

Pre-Cambrian

- Over about 3.2 billion years the following things evolved:
 - DNA replication, protein synthesis, respiration, cell division, photosynthesis and the nuclear membrane
- Nearly all organisms prior to 565 Ma are unicellular (some alga were multicellular)

The Cambrian Explosion

- The first multicellular animals appear ~565Ma
- They're small and simple jellyfish and sponges and stay this way for about 20Ma
- From 543-506Ma most known phyla appeared: arthropods, annelids, molluscs, and chordates
- This Cambrian period represents <1% of earth's history but it's one of the great events

Phanerozoic Era- "visible life"

- 543Ma to now
- Several periods of rapid diversification
 - Why did some groups diversify quickly at certain times and places while others show little change over time?
- 5 cataclysmic extinctions
 - Why so many?

Types of Fossils

1. Compression/impression fossils
2. Permineralized fossils
3. Casts and Molds
4. Unaltered remains

The remains are very rare and the others depend on a durable specimen--hard structures like teeth bones and shells, and usually the organisms had to live in or near water

Biases of the Fossil Record

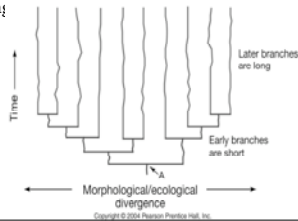
1. Geographic-fossils all tend to come from lowlands and marine habitats where scientists have access
2. Taxonomic-marine organisms dominate the fossil record but make up only 10% of extant species and 2/3 of animal phyla today lack any hard parts
3. Temporal-when tectonic plates subduct and mountains erode, their fossils go with them

Life Through Time: Overview

- Phanerozoic Eon: 543Ma-present
 - Paleozoic: "ancient life," 543-251 Ma
 - radiation of animals (Cambrian) to mass extinction (Permian)
 - Mesozoic: "middle life," 251-65Ma
 - extinction to extinction (Permian to K/T)
 - "age of reptiles"
 - Cenozoic: "recent life," 65Ma-now
 - "age of mammals"

Adaptive Radiation

- A single or small group of ancestral species diversifies into a large number of descendent species occupying a wide variety of ecological niches
 - Galapagos



What triggers the radiations?

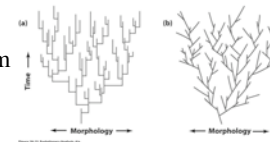
1. Ecological opportunity mostly resulting from luck
 1. Flies and finches
2. Mass extinction opening up niches
 1. Mammals following dinosaurs
3. Morphological innovations that work
 1. Arthropods everywhere!
 2. flowers

Plants

- Radiation of terrestrial plants from aquatic ancestors in the Devonian comparable to the Cambrian explosion in animals
 - Evolved waxy cuticle and stomata and alternation of generations---life on land
- Cretaceous explosion of angiosperms
 - Over 240,000 species of angiosperms exist now
 - They live just about everywhere
 - Probably the result of those flowers

Stasis

- Common evolutionary pattern where new morphospecies appear suddenly and then persist unchanged for millions of years
- Problem for Darwin
- Punctuated Equilibrium
 - Problem of scale?
- Gradualism and Stasis
 - Microscopic--gradualist; macroscopic--stasis

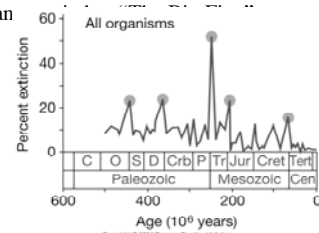


Examples?

- Horseshoe crab
 - Lack genetic variation?
 - Compare with hermit crabs---No, that's not it
 - Some clams
 - “zig-zag evolution”--fluctuations with little net change
 - Response to the environment over time?
- Maybe it just varies lineage to lineage?

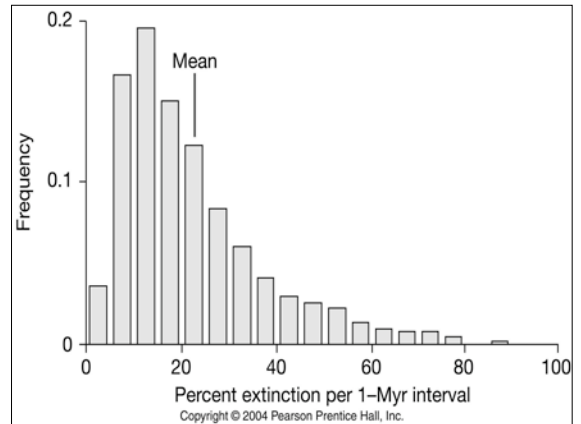
Mass Extinctions

- An interval where over 60% of species that were alive went extinct in a span of 1 million years
- The Phanerozoic



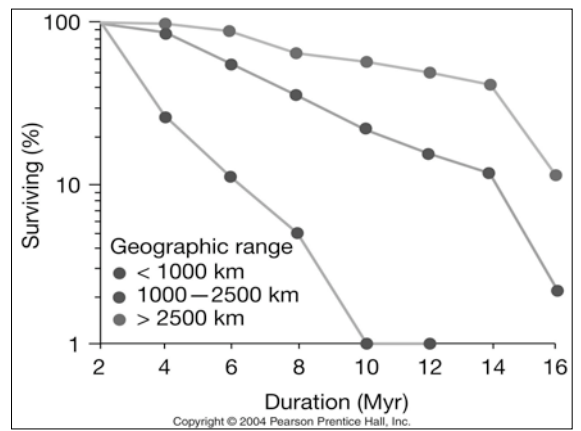
Background Extinction

- The Big Five are responsible for maybe 4% of all extinctions during the Phanerozoic
- The other 96% were the result of normal “background extinction”
- What’s the difference?
 - A mass extinction is a global event, involves a wide range of organisms, and is rapid relative to the expected lifespan of the taxa that are wiped out



