

Introduction to Biology. Lecture 14

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Outline

- 1 Prokaryotes
 - First life and oxygen revolution
 - Photosynthesis and respiration
 - Prokaryotic cell
 - Protein biosynthesis
- 2 Eukaryotes
 - Eukaryotic cell
 - Mitosis
 - Precambrian life

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Prokaryotes

First life and oxygen revolution

Two first bacterial lineages

- Stromatolites: microbial mats from (mostly) cyanobacteria (photosynthetic bacteria)
- *Metallogenium* and others: proteobacteria (e.g., aerobic metal-oxidizing bacteria)

Prokaryotes

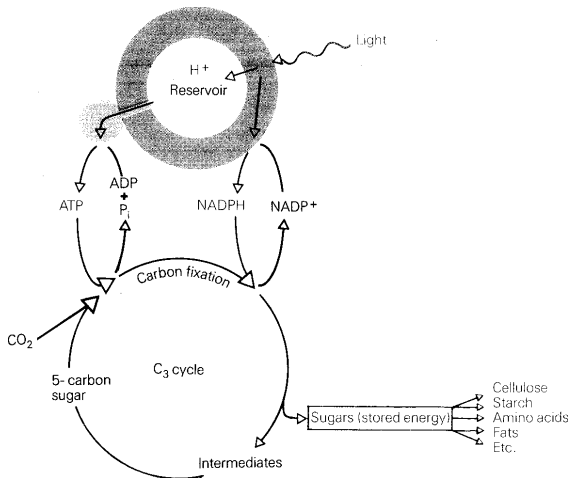
Photosynthesis and respiration

Photosynthesis

- $\text{CO}_2 + \text{H}_2\text{O} \xrightarrow{\text{light, chlorophyll}} \text{carbohydrates} + \text{O}_2$
- Two stages:
 - A Light-dependent: production of energy (ATP) and photolysis of water
 - B Light-independent: assimilation of CO_2 into carbohydrates
- Then carbohydrates are partly converting into lipids; with addition of N—into amino acids; with addition of N and P—into nucleotides



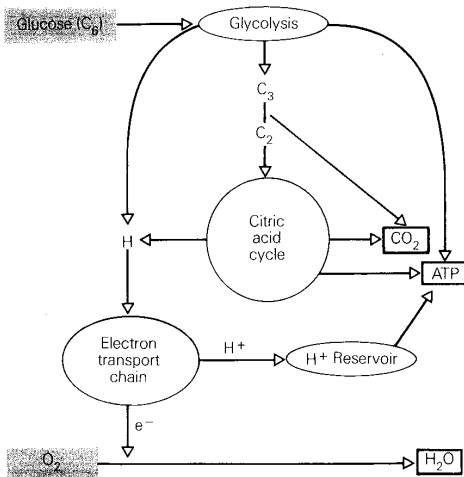
Photosynthesis



Glycolysis (fermentation) *versus* respiration

- carbohydrates \rightarrow CO_2 + ethanol + 2 ATP
- carbohydrates + $\text{O}_2 \rightarrow \text{CO}_2$ + H_2O + 38 (!!!) ATP

Glycolysis and respiration



Ways of life

- How to obtain energy?
 - A From sun light: **phototrophy**
 - B From chemical reactions with inorganic matter (“rocks”):
lithotrophy
 - C From breaking organic molecules into inorganic (typically, carbon dioxide and water): **organotrophy**
- How to obtain building blocks?
 - A From assimilation of carbon dioxide: **autotrophy**
 - B From other living beings: **heterotrophy**



Six life styles

	Phototrophs	Lithotrophs	Organotrophs
Autotrophs	Plants	Bacteria	Bacteria
Heterotrophs	Bacteria	Bacteria	Animals

Prokaryotes

Prokaryotic cell

Main components of prokaryotic cell

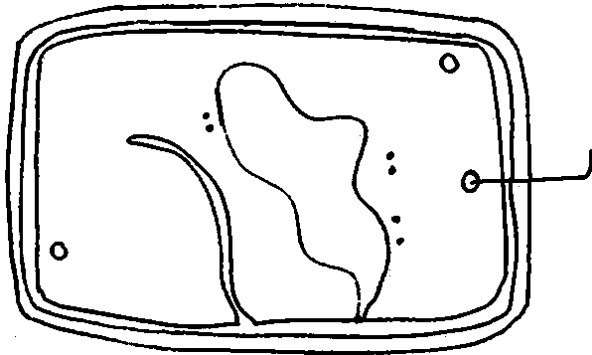
- Cell wall
- Membrane
- Cytoplasm
- DNA
- Ribosomes
- Tylacoids (membrane pockets)
- Vesicles
- Flagella



Prokaryotes
Eukaryotes

First life and oxygen revolution
Photosynthesis and respiration
Prokaryotic cell
Protein biosynthesis

Prokaryote



Digestion

- Digestive proteins are transported outside membrane
- They destroy polymers into monomers
- Monomers then are pumping through membrane into the cell
- If cell is photosynthetic, it produce monomers itself

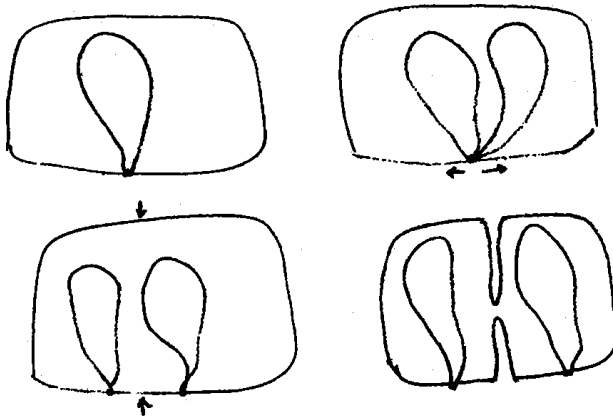
Catabolic and anabolic reactions

- Monomers could be spend:
 - in destructive reactions to obtain ATP, **or**
 - in synthetic reactions to make new polymers. These reactions are using ATP

