## EVOLUTION AND CLASSIFICATION

Unit 8

#### Topics

- Topic 1: History of Life
  - Spontaneous generation v. biogenesis
  - Age of earth
  - Order of life on earth
- Topic 2: Evolution
  - Theories and the people they came from (Lamarck, Darwin)
  - Evidence for evolution (fossils, structures, molecular)
  - Speciation
- Topic 3: Classification
  - Domains & kingdoms
  - Characteristics
  - Dichotomous keys, cladograms





## TOPIC 1

History of life



#### Topic 1: History of Life

- Earth + solar system formed about 4.6 billion years ago
- Bombardment of Earth by rocks and ice likely vaporized water and prevented seas from forming before 4.2 to 3.9 BYA
- Earth's early atmosphere likely contained:

water vapor and chemicals released by volcanic eruptions like nitrogen, nitrogen oxides, carbon dioxide, methane, ammonia, hydrogen, hydrogen sulfide.

- NO free oxygen in atmosphere!





#### Formation of Life on Earth

Chemical evolution occurred prior to biotic evolution



- Energy from <u>sun, volcanoes and lightning</u> combined w/ gases to form chemical substances (Sugars, nucleotides, amino acids) which then combine to form all life on Earth
- In the 1950s, scientists Miller & Urey set out to demonstrate that it was possible for macromolecules to appear on earth, given the early atmospheric conditions, without organisms actually present yet
  - Recreate earth's early atmosphere (H, CH4, NH3, H2)
  - Add electric sparks (simulate lightning)
  - Gasses cooled, leaving water droplets
    - Water droplets contained amino acids and adenine!
      - Yes, amino acids and nucleotides could have formed under early conditions on earth

#### Miller-Urey

#### Bottom line:

#### Organic molecules CAN form from inorganic molecules

- RNA evolved before DNA. Why does this make sense?
  - RNA codes information (makes inheritance possible)
  - Self-replicates
  - First step of evolution in the Central Dogma
    - DNA→RNA→Protein



# How Life Came to Be (Origin of Life Scientists)

Spontaneous Generation v. Biogenesis: for a very long time (until ~200 years ago), many people believed life could arise from nonliving matter.





#### Spontaneous generation

- The belief that life can arise from nonliving things
  - Frogs arise from mud
  - Flies arise from rotting meat
  - Mice arise from dirty underwear
- Church approved this belief people trust the church, this must be right
- Francesco Redi is the first big name to say something different (biogenesis)
- Battle of experiments to determine how life actually comes to be

"So with animals, some spring from parent animals according to their kind, whilst others grow spontaneously and not from kindred stock; and of these instances of spontaneous generation some come from putrefying earth or vegetable matter, as is the case with a number of insects, while others are spontaneously generated in the inside of animals out of the secretions of their several organs." —Aristotle, History of Animals, Book V, Part 1 [1]

#### Biogenesis

- The belief that life can only come from living matter
  - All life is from life
- Now widely accepted, but was not until about 1860
- In the life cycle of a frog, tadpoles hatch from eggs, eventually are frogs
- Flies were previously larvae, which hatched from eggs (deposited on the meat)
- Mice are born from other mice



#### The people involved

- Francesco Redi (1668): designed experiment to test spontaneous generation
  - In support of: **BIOGENESIS**
  - Setup: three jars, each holding meat
    - Control: no lid
      - Flies and air have access to meat
    - Experimental setup 1: closed lid
      - Neither flies nor air can access meat
    - Experimental setup 2: mesh lid (cheesecloth)
      - Flies cannot access meat, air can
  - Findings: the only jar with flies was the control!



### Needham (1748), Spallanzani (1770)

- John Needham, an Englishman, wanted to prove Redi wrong
  - In support of: SPON.GEN.
  - Experiment: heat broth to remove microbes; seal and let sit... check for life
  - Findings: there is bacteria in the broth! Spontaneous generation must be right.
  - Problem: did not heat broth long enough to remove all microbes



- Lazzaro Spallanzani, an Italian doctor, was sure Needham made a mistake when attempting to remove all microbes and repeated his experiment
  - In support of: **BIOGENESIS!**
  - Experiment: pour broth in two flasks; heat broth (kill microbes); seal one flask and leave the other open
  - Findings: only the open flask contained microbes



#### Pasteur (1862-1864)



- French scientist that ended the debate
  - In support of: **BIOGENESIS!**
  - Setup: built upon the work of Needham and Spallanzani, but with a twist
    - Control: flask with broth that had been heated to kill microbes
    - Experimental setup: swan-neck flask with broth heated to kill microbes
      - Air has access to the broth!
  - Findings: swan-neck flask remained microbe-free until tilting the flask, allowing the broth to pick up microbes from the bend... spontaneous generation is not real!

