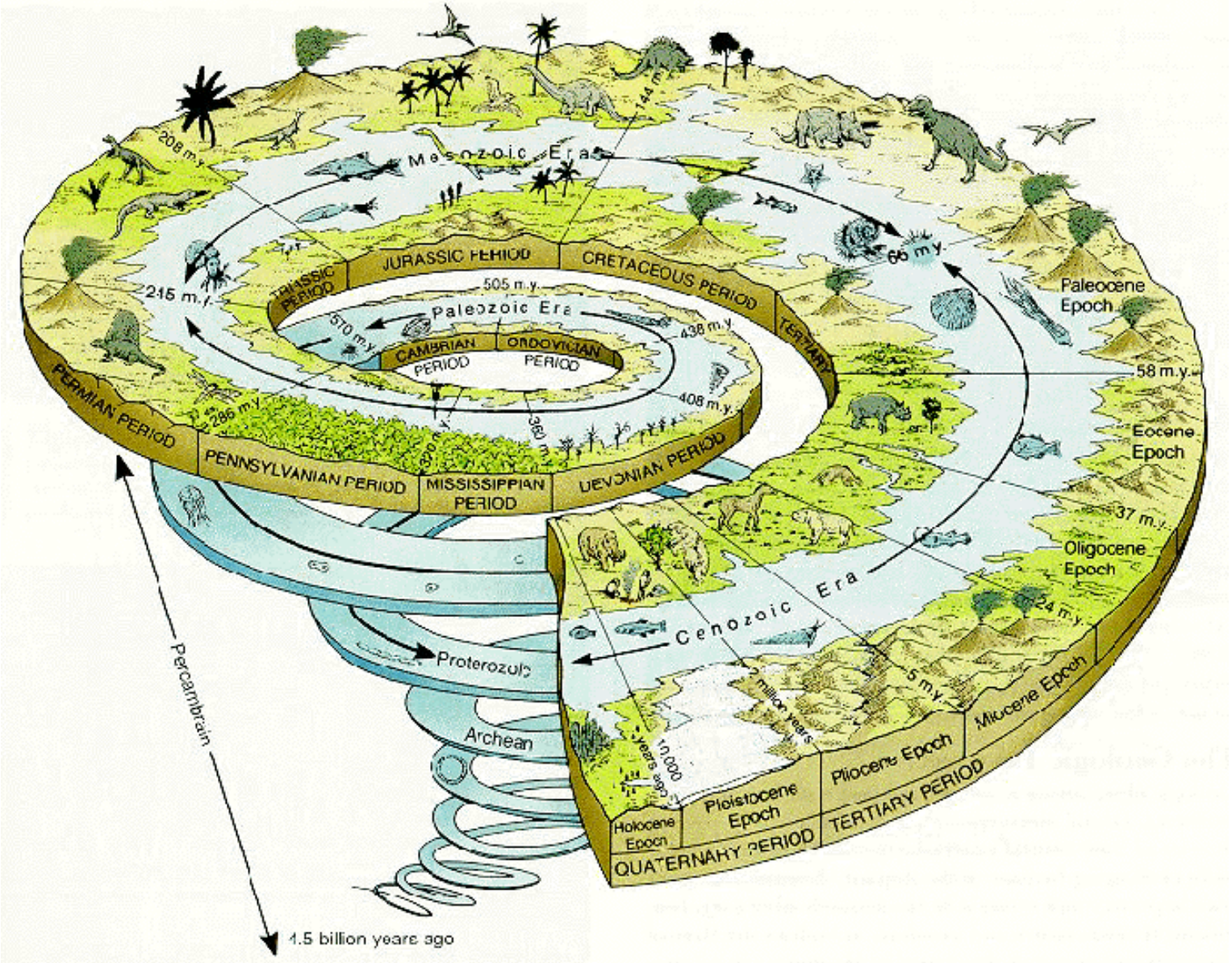


"There are some four million different kinds of animals and plants in the world. Four million different solutions to the problems of staying alive."

