

# CH 24 - Early Life & Prokaryotes

(1)

## Conditions Necessary for First Cells



- (1) Abiotic Synthesis of amino acids & nucleotides
- (2) Formation of macromolecules  $\Rightarrow$  Proteins - nucleic acids
- (3) Proto-cells with membranes
- (4) origin of self-replicating molecules - DNA/RNA

## Experiments

### Oparin & Haldane

- UV radiation, lightning, reduction (+  $e^-$ )
- "primordial soup" of organic compounds

### Miller-Urey

- tested Oparin-Haldane hypothesis in LAB
- was widely cited; now controversial
- ?? composition of atmosphere
- ?? oxidizing, reducing, or neutral
- "micro" atmospheres near volcanoes?

$\hookrightarrow$  Amino acid synthesis possible !!

Meteorites - another source of AA's

### Clay Polymerization

- experiments to see if synthesis of proteins/DNA/RNA possible from precursors.
- AA's or nucleotides dripped slowly onto hot clay can produce polymers

### Proto-cells

- Vesicles - aka coacervates - form when lipids added to water

↳ our 2<sup>nd</sup> LAB

↳ bilayer forms

↳ in clay especially

↙ !!

### Self-replicating RNA

- RNA was likely first
- Ribozymes (remember?) are RNA that perform enzyme-like catalytic functions

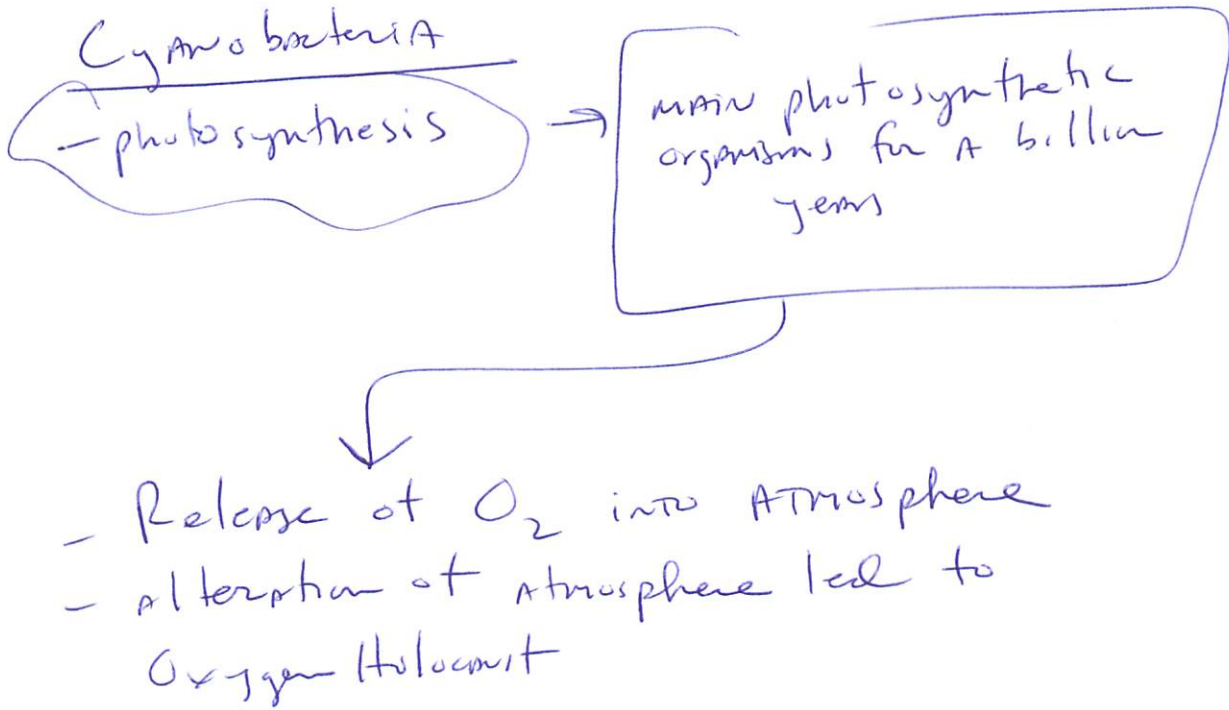
↳ "RNA World"

↳ RNA can make variety of 3-D shapes

↳ RNA led to more stable DNA which replicates more accurately

# Fossil Evidence of Early Life

Stromatolites — 3.5 bYA



# CH 4

①

Ribozymes - RNA catalysts

"RNA world" - vesicles with self-replicating catalytic RNA

Stromatolites - layered rocks formed by bacterial activity. 3.5 bya

Cyanobacteria - photosynthetic.

