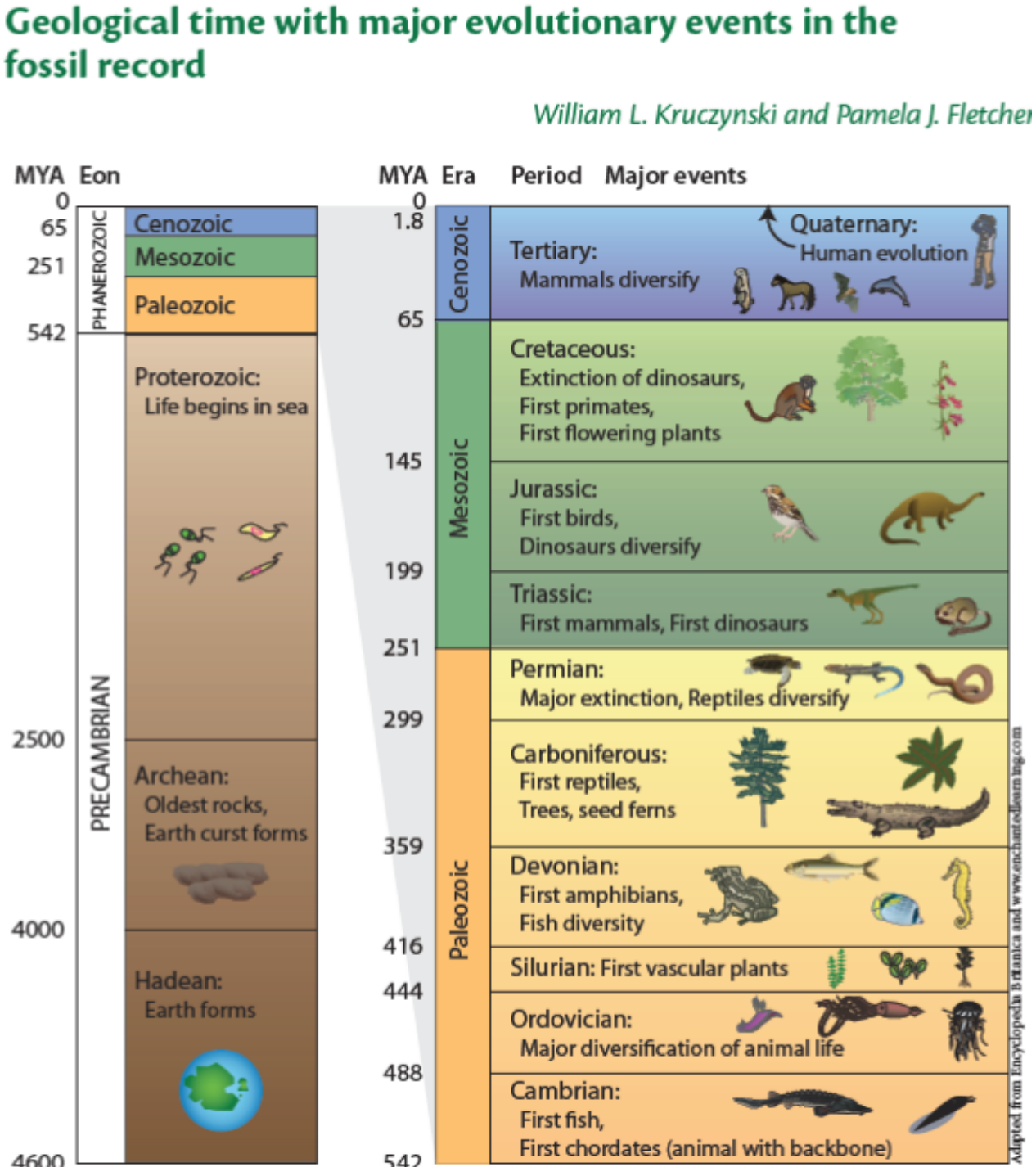
CLASSIFICATIONS OF ORGANISMS

- ***Species*** are groups of interbreeding organisms that are reproductively isolated from other groups
- A ***genus*** (plural genera) is a group of species that are closely related. E.g. when an organism is named it is given a genus as well as a species: for example *Homo sapiens* is the Linnaean classification name for the human species.
- The higher ranks in the hierarchy are *family, order, class, phylum* and *kingdom* in order of scale (Refer to first slide).
- The major phyla (*Mollusca*, *Arthropoda*, etc;) have existed through the Phanerozoic and it is possible to compare fossils to modern representatives of these subsets of the main kingdoms (animal and plant).
- The *ammonites*, for example, formed a very large and diverse order from Ordovician to Cretaceous times
- The *graptolites* are commonly found in Palaeozoic rocks

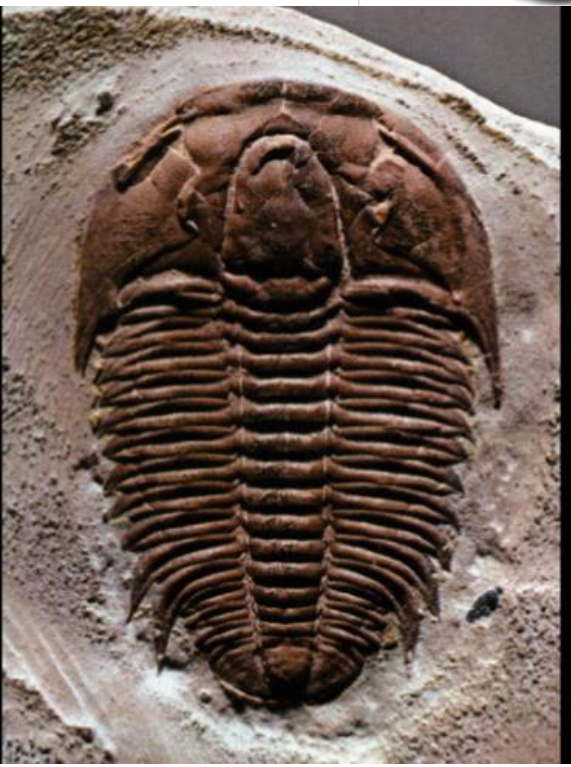
CHANGES IN SPECIES THROUGH TIME

- All indications from the geologic record suggest that species variations are *one-directional and nonreversible*. Once a species has become *extinct*, it does not reappear in the fossil record.
- As members of a new species increase in numbers, they may eventually become abundant and widespread enough to show up in the geologic record as the *first appearance* of the species. When the species is no longer able to adjust to shifting environmental conditions, its members decrease in number and eventually disappear-the extinction, or *last appearance*, of the species.
- *Pseudoextinction*, or phyletic extinction, refers to an evolutionary process whereby a species evolves into a different species. Thus, the original species becomes extinct, but the lineage continues in the daughter species