Cell division

- DNA is a double helix which may copy itself
- Two copies of DNA untangled and separated, then cytoplasm and membrane divide
- Of course, these processes spend lots of ATP

Prokaryote cell division



Conjugation

- If DNA will stay unchanged, cells cannot evolve
- To make evolution possible, there are processes which modify DNA:
 - Mutations
 - Recombinations
- Sexual process allows DNA recombination
- Prokaryotic cells simply connect and exchange pieces of DNA (“bacterial conjugation”)



Prokaryotes

Protein biosynthesis

DNA

- Proteins are chemical machines of cell
- Each machine is described in **gene**
- The only way to make them is DNA → RNA → proteins
- DNA is a folded double spiral; it has two chains
- Every chain consists of four “letters”—nucleotides (A, T, G, C)
- Two chains are complimentary, and only A–T and G–C pairs are possible



Transcription

- DNA may duplicate: every chain of “old” DNAs will build a complimentary chain; they become exact copies
- DNA may also “produce” RNA: one of chains serves as matrix for new RNA
- RNA also has four letters (A, U, G, C)
- When RNA is building on DNA, RNA’s “U” will be complimentary with DNA’s “A”; all other rules are the same



Translation

- New RNA is a messenger (matrix) RNA (mRNA)
- It will come into ribosome, and ribosome will translate every three letters (triplet) into amino acid
- mRNA moves within ribosome, and new amino acids are joining into growing protein
- Translation rules are known as “genetic code”
- There are 64 possible triplets and only 20 amino acids—genetic code is redundant



Eukaryotes

Eukaryotic cell

Six basic ecological interactions

	+	0	-
+	mutualism	commensalism ¹	exploitation ²
0	...	neutralism	amensalism
-	interference ³

¹ Includes phoresy (transportation), inquilinism (housing) and “sponging”

² Includes predation, parasitism and phytophagy

³ Includes competition, allelopath and aggression



Eukaryotes are flexible predators escaped from antibiotics

- New protein synthesis pathways
- Cytoskeleton (made from actin and other proteins) supports big size, flagella, cytoplasm motility and phagocytosis
- Nucleus keeps bigger, regulative DNA
- Symbiotic mitochondria supports intensive ATP production

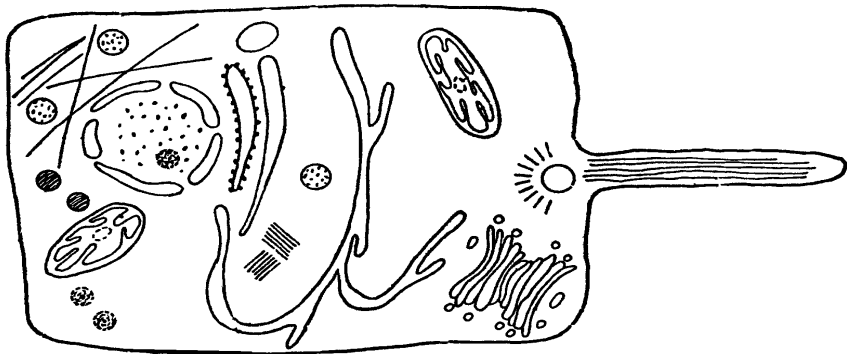
Evolutionary steps towards the eukaryote

- Archebacteria
- Symbiogenesis

Eukaryotic cell

- A Membrane and cytoplasm
- B Cytoskeleton
- C Nucleus
- D Mitochondria
- E Internal membrane system

Eukaryote



Eukaryotic cell trade-off: pluses and minuses

- Flexible, but bigger and no cell wall
- Nucleus, but cell division will pose a problem
- Mitochondria are very effective, but less controlled

Eukaryotes

Mitosis

Cell cycle

- Interphase
 - Pre-synthetic period (G_1)
 - Synthetic period (S): duplication of DNA
 - Post-synthetic period (G_2)
- Mitosis: $X \rightarrow I + I$
 - Prophase
 - Metaphase
 - Anaphase
 - Telophase
- Cytokinesis

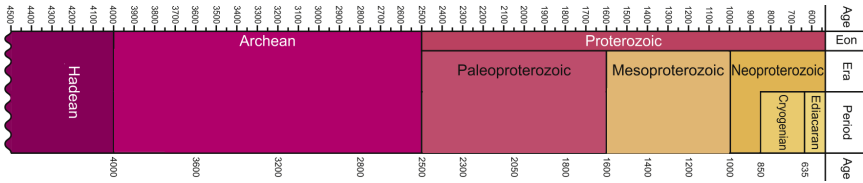
Eukaryotes

Precambrian life

Prokaryotes
Eukaryotes

Eukaryotic cell
Mitosis
Precambrian life

Time scale for Precambrian



Main events in Precambrian

- Rodinia and Marinoan glaciation
- Multicellular algae
- Multi-tissued animals

Algae

- Result of symbiosis with photosynthetic cyanobacteria or other algae
- Multicellularity: escape from predators and division of labor between somatic and generative cells

Animals

- Started as hunting cell assemblages
- Two primary tissues: kinoblast and phagocytoblast

Ediacarian fossils

