Alex Kasatkina September 5, 2018
E. Beaulieu BIO 3124

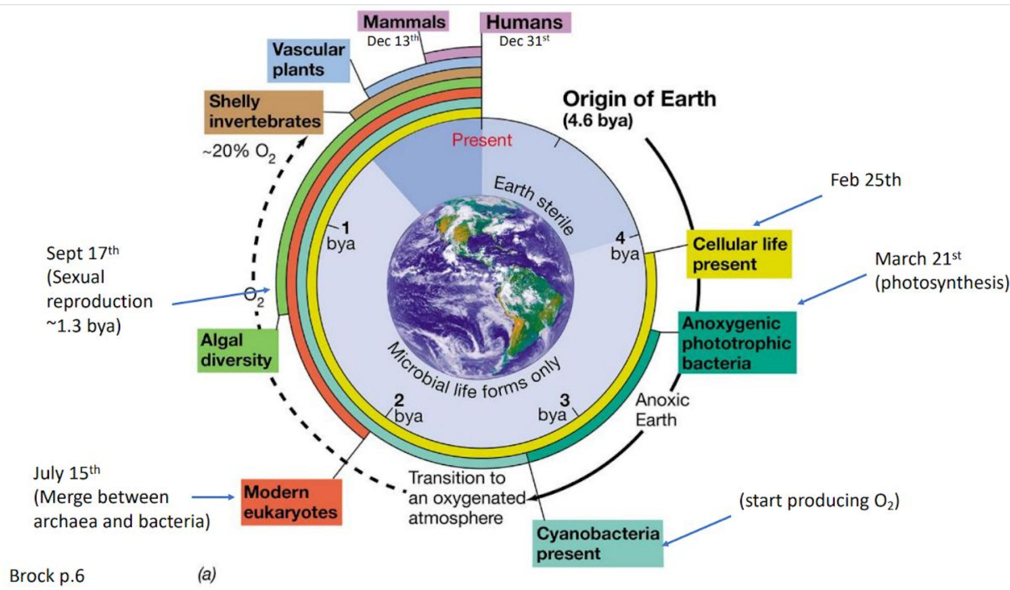
LECTURE 1: Introduction to Microbiology

"Precautions must also be taken in the neighborhood of swamps… because there bred certain minute creatures which cannot be seen by the eyes…"

- Marcus Terentius Varro, Roman Scholar, 2000 years ago.

Microbes are ANCIENT.

- Our planet is 4.5 billion years old. Life appeared around 3.8 billion years, and oxygen entered when when bacteria appeared and begun to change Earth's atmosphere.
- Later, bacteria and archaea merged to create the first eukaryotic cell.
- It wasn't until "recently" that single cells colonized and evolved with multicellular organisms.



Brock p.6

Microbes are NUMEROUS.

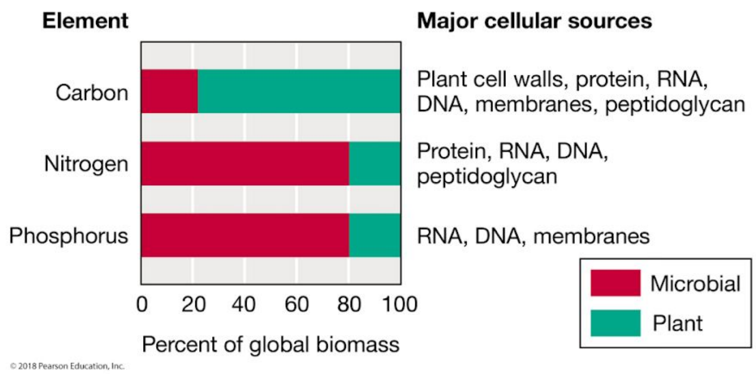
- World Population: 7.6 billion, or 7.6 x 10^9 as of July 2018.
- Microbial Population: 5 x 10^{30}, more than stars in the universe.
- If a microbe is 1 um in length, stacked next to each other in a row, microorganisms cover the distance between the earth and sun about 200 trillion times.
- <u>The contribution of microorganisms to the global biomass is significant.</u>

Where do they live?	
Air:	
Up to 34-46 mile high	5 x 10^{19}
Animals:	
All humans	4 x 10^{23}
Domestic animals, termites	5 x 10^{24}
Soils:	
Forests, grasslands, desert, tundra, swamps	2.5 x 10^{29}
Aquatic:	
Marine and freshwater	1 x 10^{29}
Subsurface:	
Terrestrial and deep ocean	3.8 x 10^{30}

LECTURE 1: Introduction to Microbiology

- 90% of plants have symbiotic relationships with fungi or bacteria. Plants cannot fix enough nitrogen without microorganisms, and therefore wouldn't be able to exist.

