

Hadean and Archean eons

Hadean and Archean eons.



BIO1130 Organismal Biology Whirlpool galaxy M51

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Geological time scale and life forms
(Table 1.1 pg xii)


- **Major Eons**
 - **Phanerozoic** (543 Ma to present time)
 - Multicellular organisms
 - **Proterozoic** (2,500 – 543 Ma)
 - Oxygen atmosphere, single celled aerobic organisms
 - **Archaean** (3,800 – 2,500 Ma)
 - Anaerobic bacterial life, oxygen starts to accumulate
 - **Hadean** (4,600 – 3,800 Ma)
 - Formation of the solar system and planet, ends with origin of life

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Geological time scale and building height
(1 floor – 60 Ma, 72 floors, 12 feet/floor)

- **Major Eons (Ma)**
 - **Phanerozoic**
 - (543 Ma to present time, top 9 floors)
 - **Proterozoic**
 - (2,500 – 543 Ma, 33rd – 63rd)
 - **Archaean**
 - (3,800 – 2,500 Ma, 12th – 33rd)
 - **Hadean**
 - (4,600 – 3,800 Ma, 0–12th)



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Hadean and Archean eons

Geological time scale and life forms
(Table 1.1 pg xii)

- **Major Era**
 - **Phanerozoic** (550 Ma to present time)
 - **Cenozoic** (65Ma to present time)
 - Dinosaurs disappear, mammals and birds
 - **Mesozoic** (251-65 Ma)
 - Flowering plants, dinosaurs, even more insects
 - **Paleozoic** (543-251 Ma)
 - Marine invertebrates, algae, “Cambrian explosion”, first land plants and insects.
 - **Proterozoic** (2,500 – 543 Ma)
 - **Archaean** (3,800 – 2,500 Ma)
 - **Hadean** (4,600 – 3,800 Ma)

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Geological time scale and building height
(1 floor – 60Ma, 72 floors, 12 feet/floor)

- **Major Era**
 - **Phanerozoic**
 - **Cenozoic**
(65 Ma to present time, 72nd floor)
 - **Mesozoic**
(251-65 Ma, 65th to 71st)
 - **Paleozoic**
(543-251 Ma, 63th to 65th)
 - **Proterozoic** (2,500 – 543 Ma)
 - **Archaean** (3,800 – 2,500 Ma)
 - **Hadean** (4,500 – 3,800 Ma)

Your life span = 0.0002 inches
Human hair = 0.001 inches



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Hadean eon
(4,600 – 3,800 Ma)




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Hadean and Archean eons

Galaxies



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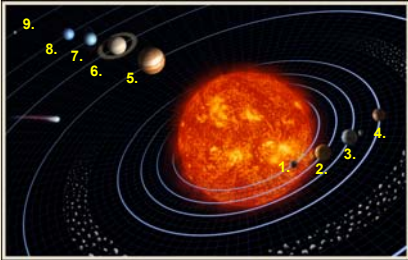
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Our Solar system

Sun video

1. Mercury
2. Venus
3. Earth
4. Mars
5. Jupiter
6. Saturn
7. Uranus
8. Neptune
9. Pluto



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Hadean eon

- Building phase
- _____



Orion nubula (NASA)

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Hadean and Archean eons

Earth 4,000 Ma



Figure 2.7

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Origins of life on earth

- Special creation
- Extraterrestrial origins (_____)
- Spontaneous origins



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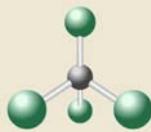
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Organic evolution

"Carbon is central to life...carbon atoms link in chains, bind with other atoms to make the array of organic chemicals that constitute life itself, from DNA to toenails" – Richard Fortey – Life



Carbon molecule

| Period | | | | | | | | | | | | | | | | Group | | | | | | | | | | | | | |
|-------------|---|----|----|----|----|----|----|----|----|----|----|-----|----|----|----|-------|------|----|----|----|----|----|----|----|----|----|----|----|----|
| 1 | 2 | | | | | | | | | | | III | IV | V | VI | VII | VIII | | | | | | | | | | | | |
| 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 |
| 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 |
| 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 |
| 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 |
| 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 |
| 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 |
| 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 |
| Lanthanides | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Actinides | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