#### Life on Earth

- Earth: 4.6 billion years old
- Method of aging: radioactive/absolute dating v. relative dating
- Early atmosphere: CO2, SO2, Methane, ammonia... no free O2
  - RNA, amino acids form and lead to first cells





#### Determining the Age of Fossils

**Relative Dating** 

- Approximate age based on the position in the layers of the sedimentary rock
- Fossils form when fine sediment buries organisms, but if they are not buried, it is possible to decay before fossilizing
- Areas with wet lowlands or slow moving water are excellent for fossil formation



Absolute Dating

- Exact age based on half-life of remaining fossil using radioactive dating (carbon-14)
- Half-life: amount of time it takes for <sup>1</sup>/<sub>2</sub> of the radioisotope to decay
- Remember: isotopes are the same atom with different numbers of neutrons
- Carbon Dating: You want to determine how long it is taking for half of the sample of the isotope to decay.



#### Breakdown of Time (Eras)



#### Oldest Life: 3.5 billion years ago (Precambrian Time)

- Atmosphere lacked free oxygen
  - Organisms had to be anaerobic
- First cells were archaebacteria (prokaryotes)
  - Cell walls lack peptidoglycan
  - Methanogens, halophiles, thermophiles
- First cells were heterotrophic
  - There were autotrophic archaebacteria (chemosynthesis, not photosynthesis)
    - As autotrophs began living, they put oxygen into the environment (produce ozone layer)
    - Oxygen began accumulating 2.7BYA (banded iron/rust in rocks)







#### Photosynthetic Prokaryotes (Precambrian Time)

- Blue green algae, cyanobacteria, were the first photosynthetic organisms
  - Produce: glucose, a carbohydrate (and oxygen)
  - Require: carbon dioxide (and water)
- Significant oxygen in the atmosphere 2 billion years ago





#### Eukaryotes Evolve (2.7 BYA - (Precambrian Time) Larger, more complex than prokaryotes

- Can reproduce sexually, increasing genetic variation
- Contain a nucleus and other membrane-bound organelles (golgi, lysosomes) for specific jobs in the cell
  - Internal membranes increase efficiency
- Process of evolution: Endosymbiosis



#### **Endosymbiotic Theory**



- Ancestral cell engulfed smaller cell (aerobic bacteria or photosynthetic bacteria), but did not digest it
  - Origin of the mitochondria and chloroplast
    - Mitochondria and chloroplast contain their own (circular) DNA; have bacterial shape/structure
  - Formed a mutually beneficial relationship



#### Paleozoic Era (245-542 MYA

- The first complex multicellular organisms evolve: FISH!
  - Fish are vertebrate (have a backbone)
- First plants evolve from seaweed and move to land
- Traces of complex burrows have been found- worms very active
- Dominant animal life: amphibians
  - Vertebrate that spends half its life in the water, the other half on lai
  - Certain fish evolved limbs and lungs for land life around 380 MYA
- Conifer, a type of plant, evolves
  - Better adapted to drier climates
  - Flowering plants not yet established (all other major plant groups are)
  - Mass extinction to close this period ended 95% of life on earth





#### Mesozoic Era (65-245 MYA)

- Pangea breaks and continents begin forming
- Reptiles begin to dominate
- Dinosaurs roamed in this period
  - First 150 MY of period is ruled by dinosaurs
- Birds evolve from dinosaurs about 155 MYA
- Mammals evolve at the same time as dinosaurs, but do not dominate
  - Many were very small, nocturnal insect eaters
    - Nocturnal: active at night (warm-blooded)
- Flowering plants and insects co-evolve
  - When two organisms evolve at the same rate, same time
- Leafy trees and shrubs also evolve



#### Cenozoic Era (Present)



- Comparatively short when compared to other eras, but full of fossils! (deep record)
- Mammals replace reptiles as the dominating group
  - Mammals: fur, fat, mammary glands, vertebrates
  - Angiosperm dominance (flowering plant) influenced faster evolution of birds and mammals
- ~35 MYA- climate became cooler/drier
  - Remember, mammals are warm-blooded
- ~2 MYA, humans evolved
  - Use of fire
  - Society and culture
  - Tools to control world



#### What you are doing now...

Theories of life/origin of life/sequencing life

- Answer questions
- Order events
- Make timeline on computer paper
  NEED DATES, IMAGES, DESCRIPTIONS