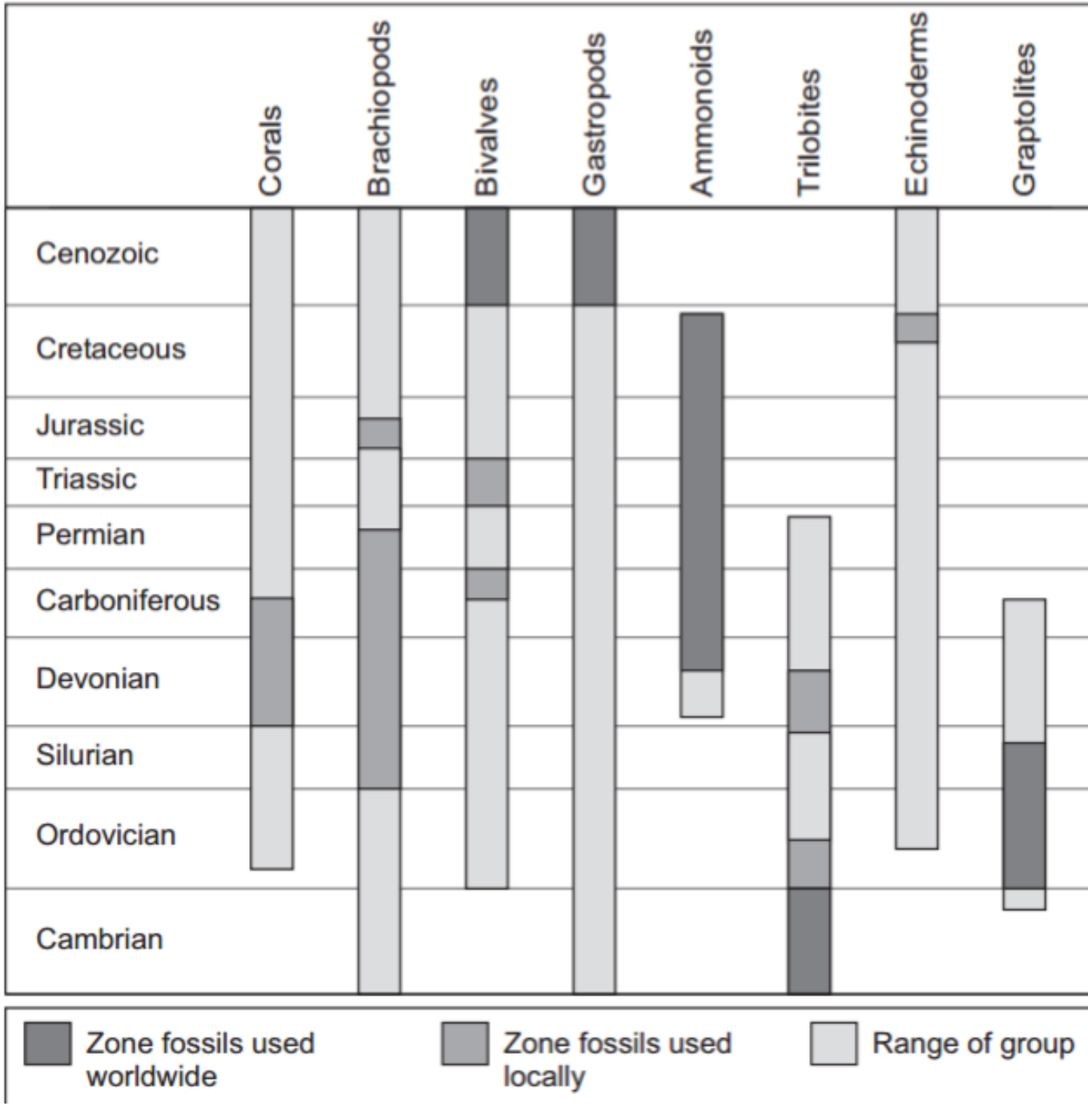
- Useful fossils for biostratigraphic purposes are called *guide fossils or index fossils.*
- Ideally, index fossils should be *(1) independent of their environment, **(2)** fast evolving, **(3)** geographically widespread, **(4)** abundant, **(5)** readily preserved, and **(6)** easily recognizable*

