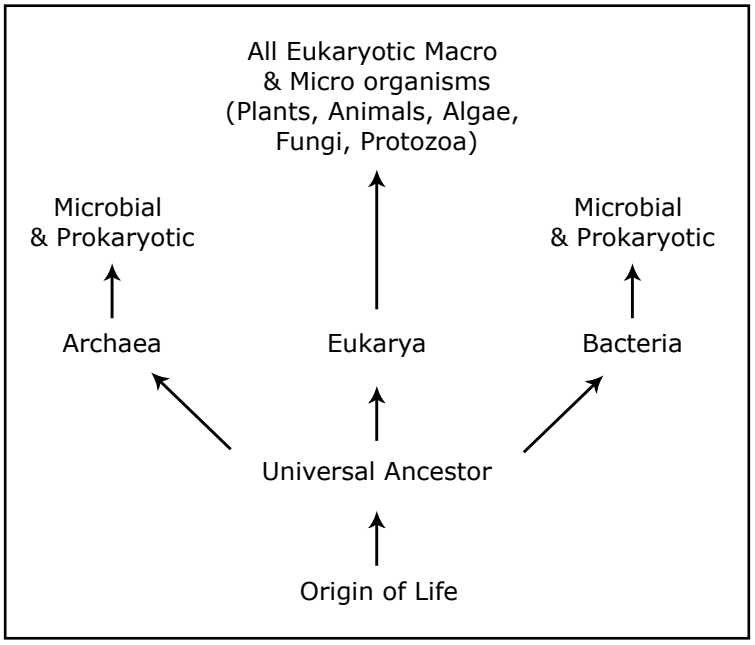
1.89, Environmental Microbiology
Prof. Martin Polz
Lecture 2

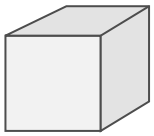
Microorganisms



- Small, 10^{-6} m = 1 µm
- Unicellular (∴self-sufficient)
- Diverse metabolism, physiology (20 million organic substrates)
- Adaptability → physiological
  → genetic
- Ubiquitous
  - 10^{6} cells/mL (natural waters)
  - 10^{9} cells/g (soils + sediments)

~ 10^{6} cells/mL → 1 µm

1 mL H_2O = 10^{12} µm^3



individual cell 10^{12} µm^3 → $1/10^{9}$ of volume occupied by bacterial cells

Today

1. Observational tools
2. Chemical composition
3. Cells architecture

1. Tools

1) Light Microscope: maximum magnification = 1,500 fold
   resolution ≅ 0.2 µm
   → Staining to increase contrast:
   - color stains
   - fluorescent stains - "epi-fluorescent microscopy"
   - confocal laser stains

2) Electron Microscope: ~ 1000 higher fold resolution (2,500 fold)

   → Transmission EM (TEM) – 2D → fix (example: aldehydes), dehydrate, embed in plastic, section, stain (with heavy metals), mount

   → Scanning EM (SEM) – 3D → fix, dehydrate, coat with heavy metals

Bacterial Shapes: coccus, rod, spirillum, spirochete, stalk, hypha, flamentous

→ Can not use cell morphology to identify a cell because some types take many shapes.

Cell Morphology:

- Shape: >6 types
- Size:
  - Bacteria archaea (size varies with nutritional state): 0.1-600 µm (~ 1 µm avg.)
  - Eukarya: 2-200 µm

Smaller cells have a higher surface volume ratio than larger cells, so they (small) can take up nutrients more efficiently than big cells because more surface per unit volume.

2. Chemical Composition

Bacteria/archaea:

Dry weight (DW):wet weight (WW) = 0.2-0.4
DW:WW ≅ 0.3 (avg). So 70% H_2O

Bacteria: DW (composition):

C:N ≅ 5:1

C: 50%	P: 3%
O: 20%	K: 2%
N: 14%	S: 1%
H: 8%	Ca, Mg, Cl: 0.05%

C, N, P are ~ constant because need a certain ratio to grow

Eukaryotes: DW:WW ~ 0.1 (90% H_2O)

– Macromolecular composition

↳ Avg. e. coli: ~ 50% composition

Size & mass variation: example - *Applied & Environmental Microbiology* 64 (1998): 688.

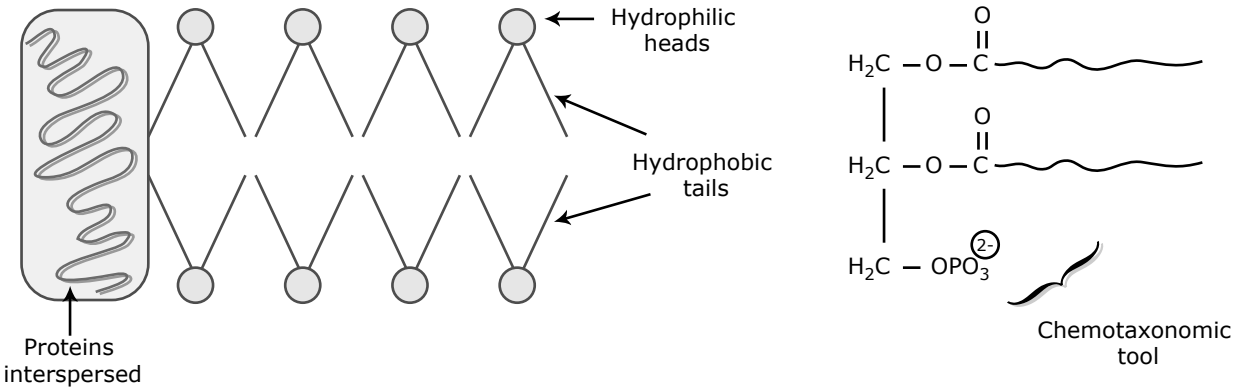
DW (fg)	25%	Median	75%
Exponentially growing cells	358	489	622
Stationary cells	148	179	211

} demonstrates available nutrients : size

⚠ Conclusion: Starved cells shrink to increase Surface Area:Volume ratio so that they can take up more nutrients relative to their size.

3. Cell Architecture

- Cytoplasmic membrane: phospholipids bilayer



membrane is semipermeable: small >> large
uncharged >> charged

∴ charged molecules must move across membrane via active transport.

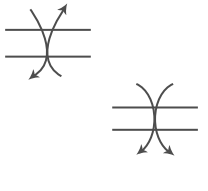
- 3 types of carriers/transport strategies:

1) intracellular concentration gradient

$pK_a = 9.3 : NH_3 \rightleftharpoons NH_4^+$ (becomes protonated because more acidic in cell, so now has charge, stays in cell)

2) Pump: antiporters

↳ Simple { Symporters / Uniporters



} Simple transporters

↳ Group {example PTS (Phosphotransferase System)

3) ABC transporters (antigen binding casette)

→ Transport
- Energy intensive!
- Transport can increase concentration up to 1,000 fold
- Often decisive in competitive interactions