

Steve Gould's Three Tiers of Evolution

- 1. *Microevolution*: at the level of the individual
- 2. *Macroevolution*: at the level of species
- 3. *Mass extinctions*: at the level of whole faunas

Mass Extinctions and the History of Biodiversity

- What is the history of global biodiversity since the Cambrian Explosion?
- What is the history of *biosdisparity* since the Cambrian Explosion?
- What is the role (if any) of mass extinction in affecting these two histories?
- Does global productivity affect or drive diversity through time?

Disparity (number of body plans) through time

- Steven Jay Gould: There were more phyla in the Cambrian than now. Even though the number of species has increased from then to now, the number of higher taxa has decreased: disparity has decreased since the Cambrian. Many Burgess Shale fossils cannot be assigned to known phyla or classes.
- Simon Conway Morris: Both diversity and disparity have increased through time. Most or all Burgess Shale fossils can be assigned to known phyla and classes
- Third possibility - disparity has stayed the same

Mass Extinctions

- Prior conditions
- Onset of killing mechanisms or conditions
- Diversity minimum
- Recovery
- *Key questions:*
 - *How rapid was extinction?*
 - *What percentage of species died out?*
 - *Did extinction happen at same time all over globe?*
 - *Can the killing mechanism be ascertained?*

How to study mass extinctions

- Global compendia - literature
- From individual measured stratigraphic sections
- Using fossils
- Using biomarkers
- Using carbon isotopes

Why were mass extinctions important

- Changed nature of biota on Earth
- Removed incumbents, allowed new evolutionary innovations
- Somehow related to levels of global biodiversity - is there some minimum number of mass extinctions that maximizes global biodiversity?
- Can too many mass extinctions sterilize a planet or at least specific groups (such as animals?)
- Must occur on planets other than just Earth - therefore of interest to Astrobiology

Problems with ascertaining rate of extinction:

- Hiatus: removal of sediment can make a gradual extinction look sudden
- Signor Lipps effect: incomplete sampling can make sudden extinctions look gradual.

Both of these problems affected interpretation of the Cretaceous -Tertiary mass extinction

Extinction rates

- Rapid, or catastrophic -majority of lineage extinctions take place over narrow stratigraphic (=time) interval
- Gradual - extinctions spread out over relatively long period of time
- *Extinction mechanisms (cause) for these two end members usually different*

Major problems

- How fast was the extinction?
- Was it synchronous on land and sea?
- Few boundary sections
- Poor correlation
- Endemic faunas

The irony of mass extinction studies

- Prior to 1800, there was no concept of extinction.
- Baron Georges Cuvier: father of Comparative Anatomy,
- Made first demonstration of extinction - proved that Mastodon is extinct

External causes of mass extinction

- Asteroid or comet impact
- Nearby supernova
- Gamma ray jet
- Solar flare
- Alien invasions? (Seeing if you are awake)

Intrinsic causes of mass extinction

- Rapid temperature change - hot or cold
 - Runaway greenhouse, Snowball Earth
- Change in atmospheric gas levels
 - Too little oxygen, too much methane or carbon dioxide, sudden and large volumes hydrogen sulfide coming out of seawater solution
- Sea level change
- *The rise of intelligence on a planet?*

The history of mass extinctions on Earth:

A. Cambrian events:

Vendian (?), trilobite biomere events >40% marine families.

Causes unknown (sea level change, anoxia?)

B. Ordovician >20% marine families Cause:

Climate change, anoxia?

C. Devonian >20% marine families Cause: Impact?, anoxia?

D. Permian >40% marine families, Cause climate change, oceanography, perhaps impact

E. Triassic >25% families, cause impact, sudden climate change?

F. Cretaceous/Tertiary, >20% families, Cause: impact

G. Holocene. Underway, Cause:

human overpopulation

Hopefully testable hypotheses:

- Does Mass Extinction accelerate processes set in motion during times of less intense turnover, *or* play a more special role in the evolutionary process?
- Does the role of Mass Extinction vary with their magnitude, timing, and/or cause(s)?
- Do Mass Extinctions break the dominance of incumbent groups and open opportunities for diversification and evolutionary novelties?

Diversity

Cenozoic Life

Mesozoic Life

Palaeo-
zoic
Life

Time

adapted from Phillips, 1867