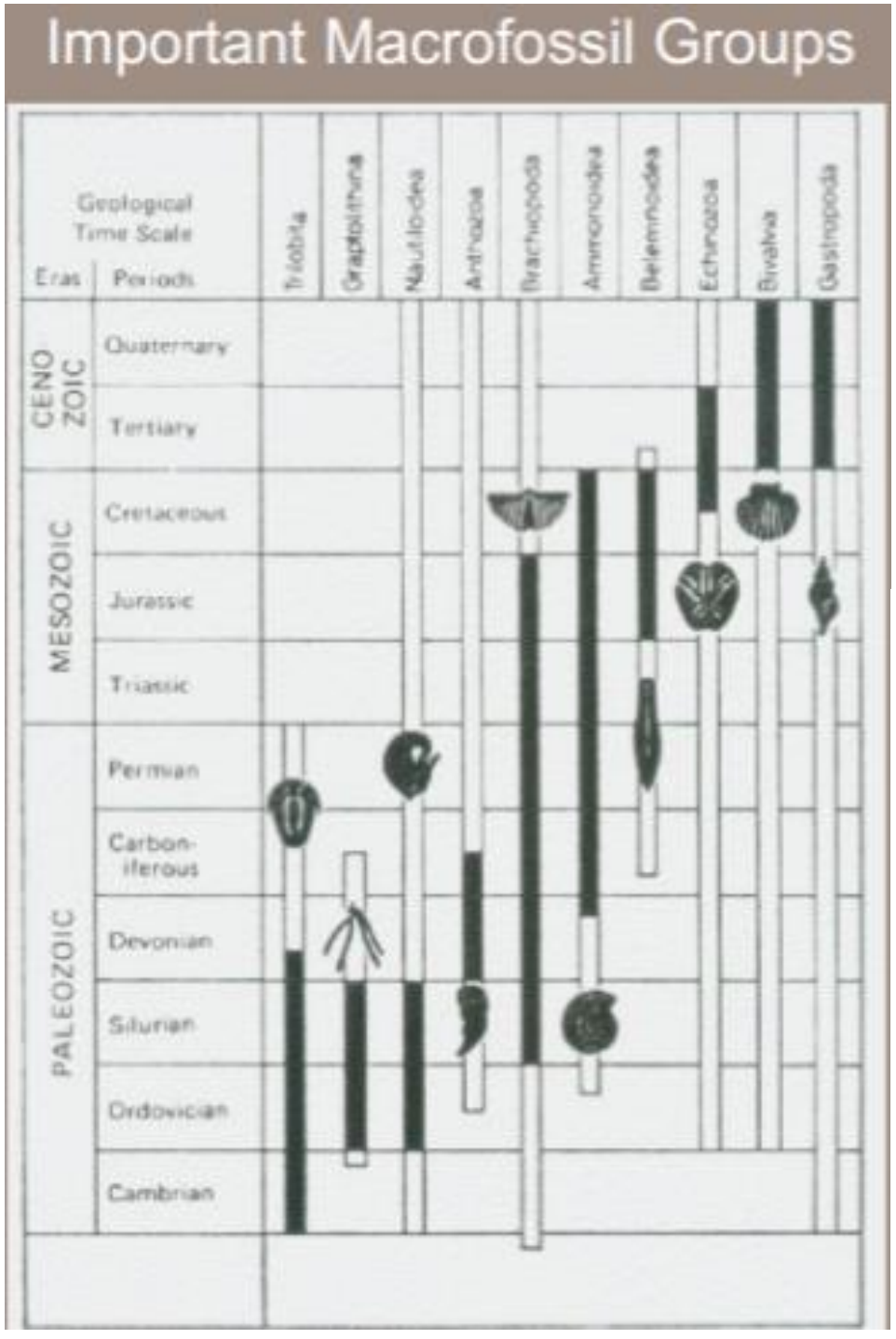


Cretaceous Biozones based on microfossils and ammonites



Trilobites are the best index fossils for the Cambrian.





Proposed causes for the main Phanerozoic extinction events

- Five extinction events have become so important and far reaching that they are now commonly referred to as the big five. These major extinction episodes took place near the end of the Ordovician, Devonian, Permian, Triassic, and Cretaceous

Extinction Event	Proposed Cause of Extinction					
	Bolide impact	Volcanism	Cooling	Warming	Regression	Transgression Anoxia
Late Precambrian						●
Late Early Cambrian					●	●
Late Cambrian			○			●
Late Ordovician			●	●	●	●
Late Devonian			○		○	●
Devonian-Carboniferous						●
Late Permian					●	
End-Permian		●		●	○	●
End-Triassic					●	○
Early Jurassic						●
Late Cretaceous			○			●
End-Cretaceous	●	●	●		●	○
End-Paleocene		●		●		●
Late Eocene			●			

● strong link ○ possible link

Causes proposed for the main mass-extinction events are summarized Table given (See preceding slide)