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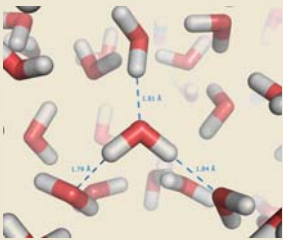
Wacky water

• Cohesion, adhesion and surface tension

• Solvent properties

• Ice formation

• Temperature



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Wacky water

Polar bonds and hydrogen bonding

_____ bonds



_____ bonds



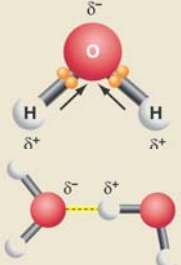


Figure 2-5, 12

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Wacky water

Solvent properties

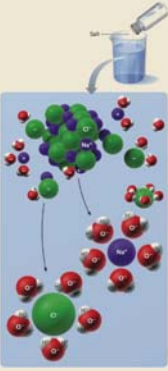


Figure F-13

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Page 5

Hadean and Archean eons

Wacky water
Ice and water formation

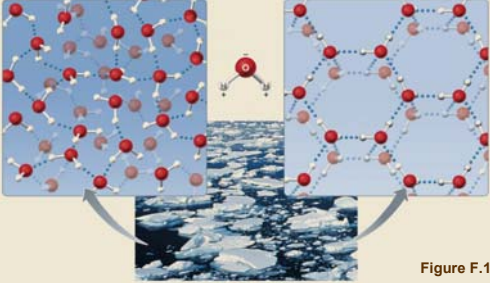


Figure F.11

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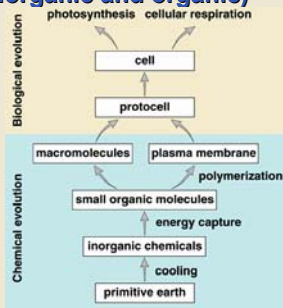
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Wacky water
Temperature

| Specific heats of some liquids (joules) | |
|---|------|
| Liquids with high levels of hydrogen bonding | |
| Ammonia (NH_3) | 4.70 |
| Water (H_2O) | 4.18 |
| Liquids with moderate levels of hydrogen bonding | |
| Ethanol ($\text{CH}_3\text{CH}_2\text{OH}$) | 2.44 |
| Ethylene glycol ($\text{HOCH}_2\text{CH}_2\text{OH}$) | 2.22 |
| Liquids with low levels of hydrogen bonding | |
| Benzene (C_6H_6) | 1.80 |
| Zylene (C_8H_{10}) | 1.72 |
| Sulfuric acid (H_2SO_4) | 1.40 |

Chemical evolution
Origins of organics (inorganic and organic)

- Prebiotic soups
- Hydrothermal vents
- _____



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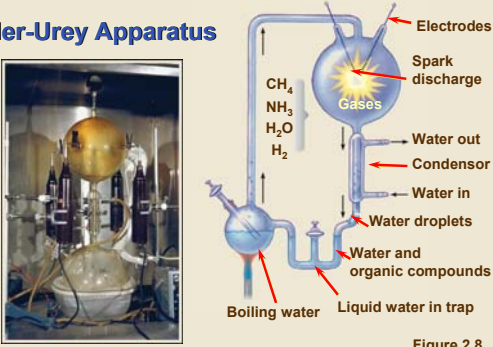
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Miller-Urey Apparatus



The diagram illustrates the Miller-Urey apparatus, a closed system for simulating the conditions of the early Earth. It consists of a round-bottom flask containing water, which is heated by a boiling water bath. The vapor rises through a vertical tube into a spherical chamber containing a mixture of gases: CH_4 , NH_3 , H_2O , and H_2 . Inside this chamber, two electrodes create a continuous spark discharge. The mixture then passes through a condenser, where it is cooled and falls back into the boiling water bath. Labels indicate the flow of 'Water out', 'Water in', 'Water droplets', and 'Water and organic compounds' in a trap. A photograph of the actual apparatus is shown on the left.

