Evidence for A Long History On Earth

1. Tree-ring chronology (Bristle Cone Pine record goes back to 8,000 years ago)
2. Ice Cores in Greenland and the Antarctic
   - Annual layers go back more than 100,000 years
   - Ice would require more than 10 million years to accumulate at present rates
3. Varves
   - Repetitive annual layers produced during summer/winter cycles
   - 6 million varves in a single formation in Utah-Wyoming area
4. Salt in the oceans comes from rivers
   - Would take 330 million years to accumulate
   - Minimum age since some salt is lost from the sea during deposition of marine salt beds
5. Rates of plate movements can be measured by satellites
   - Hawaii moving 8 cm/year toward Japan (consistent with direction/rate of hot-spot trace)
   - Would take over 100 million years for Atlantic Ocean to have grown at present rates
6. San Andreas fault
   - Has 560 km of total movement based on matching rock units on opposite sides of fault
   - Would require more than 10 million years at present rate
7. Radiometric age determinations
   - Nuclear reactors and modern medical devices show that half-lives are really known
   - Ages are reproducible, within analytical limits, by a single lab or between several labs
   - Consistency of ages by different methods on the same sample (progressive cooling of the rock)
   - Consistency with fossil record (geologists argue whether Mesozoic-Cenozoic boundary is at 66 or 65 Ma because of very minor differences in dating the extinction layer at different sites)
   - Consistency with geologic events
     - Subduction-related volcanism in Arizona stops when the North American- Pacific plate boundary switches from convergent to a transform boundary (San Andreas fault)
     - Formation of Appalachian Mtns. matches mountain-building event in Europe-Africa -- old continental collision
   - Consistent with paleomagnetic data in oceans and on land
8. Explains things, is predictive, and we can use it
Chronicle of Life on Earth

4.6 b.y. - Origin of earth
4.6 b.y. - based on dates of meteorites, moon
4.0 b.y. - Oldest rocks preserved
3.8 b.y. - Oldest evidence of life; bacteria and blue-green algae (reproduce asexually = don't evolve)
   Rocks show that not much oxygen in atmosphere
2.0 b.y. - Increase in oxygen in sea water (many iron deposits formed as water became oxygen rich)
   Oldest rocks in Arizona
1.0 to 1.5 b.y. - Green algae (reproduce sexually = exchange genetic material = evolve)
   800 m.y. - Soft-bodied, but complex organisms (primitive jellyfish, other oddities)

570 m.y. - End of Precambrian, start of Paleozoic
   Major extinction
   First abundant sea critters with hard parts
   Trilobites, clamlike and squidlike things
500 m.y. - First fishes
400 m.y. - End of early Paleozoic; start of late Pz
   Plants move onto land
   Lots of fishes, sharks, lungfish, lobe-finned fish
360 m.y. - Amphibians (ancestors of frogs and salamanders) invade land and diversify
300 m.y. - Huge tropical swamps of scale trees and seed ferns (much coal); nice place for amphibians
   Oldest Reptiles (not so tied to water)

250 m.y. - End of Paleozoic; Start of Mesozoic
   Major extinction of many sea creatures, plants, and amphibians
   • Extinction of 50% of families of marine vertebrates (maybe 95% of species)
   • All six types of reptiles survived
   • Climate dries out; favors creatures that could survive in drier places
   Conifers become dominant (not dependent on free-standing water for fertilization)
   Reptiles become dominant (lay eggs on land; watery fluid inside reptile egg is like sea water)
   Dinosaurs Rule, but some mammals
100 m.y. - Flowering plants come on strong
   Birdlike Dinosaurs (Archaeopteryx); had wings with claws, and teeth; feathers = modified scales

65 m.y. - End of Mesozoic; Start of Cenozoic
   Extinction of dinosaurs, many sea critters
   Wiped out 15% of marine families
   Due to asteroid impact in Caribbean?
   Mammals Galore!
   Birds and mammals evolve to eat seeds and fruits of flowering plants
35 m.y. - Grasses spread over plains, which led to diversity of grazing animals and carnivores
4 m.y. - First human/apelike creatures in Africa; human teeth and pelvis, apelike skull
3 m.y. - Volcanoes join central and South America; Central/North American mammals migrate south
   and kill off South America marsupials
   Some marsupials (opossums) migrated north
35,000 years - Homo sapiens; used fire, made music, art, and jewelry, had tattoos
   Modern humans and chimpanzees are 99% alike in proteins and DNA
15,000 years - Asian peoples migrated across Alaskan-Siberian land bridge, probably contributing to
   the extinction of large mammals like mammoths, camels, saber-tooth cats
10,000 years - Agriculture; larger groups possible
5,000 years - first writing = first recorded history
Extinctions

Species: organisms can breed successfully and have fertile offspring
Natural populations within a species are variable (size, shape, speed = genes)
Organisms occupy environmental (ecological) niches
Probably over 99% of all species that ever lived are extinct
  • "Real" extinction -- species dies without descendants (evolutionary dead end)
  • "Pseudo"extinction -- species disappears because it has changed into something new
Rapid diversity develops just after an extinction event (lots of open niches)
Early experimentation, later standardization (failed experiments go extinct)

Possible causes of Extinction
1. Environmental Changes (temperature, moisture, atmosphere gases, volcanic dust, salinity of water, type of flora, destruction of habitat, disease)
   • Many extinctions may be related to a change in sea level (changes amount of available habitat on continental shelves)
   • Extinctions commonly most affect tropical, marine fauna and flora of shallow habitat
   • Species-poor genera fare better than species-rich ones because individual species occupy more niches and have broader geographic range
2. Competition
   • 3 m.y. - Volcanoes join central and South America; Central/North American mammals migrate south and kill off South America marsupials
   • End of Ice Ages
     • 200 genera of large animals became extinct between 50,000 years (Europe-Asia) and 10,000 years (America)
     • Coincides with the arrival of humans
     • Extinctions due to overhunting Plus climate change
3. Bad luck (catastrophe; wrong place at the wrong time)
   • Dinosaurs
   • Creatures least likely to die include those that feed on insects or dead plants
Dinosaurs

Laid eggs in nest
Some nested in large colonies (social)
Returned to colonies and reoccupied nests in successive years

Warm blooded versus cold blooded

1. Mobility
   • Wide distribution of species (able to migrate fairly fast)
   • Some formed herds that migrated to places like Alaska

2. Speed from length of leg and length of stride
   • T-Rex = 15 to 20 MPH
   • Triceratops = 30 MPH (like a rhino)

3. Ratio of Prey/Predator ratio
   • 50:1 for warm-blooded predators
   • 5:1 for cold blooded ones
   • 50:1 for dinosaurs (look warm blooded)

4. Bone structure
   • Cold blooded (reptiles) are slow growing and have few vascular canals
   • Warm blooded have lots of vascular canals
   • Dinosaur bones have lots of vascular canals (look like birds)

Evidence of a meteorite impact

• Apparent sudden demise (flourishing up to the end)
• Anomalous concentrations of Iridium, an element most common in meteorites
• Shocked quartz (metamorphosed by very high pressures = an impact)
• Streamlined blobs of glass formed when melted rock thrown into the air
• Microscopic carbon spheres along boundary (global forest fires)
• Deposits formed by huge waves around the Caribbean
• Possible large crater of appropriate age
• Also affect shallow marine creatures