- The catastrophic theory, especially for the sharp Cretaceous/Tertiary boundary event, suggest that the impact of extraterrestrial objects called *bolides (meteorites and comets)* created major climatic change *(global winter)* by throwing up huge clouds of dust and/or generated acid rain, tsunamis, and wildfires that caused extinction of some taxonomic groups.
- Intense explosive *volcanic activity* may have adversely affected climates through discharge of excessive gas clouds *(greenhouse warming)*
- Gradual, progressive changes in climate (either warming or cooling) together with changes in sea level are adequate to account for the mass extinctions.
- Lowering of sea level during major episodes of *regression* reduces habitats for shallow-water organisms and increases competition.
- Marine *transgressions* appear to be linked to development of anoxic (low oxygen) conditions that adversely affect some organisms and cause extinction

CLASSIFICATION OF MARINE ORGANISMS BY HABITAT/LIFE STYLE

Classification	Description	Example
Planktonic	Organisms that live suspended in the upper water column and which have only a very weak or limited ability to direct their own movements	
Phytoplankton	Have the ability to carry on photosynthesis; primary food producers, or autotrophs	Diatoms, dinoflagellates coccolithophoridae
Zooplankton	Do not carry on photosynthesis and thus cannot produce their own food (heterotrophs); feed on phytoplankton	Foraminifers, radio-larians, graptolites
Meroplankton	Spend only their juvenile stage as plankton; later become free-swimming or bottom-dwelling organisms	Larvae of most benthonic organisms such as molluscs
Pseudoplankton	Organisms distributed by waves and currents as a result of attachment to floating seaweed, driftwood, etc.	Mussels, barnacles
Benthonic	Bottom-dwelling organisms that live either on or below the ocean floor	
Sessile benthos	Benthos that attach themselves to the substrate (epifauna)	Crinoids, oysters, brachiopods
Vagrant benthos	Benthos that either creep or swim over the bottom (epifauna) or burrow into the bottom (infauna)	Starfish, echinoids, crabs, clams, worms
Nektonic	Organisms able to swim freely and thus move about largely independently of waves and currents	Mobile cephalopods, fish, sharks

Cambrian strata of the Grand Canyon: Note the two time lines from biostratigraphy.