Figure 2.8

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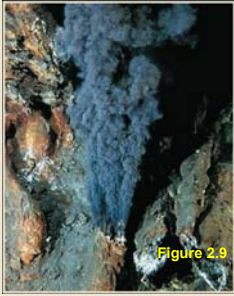
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Chemical evolution
Origins of organics (monomer)

- Prebiotic soups
- Hydrothermal vents
- _____



A photograph of a hydrothermal vent, showing a dark, mineral-rich chimney structure with a blueish-white mineral deposit at its base.

Figure 2.9

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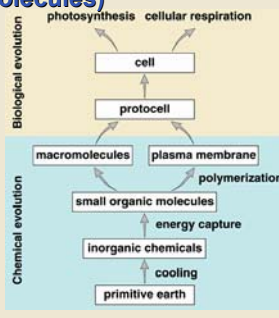
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Chemical evolution
Biopolymers (macromolecules)

- Proteins
- Nucleic acids
- Carbohydrate
- Lipids



The diagram shows the progression of chemical and biological evolution. At the bottom, 'primitive earth' leads to 'inorganic chemicals' through 'cooling'. 'Energy capture' leads to 'small organic molecules', which then undergo 'polymerization' to form 'macromolecules' and a 'plasma membrane'. These components form a 'protocell', which eventually becomes a 'cell'. The 'cell' is shown with 'photosynthesis' and 'cellular respiration' processes. The diagram is divided into 'Chemical evolution' (bottom) and 'Biological evolution' (top).

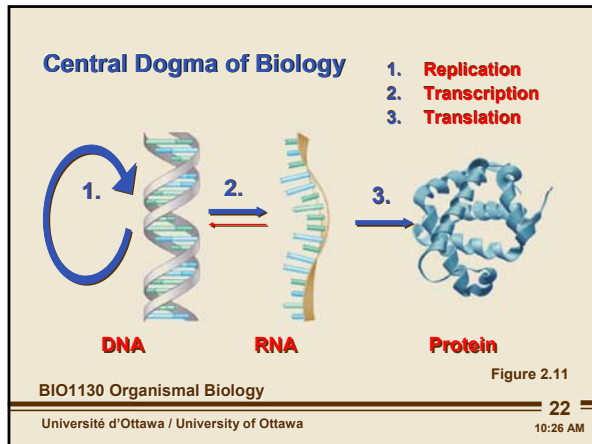
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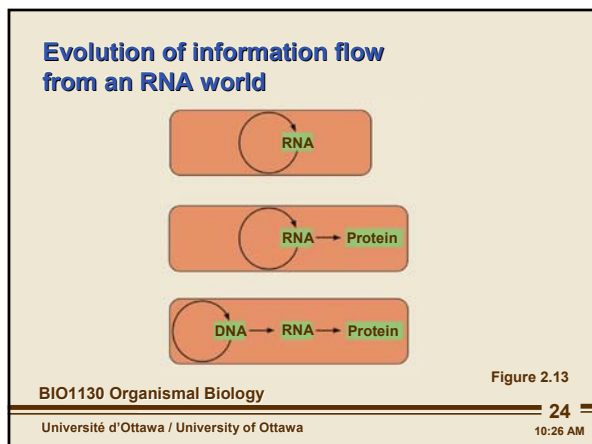


Biotic chemistry (Polymers)

- Panspermia
- The RNA world
 - Ribozymes
- Proteins first
- Clays

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Bubble hypothesis for cells

- **Microsphere**
- **Micelles**
- **Protocells**



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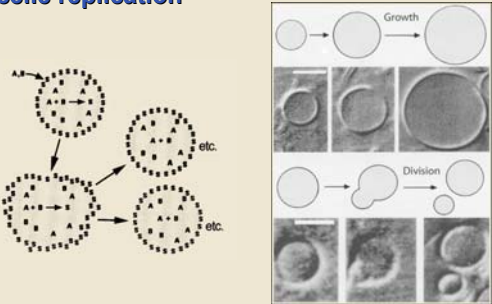
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Figure 2.10