Sir David Attenborough

What We Will Learn Today

- How long has Earth had living organisms?
- How did life arise on Earth?
- How has life on Earth evolved?
- What are the necessities of life?
- What are some conditions favored by extremophiles?

How Do We Study Ancient Life?

- Find fossils and determine their age through radiometric dating
- Find signature of life in old rocks and date them
- Hard to do because:
  - Earth is geologically alive, remember? Most rocks on Earth are young
  - Transformations due to erosion and pressure wipe out fossil records
  - All life older than a few 100 million years is microscopic and does not leave much evidence

How Do Fossils Form?

- Dead organisms fall to the bottom of the sea or other bodies of water
- They are buried in layers of sediments brought in by flowing water
- Pressure from higher layers compresses lower layers into rock, trapping the fossil
- Tectonic activity over geological scale exposes these rocks, revealing the fossil record

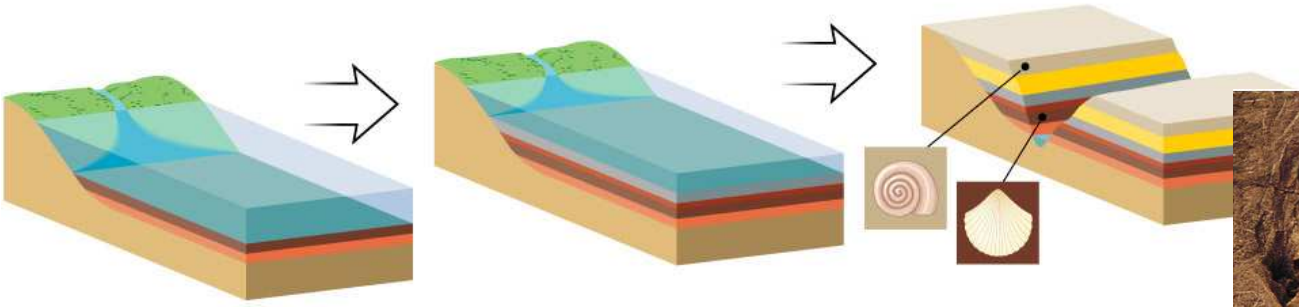


Fig 24.1

Fig 24.3

Evidence of Earliest Life on Earth

Fig 24.5

- Stromatolites
  - Sedimentary rock formed over bacterial mats
  - The oldest stromatolites have been dated to be 3.5 billion years old
- “Footprint” of ancient life
  - Rocks with life have higher C-12 to C-13 ratio
  - These are isotopes of Carbon
  - Life absorbs C-12 easier than it does C-13
  - Rocks with lifelike ratio found to be 3.85 billion years old!
- Putting it in context
  - Earth is about 4.5 billion years old
  - Heavy bombardment occurred between 4.2 and 3.9 billion years
- Earth has had life for most of its history!

How did Life on Earth Begin?