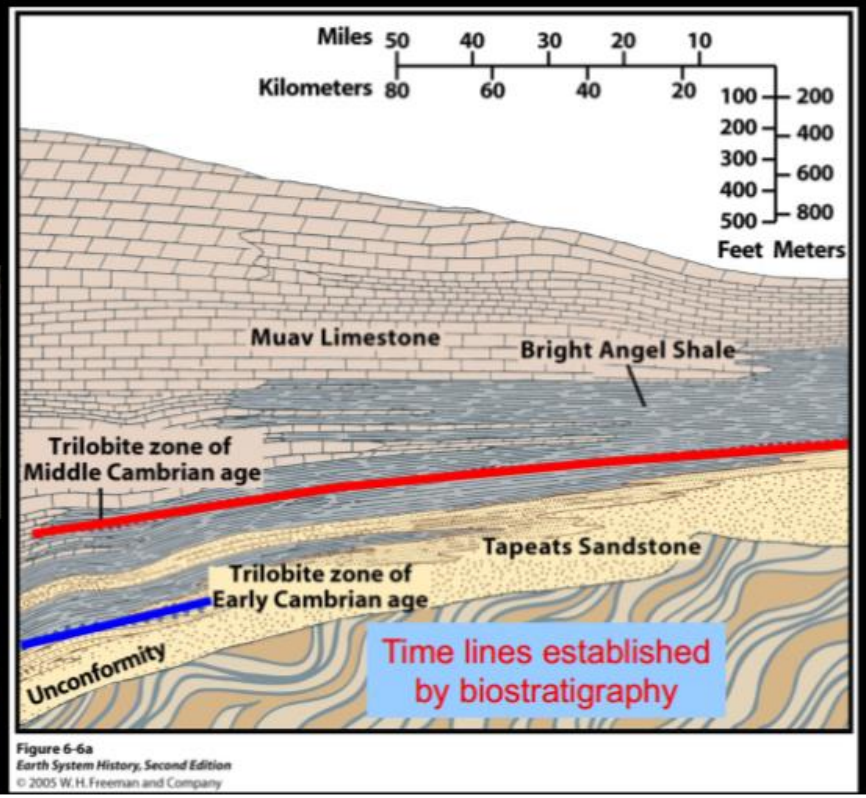
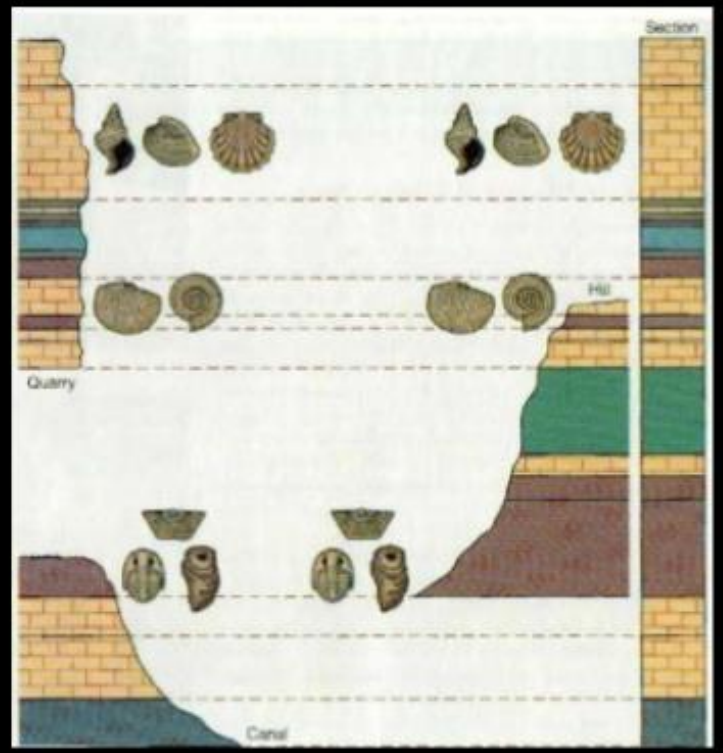