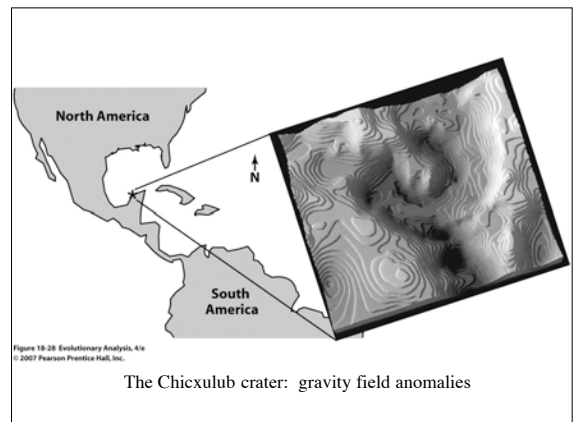
What’s Normal?

1. Extinction rates are constant within a clade but vary across clades (fig)
2. In marine organisms, extinction rates vary with how far larvae disperse after eggs are fertilized and development begins
 1. Wider dispersal correlates with lower extinction rates
 2. Wider global distribution correlates with lower extinction rates (fig)



The K/T Extinction (65Ma)

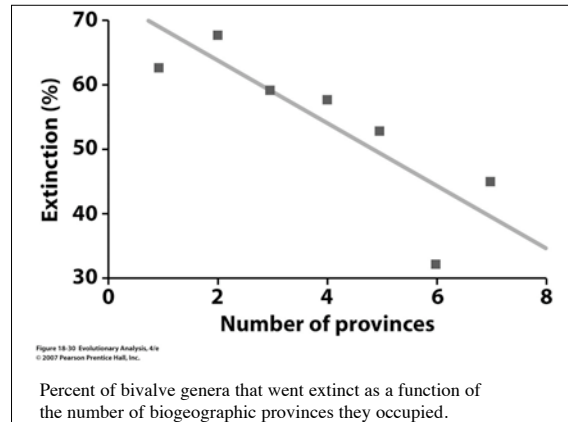
- Alvarez’s iridium layer
 - Shocked quartz
 - Microtektites (teardrop shape)
 - Gravitational and magnetic anomalies around the Yucatan peninsula
 - BIG crater there (10km meteor!)
- So we pretty much know this happened.
What we don’t know is the consequences.



Consequences of the Meteor?

- Ejected particles = acid rain and blocked light?
- Ash layer---major wildfires? Blocked more light so earth became cold and dark?
- Force sufficient to trigger earthquakes and volcanoes? Still more crud in atmosphere?
- Depositional evidence supports a tsunami--4km tall?!

So primary production declines and chemistry and temperature gradients in the entire Atlantic are altered.....longer term consequences?



Upshot?

- 60-80% of all species went extinct by the end-Cretaceous
- Amphibians, crocodilians, mammals and turtles, and insects were hardly touched
- Only one order of birds survived
- Marine plankton became scarce and ammonites and rudists were lost
- 35% of N. American plants died off

Extinction Now: Human Meteor?

- Polynesian avifauna:
 - 2000 avian species out of 9000 (20%) in the Pacific islands have died off in the past 2 millenia
 - Humans ate them and they succumbed to introduced mammals and habitat destruction for farming

Galapagos

- Humans didn't settle there at all until 1535 and then only sporadically until 1800
- Only 3 populations had been lost in the 4000-8000 years preceding humans
- Since humans, 20 taxa have been lost

So are we causing a mass extinction event?

Extinction events since 1600

	% extinct	% threatened
molluscs	0.2	0.4
crustaceans	0.01	3
insects	0.005	0.07
vertebrates	0.5	5
fish	0.1	2
amphibians	.07	2
reptiles	0.4	3
birds	1	11
mammals	1	11
Total animals	0.04	0.3
gymnosperms	0.3	32
dicotyledons	0.2	9
monocots	0.2	9
palms	0.1	33
Total plants	0.3	9

Habitat Loss

- Since the damage is already done on most islands, that problem should decline but as the human population increases, habitat loss gets worse
- From 1986-1990, 15 vertebrates went extinct. At that rate it will take just 7000 years to eliminate half the 45,000 vertebrates named
- This would affect rare or localized species first though, so that rate might not be sustained

Other ways of looking at it?

1. Multiply the number of species per hectare in different environments by rates of habitat loss from satellite photos
2. Quantify the rate that well-known species are moving from threatened to endangered to extinct status
3. Estimate the probability that all species currently listed as threatened or endangered will actually go extinct in 100-200 years

And they say?

- All those methods point to extinction rates 100-1000 times normal background
- If current rates of habitat loss continue, our present course does fit us right in with the Big Five

Where are the problems worst?

- Most extinctions have occurred in North America, the Caribbean, Australia, and the Pacific Islands.
- Roughly 1/3 of American plants and animals are threatened.
- Since 1900, the rate of extinction in North America has been about 4%--mostly freshwater animals and amphibians

The Tropical Rainforest

- Tropical rainforests occupy less than 7% of the land on earth but contain at least half the plant and animal species
- These forests are under acute threat because their human populations have been low and their climate unchanged so there hasn't been an "extinction filter"
- Now population growth is faster here than anywhere else and climate change is likely to have an impact