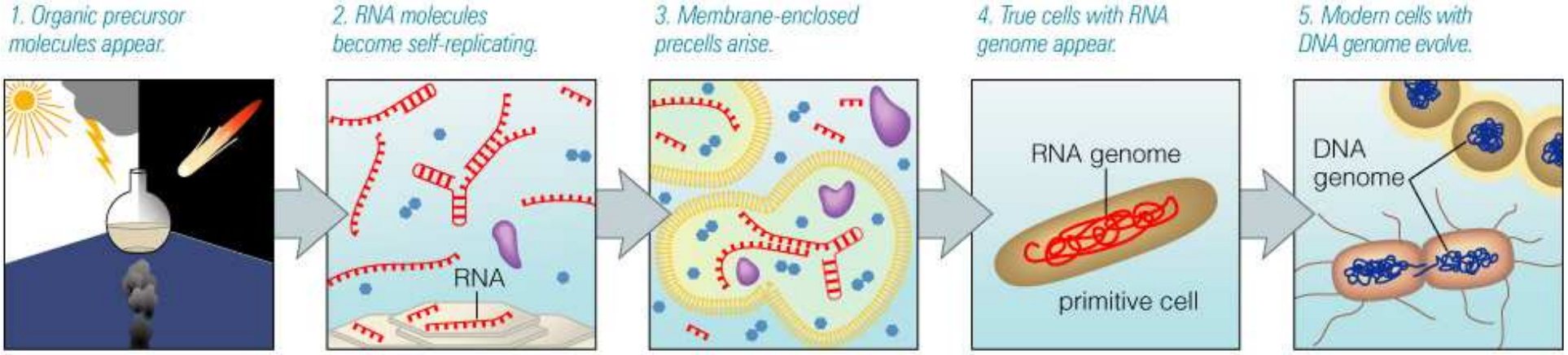


Fig 24.11

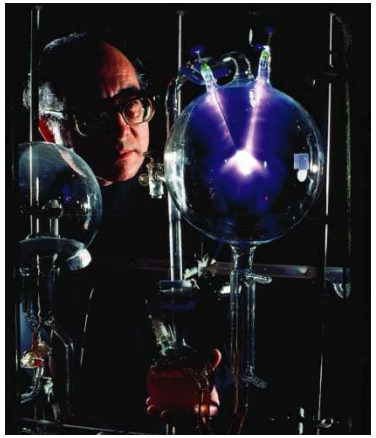


Fig 24.9

- Chemistry to Biology?
  - Miller Urey experiment
  - RNA has been chemically formed in the lab
  - Microscopic enclosed membranes formed in simulated conditions of primitive Earth
- Life brought to Earth by comets or from Mars or Venus?
  - All inner planets exchanged rocks during heavy bombardment
  - Comets seen to have amino acids