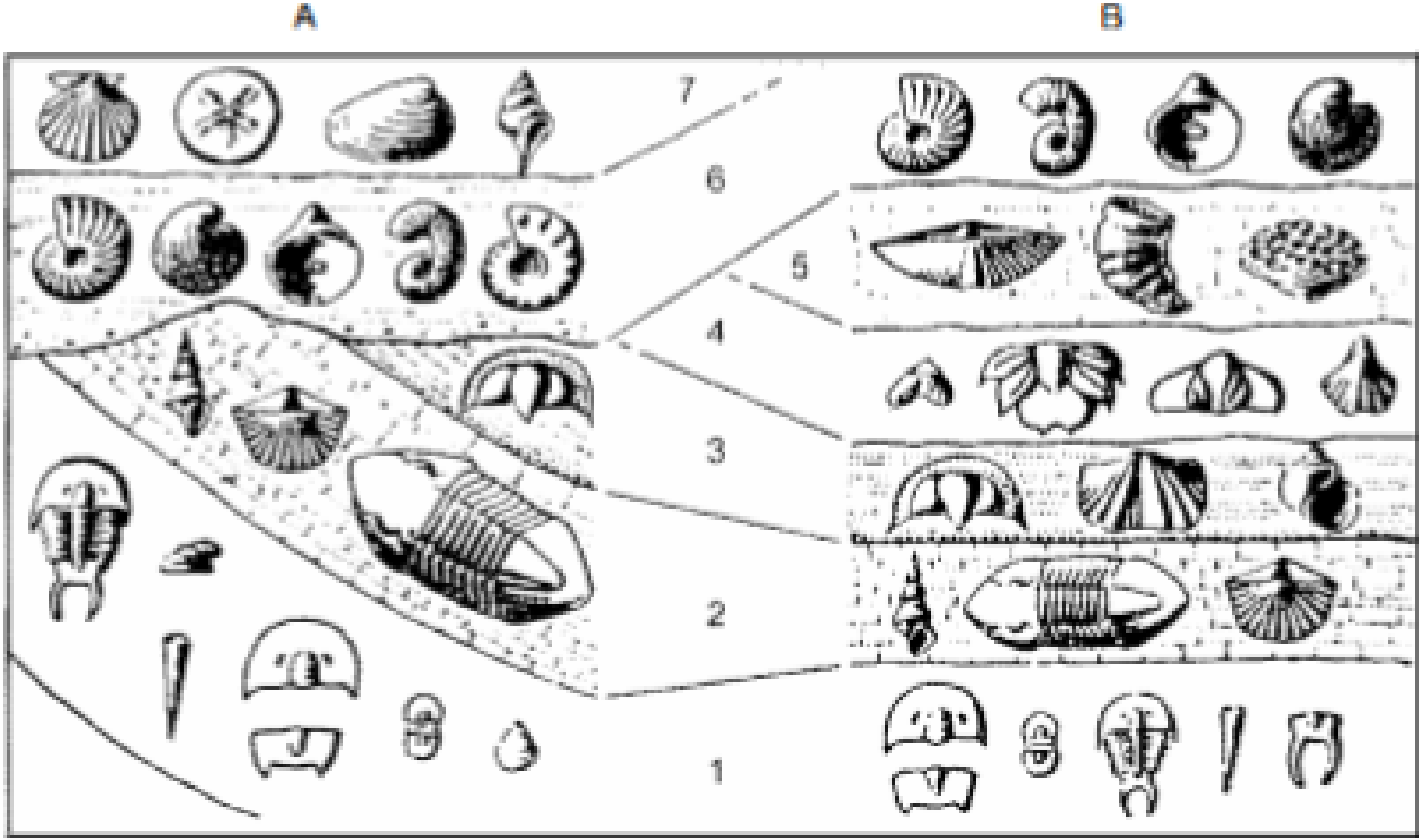