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Micelle replication



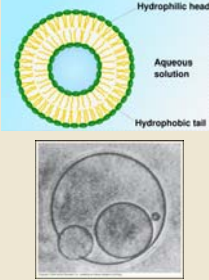
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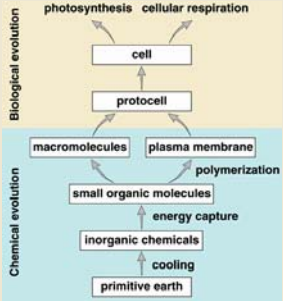
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Biological evolution: Protocells





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Biological evolution:
Protocells

The diagram illustrates a metabolic cycle within a protocell. Glucose-phosphate enters the cell and is converted to Starch by the enzyme Phosphatase. Starch is then broken down into Maltose by the enzyme Amylase. Maltose is then converted back to Glucose-phosphate, which can be used again or released as Phosphate. The cycle is contained within a green spherical protocell.

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What is life and emergence?

- **Organicists (1930)** – vital force replaced by genetic program and the importance of emergence.
- **Emergence** - More than the sum of the parts

The diagram shows two molecular models. On the left, a water molecule (H₂O) is depicted with a central red oxygen atom (labeled δ⁻) and two white hydrogen atoms (labeled δ⁺). On the right, a cluster of green and purple spheres represents the crystal lattice of sodium chloride (NaCl).

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What is life and emergence?

- **Emergence** - _____

The diagram shows two protein structures. On the left, a single globular protein chain is labeled Myoglobin. On the right, a tetramer composed of two Myoglobin subunits is labeled Hemoglobin.

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Hadean and Archean eons

What is life?

(Figure 2.2)

- **Self replicating** - Life from life with a genetic program
- **Metabolizing** - Capturing and releasing energy
- **Self regulating** - A delicate balance
- **Reproduce** - life from life
- **Evolving** - Adapting and changing
- **Responding** - Sensing and interacting with the surrounding world
- **Growth** - increase in size

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Prokaryotes - Domains Bacteria and Archaea

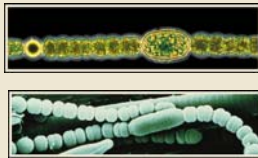


Figure 2.17

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Prokaryote diversity

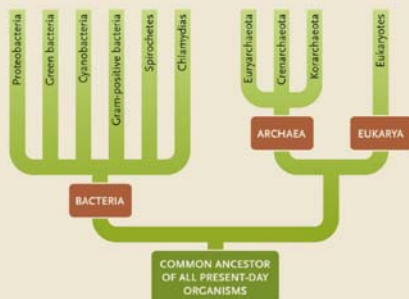


Figure 21.15

Hadean and Archean eons

Morphological diversity

● Size

● Shape

● Mobility

Cocci

1.0 µm

Bacilli

1.0 µm

Spirilla

1.0 µm

Squares

4.0 µm

Figure 21.2

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Bacterial cells

Cytoplasm

Pili

Plasmid

Flagellum

Plasma membrane

Peptidoglycan layer

Outer membrane

Capsule

Figure 21.3

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Bacterial cell walls

Gram _____

Capsule (may be present)

Peptidoglycan layer

Plasma membrane

Cytoplasm

20 nm

Figure 21.6a

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Hadean and Archean eons

Bacterial cell walls
Gram _____

Capsule (may not be present)
Outer membrane
Peptidoglycan layer
Plasma membrane
Cytoplasm

20 nm

Figure 21.6b

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Bacteria
Flagellum

Bearing Motor
Cytoplasm
Plasma membrane
Peptidoglycan layer
Outer membrane

Figure 2.24

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Bacterial reproduction

- Binary fission
- _____
- Transformation
- Transduction

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Bacterial reproduction
Binary fission

1. 2. 3. 4.

original DNA DNA copy

new membrane and cell wall

Figure 21.10

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Bacterial reproduction
Bacteria _____ **plasmid transfer**

Plasmid F factor

Bacterial Chromosome

1. 2. 2. 4.