Evolution of Life on Earth

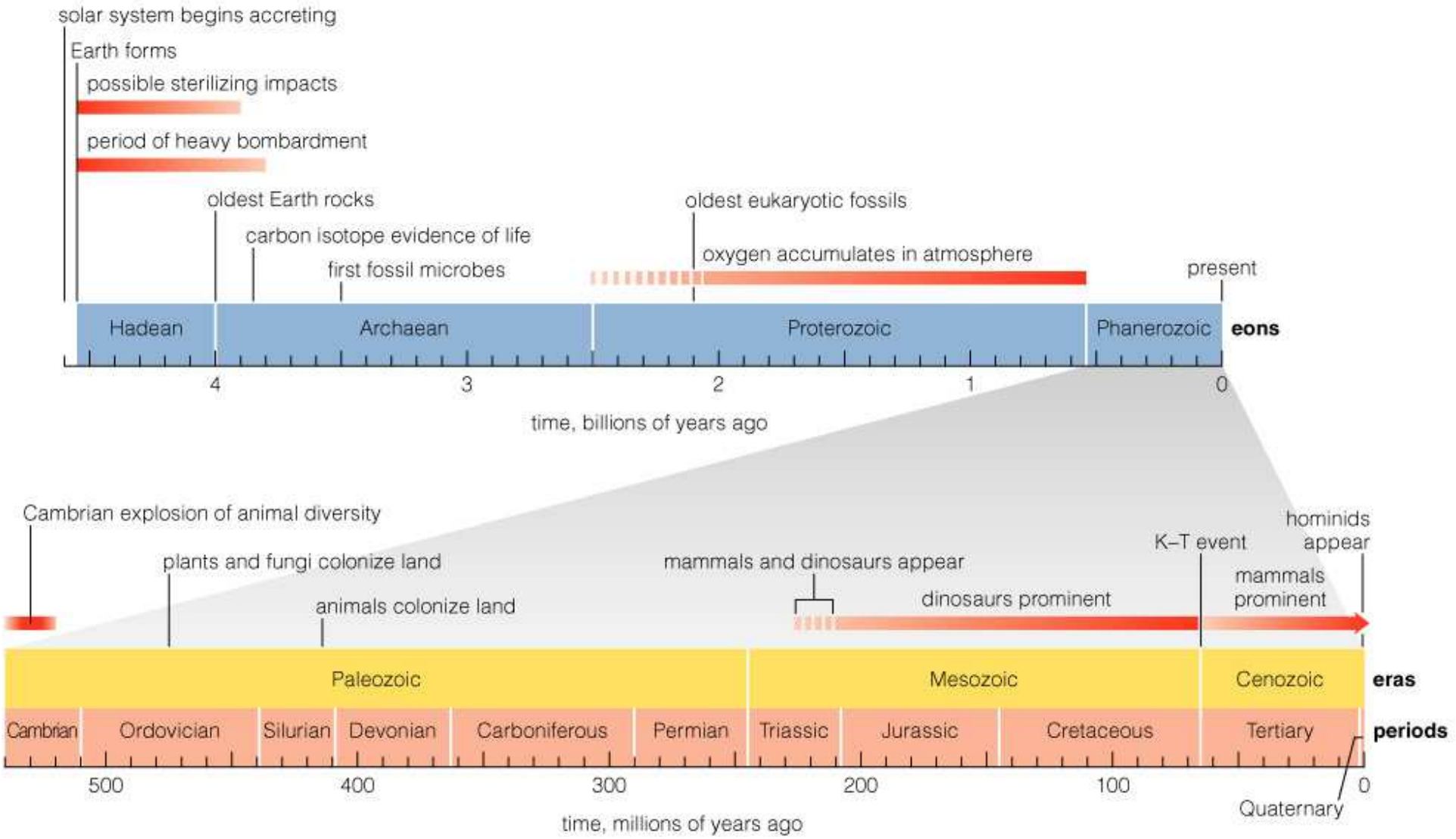
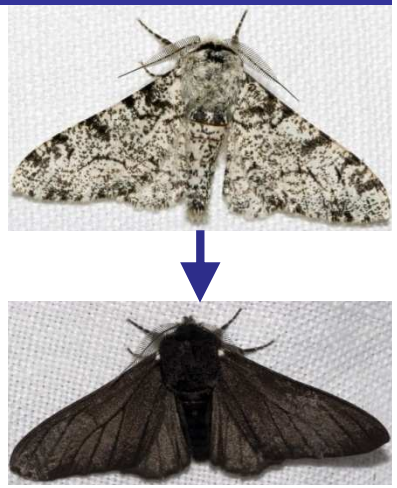


Fig 24.4

Darwin's Theory of Evolution

- Postulate for Natural Selection
  - Overproduction & struggle for survival
  - Individual variation
  - Unequal reproductive success
  - Can produce entirely new species
- Mutation: Sudden changes
  - Most are bad, but the rare good ones thrive
- Support for evolution
  - Fossil record (Galapagos islands)
  - Discovery of the DNA structure
    - Explains the mechanism of evolution at a molecular level
  - Evolution seen in our lifetimes
    - Microorganisms in the lab
    - Peppered moths evolved from white to black due to the industrial revolution
    - How do you learn new features of Word, Excel etc?