You would think plants are the greatest contributors and it's true for carbon, but not for nitrogen and phosphorus



Brock Fig 1.7 p.7

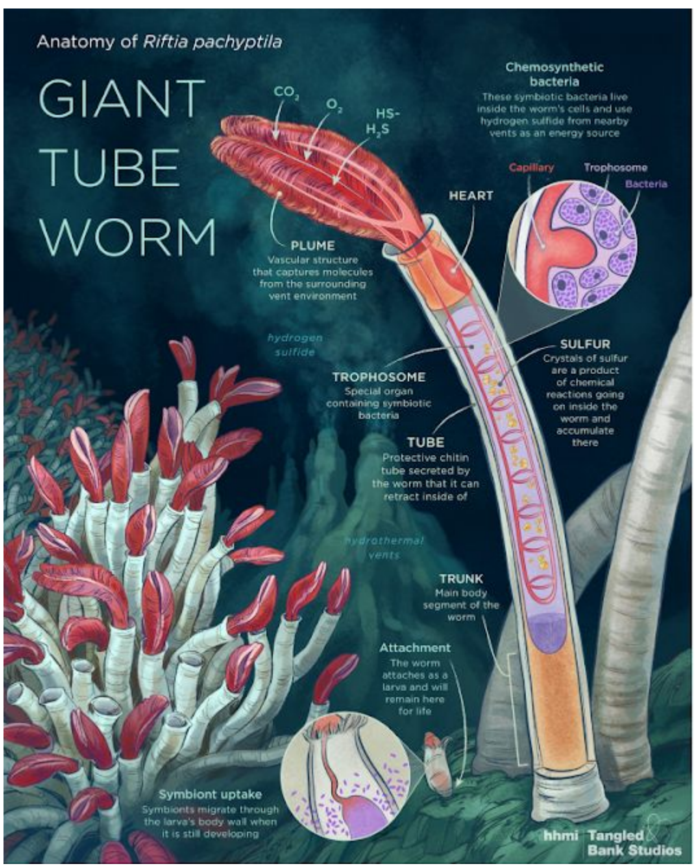
Microbes are DIVERSE.

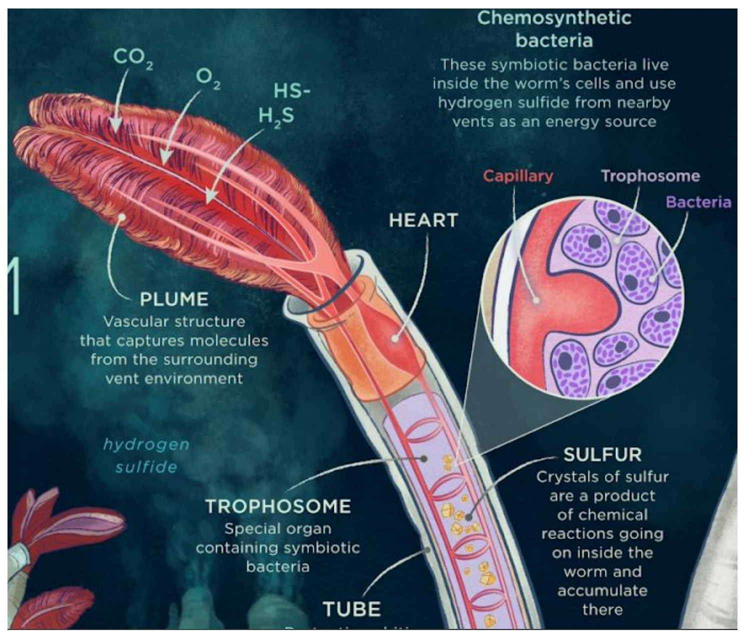
- Some bacteria are quite large (1mm) and have complex structures.
- Unicellular green algae can be huge & have complex structures (up to 200mm).

- Their immense diversity allows them to be everywhere in huge numbers. They:
  - Use different sources of energy
  - Use other organisms in symbiotic relationships
  - Developed inventive chemistry and biochemistry in order to get the metabolites they need.
  - Developed genetics that allow adaptation.
- This allowed microorganisms to **evolve** and **adapt** to every type of environment on Earth.

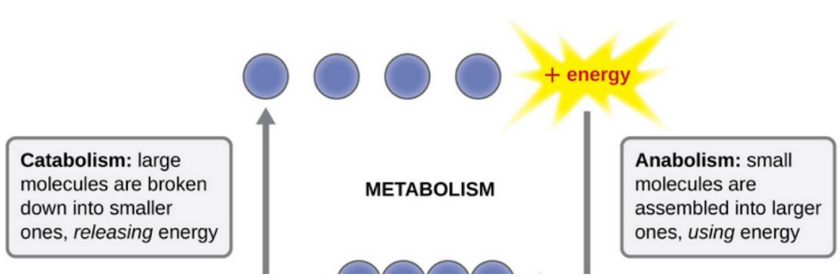
- You should look at microorganisms as ecosystems, even within medical context. They behave like communities and form relationships.
- Microorganisms can live in very extreme environments.
  - **Hyperthermophiles** can live in near boiling temperatures. *Thermus aquaticus* (used for Taq polymerase is designed to work in high temps.)
  - **Psychrophiles** live in extreme cold. There's a species that lives in Antarctica under glaciers. It has no carbon or sunlight, so it has adapted to use Iron II + SO_4^{2-} to make Iron III for energy. It pumps out this iron, creating the illusion of "blood falls".