F⁺ cell F⁺ cell

F⁺ cell F⁺ cell

Figures 10.6a

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Bacterial reproduction
Bacteria _____ **gene transfer**

1. 2. 3. 4. 5. 6.

a⁺ b⁺ c⁺ d⁺ a⁺ b⁺ c⁺ d⁺ a⁺ b⁺ c⁺ d⁺ a⁺ b⁺ c⁺ d⁺ a⁺ b⁺ c⁺ d⁺ a⁺ b⁺ c⁺ d⁺ a⁺ b⁺ c⁺ d⁺ a⁺ b⁺ c⁺ d⁺

a⁻ b⁻ c⁻ d⁻ a⁻ b⁻ c⁻ d⁻ a⁻ b⁻ c⁻ d⁻ a⁻ b⁻ c⁻ d⁻ a⁻ b⁻ c⁻ d⁻ a⁻ b⁻ c⁻ d⁻ a⁻ b⁻ c⁻ d⁻

Figures 10.6b

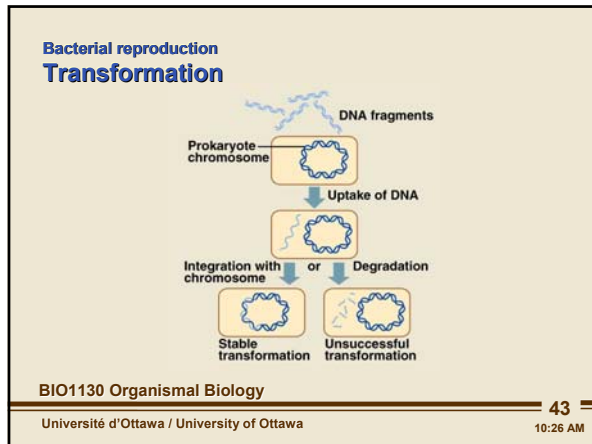
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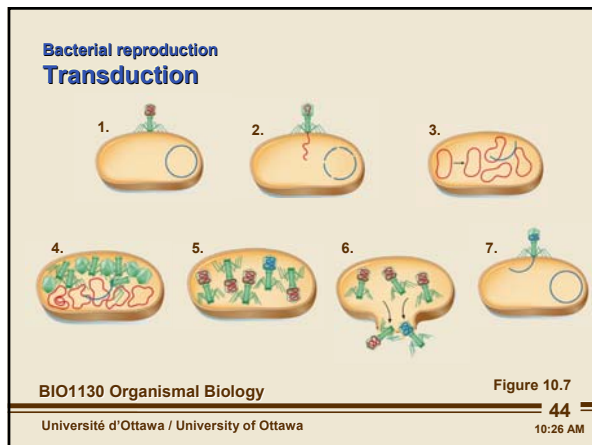
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Hadean and Archean eons





Metabolic diversity in ATP production and carbon sources

- **Autotrophic**
 - Phototrophs
 - Chemoorganotrophs
 - Chemolithotrophs
- **Heterotrophs**
 - Photoheterotrophs
 - Chemoorganoheterotrophs
 - Chemolithotrophic heterotrophs

A 3D molecular model of a protein structure, showing a complex arrangement of atoms represented by colored spheres (blue, red, yellow, green) and connected by bonds.

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Hadean and Archean eons

Redox pair

Oxidized (NAD⁺) Reduced (NADH)

$\text{NAD}^+ + 2 \text{e}^- + \text{H}^+ \rightleftharpoons \text{NADH}$

Reduction of NAD⁺ Oxidation of NADH

Figure 6.6

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Cellular respiration

(A) Direct burning of sugar (B) Stepwise oxidation of sugar in cells

Free energy

Sugar + O₂ CO₂ + H₂O

Large activation energy overcome by the heat from a fire

Small activation energies overcome by body temperature

All free energy is released as heat; none is stored

Energy transferred to carrier molecules

Figure 6.5

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Metabolic diversity

| Initial electron donor | Electron acceptor | By products | |
|--|---|---|-------------------------------------|
| | | From electron donor | From electron acceptor |
| Sugar | O ₂ | CO ₂ | H ₂ O |
| H ₂ or organics | SO ₄ ²⁻ (Sulfate) | H ₂ O or CO | H ₂ S (hydrogen sulfide) |
| H ₂ | CO ₂ | H ₂ O | CH ₄ (Methane) |
| CH ₄ | O ₂ | CO ₂ | H ₂ O |
| S ²⁻ or H ₂ S | O ₂ | SO ₄ ²⁻ (Sulfate) | H ₂ O |
| Organics | Fe ³⁺ | CO ₂ | Fe ²⁺ |
| NH ₃ (Ammonia) | O ₂ | NO ₂ ⁻ (Nitrite) | H ₂ O |
| NO ₂ ⁻ (Nitrite) | O ₂ | NO ₃ ⁻ (Nitrate) | H ₂ O |