Bind Cave Fish



Evolution of the Peppered Moth

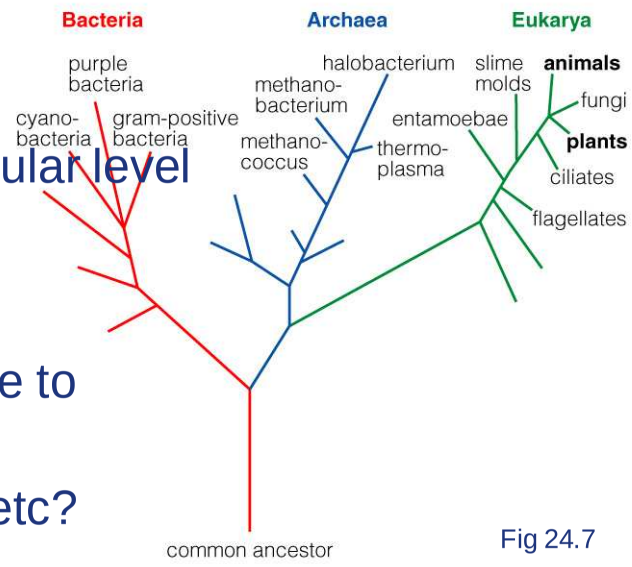
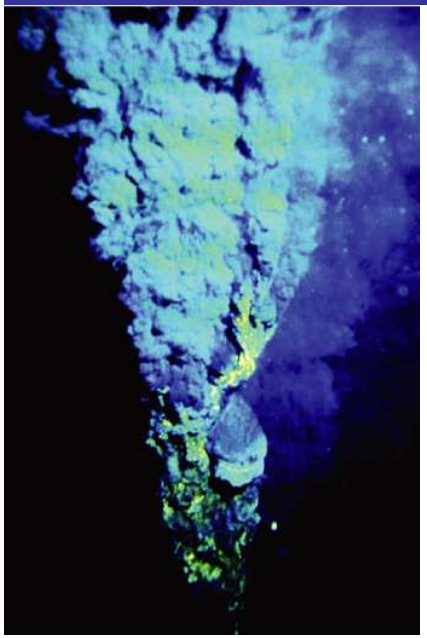


Fig 24.7

Necessities of Life

- A source of nutrients from which to build living cells
- Energy to fuel the activities of life
- A solvent liquid to carry nutrients to all part of the organism
  - Liquid water is abundant, remains liquid over a wide temperature range and a great solvent

Extremophiles



Thermophiles in black smokers 110^{o}C

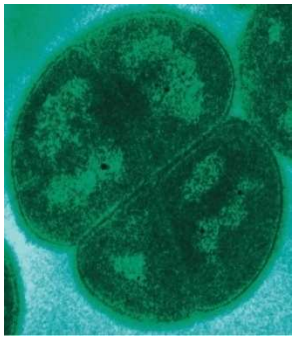
Foraminifera: Live under 7 miles of water, pressure 1,100 times that at surface

Cave Fish adapted to life in sulfuric acid water

Acidophiles

Halophiles: Stromatolites in salt evaporation ponds

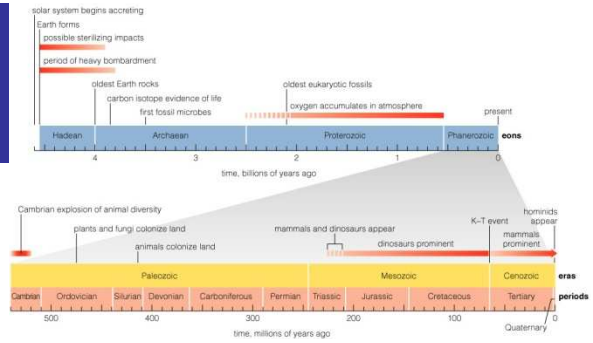
Psychrophiles: worms in Gulf of Mexico Floor living on methane hydrates



Deinococcus Radiodurans

Can live in vacuum, heat, cold, acid, and over 500 times the radiation that would kill humans

Recap Evolution



- Earth has had life for most of its history!
  - Life arose soon after heavy bombardment
- Cyanobacteria helped build an Oxygen-rich atmosphere
  - Put pressure on evolution
- Eukaryotes form about 2 billion years ago
  - Nuclear region bound by a membrane
- Cambrian explosion: about 500 billion years ago
  - Many more life forms, more complex
- Early mammals & dinosaurs enter ~ 250 million years ago
- Dinosaurs go extinct 65 million years ago
  - Likely due to impact at the Yucatan Peninsula (Iridium deposit evidence)
- Earliest humans arrive only a few million years ago
- All life on Earth likely started from one common ancestor
  - Common DNA structure