Figure 6-6a
Earth System History, Second Edition

Correlation Using Fossils



BIOCORRELATION



- ***Trilobites***
  These Palaeozoic arthropods are the main group used in the zonation of the Cambrian. Most trilobites are thought to have been benthic forms living on and in the sediment of shallow marine waters.
- ***Graptolites***
  These exotic and somewhat enigmatic organisms are interpreted as being colonial groups of individuals connected by a skeletal structure. They appear to have had a planktonic habit and are widespread in *Ordovician* and *Silurian* mudrocks
- ***Brachiopods***
  Brachiopods are used for regional correlation purposes in Silurian rocks and in later Palaeozoic strata
- ***Gastropods***
  These also belong to the Mollusca and as marine ‘snails’ they are abundant as fossils in Cenozoic rocks.

- ***Corals***
  The extensive outcrops of shallow marine limestones in Devonian and Lower Carboniferous (Mississippian) rocks in some parts of the world contain abundant corals
- ***Ammonoids***
  This taxonomic group of cephalopods (phylum Mollusca) includes goniatites from Palaeozoic rocks as well as the more familiar ammonites of the Mesozoic.

Other microfossils

Ostracods occur in a very wide range of depositional environments, both freshwater and marine, and they have a long history, although their abundance and distribution are sporadic

Diatoms are algae with a (skeleton) that can occur in large quantities in both shallow-marine and freshwater settings

BIOZONES AND ZONE FOSSILS

There are several different ways in which biozones can be designated in terms of the zone fossils that they contain;

- *Interval biozones*: are defined by the occurrences within a succession of one or two taxa. Where the first appearance and the disappearance of a single taxon is used as the definition
- *Assemblage biozones;* defined by at least three different taxa that may or may not be related. Assemblage biozones are used in instances where there are no suitable taxa to define interval biozones and they may represent shorter time periods than those based on one or two taxa
- *Acme biozones;* abundance of a particular taxon may vary through time, in which case an interval containing a statistically high proportion of this taxon may be used to define a biozone. This approach can be unreliable because the relative abundance is due to local environmental factors