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Hadean and Archean eons

Bacterial importance

- Disease
- Nitrogen fixation
- Decomposition
- Unique biochemical pathways
- Extremophiles (Archea)

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Prokaryotes and humans

| Transmission | Disease - <i>Bacterium</i> |
|--------------------|--|
| Airborne | Legionellosis - <i>Legionella pneumophila</i> Diphtheria - <i>Corynebacterium diphtherium</i> Tuberculosis - <i>Mycobacterium tuberculosis</i> |
| Arthropod | Lyme disease - <i>Borrelia burgdorferi</i> Bubonic plague - <i>Yersinia pestis</i> |
| Direct contact | Gonorrhea - <i>Neisseria gonorrhoeae</i> Anthrax - <i>Bacillus anthracis</i> |
| Food or waterborne | Food poisoning - <i>Salmonella enteritidis</i> Cholera - <i>Vibrio cholerae</i> Listeriosis - <i>Listeria monocytogenes</i> |

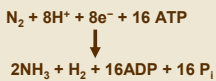
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Nitrogen fixation



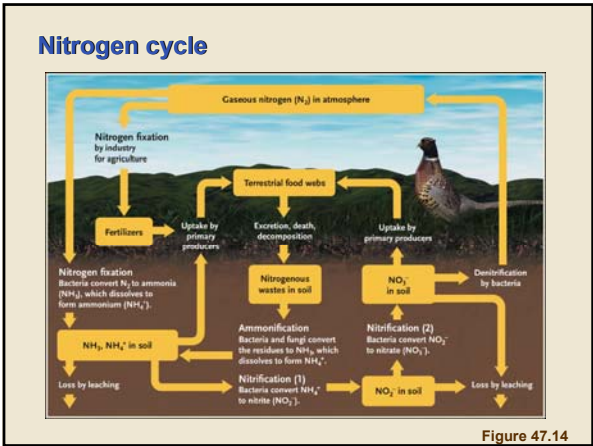
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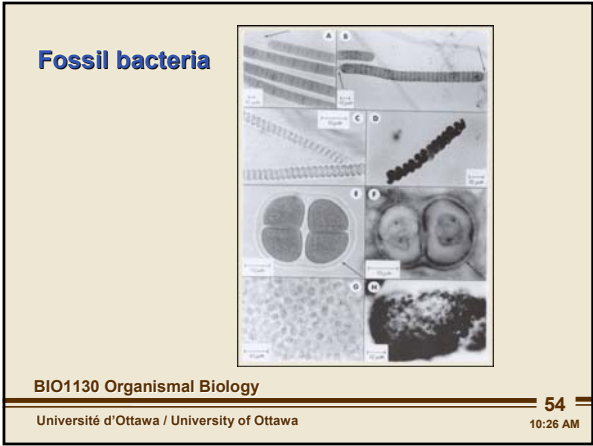
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Hadean and Archean eons







Hadean and Archean eons

Stromatolites




Figure 2.14

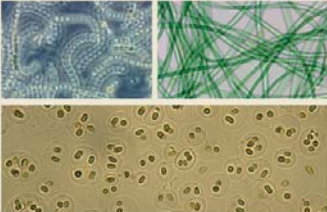
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Cyanobacteria and earth's evolution

$\text{CO}_2 + \text{H}_2\text{O} + \text{light}$
↓
 $(\text{CH}_2\text{O})_n + \text{H}_2\text{O} + \text{O}_2$



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Bacterial evolution

- Cyanobacteria
- Asexual reproduction
- “Living fossils”

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