- **Acidophiles** can live where the pH is close to 0.
- **Alkaliphiles** can survive in a pH range from 8.5 - 12.
- Some can survive immense pressure and allow life to thrive at the bottom of the ocean (make it possible for plants to grow there).
- **Halophilic** microorganisms can survive concentration of salt up to 37% (human blood salt concentration is 0.9%). They are photosynthetic, but don't produce glucose; they use sunlight directly to form a chemiosmotic membrane to produce ATP.
- **Polyextremophiles** can withstand multiple extremes. One example is "Conan the Bacterium" (*Deinococcus radiodurans*), which can withstand cold, dehydration, acid, and extreme radiation.





Microbes are genius BIOCHEMISTS.



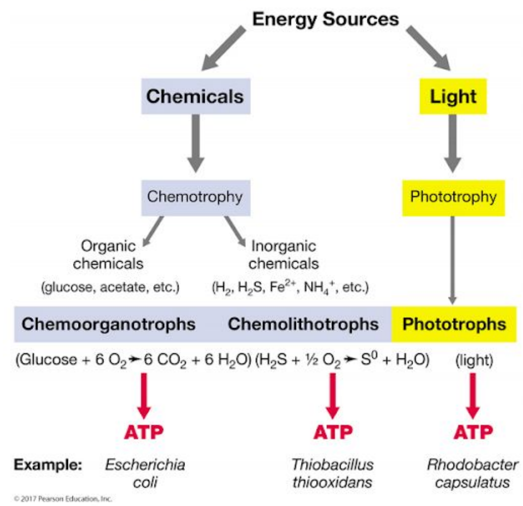
Alex Kasatkina September 5, 2018
E. Beaulieu BIO 3124

LECTURE 1: Introduction to Microbiology

All microbes want is to **divide**. To do that they need energy and carbon. It's all about metabolism.

- Where can I get energy from?
  - Chemicals (chemotrophy)
    - Inorganic (**chemolithotrophy**): H_2, H_2S
    - Organic (**chemoorganotrophy**): glucose, lipids…
  - Sunlight (**phototrophy**)

- What is my carbon source?
  - Autotrophs (use CO2)
  - Heterotrophs (from organic compounds)



Brock p.78

Limits on metabolism

1. Thermodynamic limits - Has to have a minimum amount of energy that can sustain minimal metabolic activity.
2. Substrate needed for metabolism must be bioavailable and/or transportable.
3. Substrates or products must not be toxic.

Microorganisms are neither good or bad and they are almost never alone They are opportunistic!

- Microorganisms have evolved multiple living arrangements with other organisms. This is called **symbiosis**.

Types of Symbiotic Relationships

Type	Population A	Population B
Mutualism	Benefitted	Benefitted
Amensalism	Harmed	Unaffected
Commensalism	Benefitted	Unaffected
Neutralism	Unaffected	Unaffected
Parasitism	Benefitted	Harmed

- These living arrangements are in constant flux.

- When a community of microorganisms occupying the same environment is in equilibrium, it is said to be in **symbiosis**.
  - eg: Bacteria fermenting cellulose in ruminants are the animals major source of lipids (and farts!).
  - eg: Native Mexican corn, mucus and nitrogen fixing bacteria
- When the equilibrium fails, the community is in **dysbiosis**.
  - eg: balance between “good” gut bacteria (probiotics, yeasts) and pathogenic bacteria can cause gut dysbiosis.
- When one species takes over the community, it can sometimes result in **pathogenesis**.
  - <u>OPPORTUNISTIC:</u> Fungal infection from several fungal species, including Trichophyton, Epidermophyton, and Microsporum.
  - INFECTIOUS AGENTS: vector borne (Lyme disease) or direct infection (flesh-eating bacteria).
  - eg: parasitic Cordyceps fungal infection “zombifies” ants causes the ants to move upwards into the air to spread spores.

Human - Microorganism Relationships

- Taking into consideration the genetic potential of organisms only in our gut: provides 100X the genetic potential of all our cells. The human genome consist of 23,000 genes, but there are 2,300,000 microbial genes.

- Agriculture and Food Industry:
  - Plant microorganisms relationships
  - Fermented foods
  - Food contamination
- Biotechnology
  - Using microorganisms as factories
    - To generate chemicals, pharmaceuticals, research tools, etc…
  - Using microorganisms in industrial processes
    - **Bioleaching**: extraction of metals from their ores through the use of living organisms.
    - **Bioremediation**: process used to treat contaminated water, soils.

Conclusion

- There are 5.6 x 10^6 known species… And an expected 1 x 10^{12} in total.
- The entire **Earth Microbiome Project (EMP)** sequence bank covers less than 10^7 species, 29% of which have only been detected twice.