On geological time line and major speciation/extinction events:

1. Life may have evolved a number of times but the evidence—macromolecules and L-isomers of amino acids—indicates that life on earth comes from a single common ancestor.

2. There are five essentials for the evolution of life. (Perhaps it’s time to pull out your chemistry notes.)

   - Synthesis of simple monomeric compounds
   - Nucleotide bases assemble into nucleic acids
   - Nucleic acids replicate
   - Processes become compartmentalized
   - Proteins are synthesized that catalyze catabolic and anabolic processes

Once life starts, it changes the environment. Newly evolved compounds don’t come into an empty world.

Precambrian Life (before 543 m.y.a.)

1. First evidence is presence of stromalite mounds (about 3.5 billion years ago). The environment is anaerobic, not much free oxygen around.

2. Cyanobacteria release O2. There’s a marked increase about 700 m.y.a. favoring aerobic metabolism.
3. Eukaryotic life arises about 1.4 billion years ago through endosymbiosis.
4. Animal life starts about 1 billion years ago.

Cambrian Explosion

   All this happens quickly in a rather narrow window of 30 (or low as 5-10) million years. Nearly all modern phyla and classes of marine animals arise now. There are extinct and incredibly different phyla and classes, the Burgess Shale organisms.

   This is a time of potentially the highest diversity ever. This raises some questions: Why so much diversity then but not afterwards? Why is there so much change in such a narrow window? Or is this perception correct? There’s the response of organisms to rapid environmental change and there’s evidence that the diversity had begun before the Cambrian. At the end of the period, there are mass extinctions and the emergence of the chordates.

Diversity in the Ordovician (500-439 m.y.a.)

1. New classes and orders
2. Another mass extinction, leaving much reduced taxa
**Silurian (439-408 m.y.a) and Devonian (408-354 m.y.a.)**

1. Ancestral body plans of vertebrates in the amphioxus (Branchiostoma).
2. Diversity in vertebrate fish. Jaws show up in the early Silurian.
3. Plants invade the earth in the early Devonian.
4. Animals, namely arthropods, come onto land 400-380 m.y.a. The first true insects show up in the early Devonian.
5. By the late Devonian, terrestrial vertebrates.

**Carboniferous and Permian**

1. Extensive plant communities, mainly swamp that become huge coal deposits across the world.
2. Winged insects arise.
3. Amphibians are up in the Carboniferous, but drop in the Permian.
5. First amniotes appear and develop mammal-like traits.
6. Pangaea
7. Another huge extinction, the largest so far with loss of lots of marine invertebrates.

**Mesozoic (Triassic, Jurassic, and Cretaceous)**

1. Pangaea breaks up during the Triassic.
2. Marine groups hammered in Permian extinction begin to diversify.
3. Gymnosperms, esp. cycads, dominate terrestrial plant communities. Angiosperms maybe arise late in the Triassic, but are certainly on the scene in the early Cretaceous.
4. Insect and angiosperm co-evolution begins, highly specialized insect clades appear.
5. Original amphibian lineages go extinct. (Current amphibians are not connected to earliest forms.)
6. Reptiles (amniotes) dominate. One lineage of diapsids will become modern lizards. Another, Archosauromorpha, is a huge and widely diverse group. (Get an idea of who’s in this group.)
7. Small mammal predators in late Triassic and early Jurassic. The therians might be the ancestral group to both Metatheria (Marsupials) and Eutheria (Placental) mammals, both of which are firmly in the fossil record by the late Cretaceous.
8. By the end of the Cretaceous, reptiles are very reduced. Dinosaurs had been dwindling throughout the last era, but are finished off by the asteroid impact.

Mammals start to diversify through adaptive radiation in the **Paleocene**, definitely in the Eocene. The fossil record is very poor at this important point.

By the **Pleistocene** continents are more or less in place. There are great fluctuations in temperature and sea level, which has a huge effect on the distribution of organisms. Cosmopolitan distributions are cut up (a precondition for allopatric speciation). Groups spread from refugia at variable rates.