- O<sub>2</sub>

- cellular respiration is a biochemical adaptation to O<sub>2</sub>

Prokaryotes

- cocci - spherical

- bacilli - rod-shaped

- spiral

cell wall - 0.5 - 5  $\mu$ m

- contains peptidoglycan

~~★~~ ~~★~~  $\rightarrow$  Archae lack peptidoglycan

Gram positive -  $\uparrow$  peptido

Gram negative -  $\downarrow$  peptido

$\rightarrow$  capsule or "slime layer" surrounds cell wall

Endospores - dormant for centuries !!

Fimbria - appendages to attach.

Pili - DNA transfer

(2)

Taxis - directed movement toward or away from a stimulus

i.e. positive or negative chemotaxis.

Flagella - Analogous to flagella in eukaryotes.

↳ exaptation ⇒ process in which existing structures take on new functions through descent with modification.

- Circular chromosomes
- no nucleus (DNA in a region - nucleoid)
- plasmids

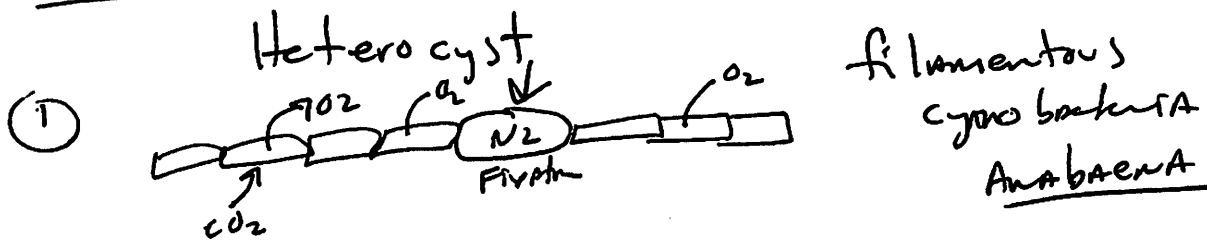
- Photo autotrophs
- Chemo autotrophs
- Photo heterotrophs
- Chemo heterotrophs

- 1) Obligate Aerobes
- 2) obligate Anaerobes
- 3) Facultative Anaerobes

(3)

Nitrogen Fixation -  $N_2$  to  $NH_3$  (ammonia)

Metabolic cooperation in prokaryotes;



② Biofilms - tooth decay.

Reproduction

- 1) Small
- 2) reproduce by binary fission (20 min to 3 hrs)
- 3) short generation times.

⇒ Prokaryotes ⇒  
Metabolic  
Diversification !!!

# Genetic Diversity

(4)

- ① rapid reproduction
- ② mutation
- ③ genetic recombination.

low mutation rate  $\times$  large population  $\times$   
short generation =

DIVERSITY

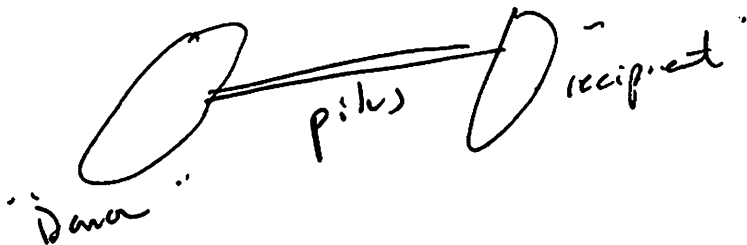
## Genetic Recombination

- ① Transformation
- ② Transduction
- ③ Conjugation

Transformation - uptake of DNA from  
another strain

Transduction - viral vector of DNA

Conjugation - "donor" and "recipient" of  
DNA



F factor (fertility) - DNA a plasmid with code  
for pilus

- cells  $\Rightarrow$  F<sup>+</sup> - donor  
F<sup>-</sup> - recipient

Shigella → dysentery → antibiotic resistance

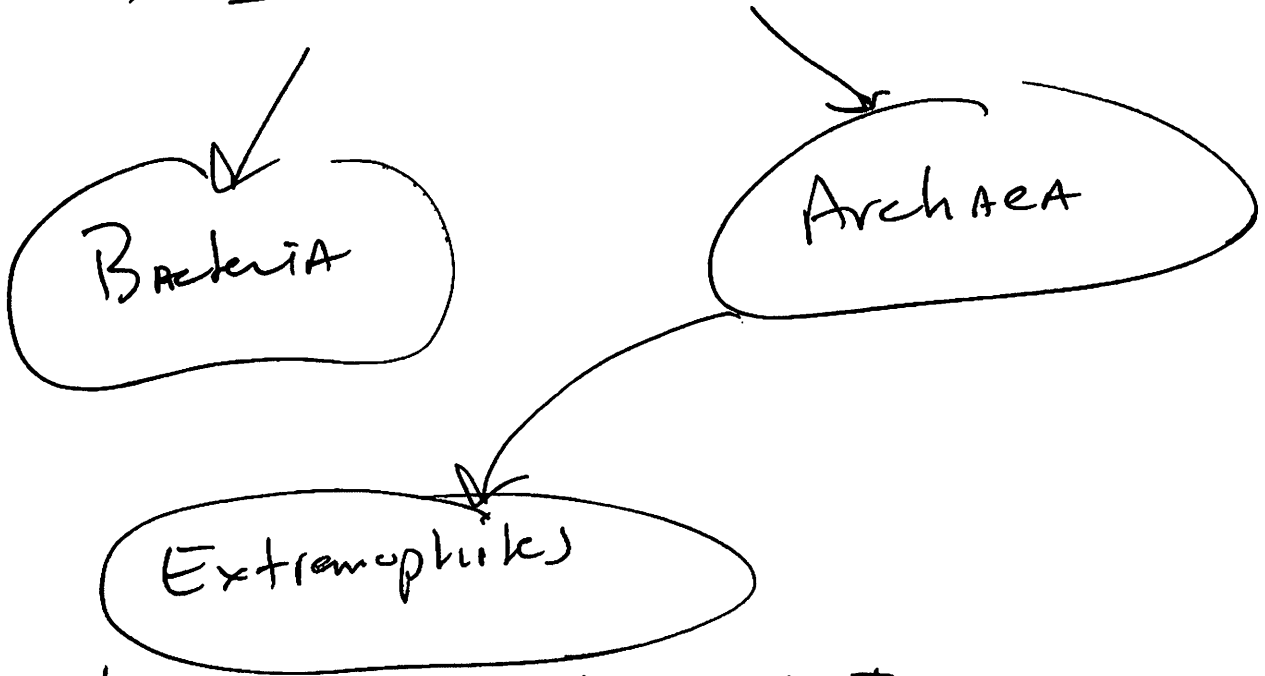
R plasmids (resistance) - confer resistance to certain antibiotics.

↳ can also carry "F" genes and form

↳ pili can confer resistance for up to 10 antibiotics.

Diversity of prokaryotes is immense

→ horizontal gene transfer



↳ extreme halophiles → salt

↳ extreme thermophiles → 121°C

⇒ methanogens → swamps → "marsh gas"  
→ sewage → guts of cattle



# Role in biosphere

- Decomposer
- produce  $O_2$
- "fix"  $N_2$

## Ecological Interactions



### MUTUALISTIC BACTERIA

- 500 - 1,000 species of bacteria in human intestines.

# Pathogenic Bacteria

- ↳ tuberculosis
- ↳ diarrheal disease
- ↳ Lyme disease carried by ticks

produce poisons → Exo toxins - secreted by bacteria

↳ Endotoxins → part of cell wall

- ↳ cholera
- ↳ botulism

↓  
salmonella

H.G. Tranter → can turn harmless bacteria into pathogens.

O157:H7 → E. coli

phage-mediated horizontal gene transfer (TRANSDUCTION)

# Positive

- ↳ cheese
- ↳ yogurt
- ↳ biotech
- ↳ bio-plastic polymer
- ↳ bio remediation → sewage
- oil
- nuclear waste.