UNIT 1: CELL BIOLOGY   TOPIC C: PROKARYOTIC CELLS

Essential Idea(s)
- Prokaryotes have a much simpler cell structure than eukaryotes.

IB Assessment Statements and Class Objectives

1.5.U2 The first cells must have arisen from non-living material.
   - Outline the four processes needed for the spontaneous origin of cells on Earth.
   - Outline the experiments of Miller and Urey into the origin of organic compounds.
   - Define polymerization, monomer and polymer.
   - Outline two properties of RNA that would have allowed it to play a role in the origin of life.

1.2.U1 Prokaryotes have a simple cell structure without compartmentalization.
   - Outline the major differences between prokaryotic and eukaryotic cells.
   - List the functions of the following structures of a prokaryotic cell: cell membrane, nucleoid, plasmid, cytoplasm, ribosome, cell wall, pili, capsule, flagella.
   - Define extracellular.
   - Contrast the size of eukaryotic and prokaryotic ribosomes.

1.2.S1 Drawings of the ultrastructure of prokaryotic cells based on electron micrograph.
   - Explain why the ultrastructure of prokaryotic cells must be based on electron micrographs.
   - Draw the ultrastructure of E.coli, including the cell wall, pili, flagella, plasma membrane, cytoplasm, 70s ribosomes, and nucleoid with naked DNA.

3.2.U1 Prokaryotes have one chromosome consisting of a circular DNA molecule.
   - Describe the arrangement of prokaryotic DNA (nucleoid and plasmid).
   - Define the term “naked” in relation to prokaryotic DNA.

3.2.U2 Some prokaryotes also have plasmids but eukaryotes do not.
   - Describe the structure and function of plasmid DNA.

1.2.A2 Prokaryotes divide by binary fission.
   - Define asexual reproduction.
   - Outline the four steps of binary fission.

6.3.U7 Antibiotic blocks processes that occur in prokaryotic cells but not in eukaryotic cells.
   - Define antibiotic.
   - Outline the mechanisms by which antibiotics kill bacteria.

6.3.A2 Florey and Chain’s experiments to test penicillin on bacterial infections in mice.
   - Explain methods and results of Florey and Chain’s experiments.

6.3.NOS1 Risks associated with scientific research- Florey and Chain’s tests on the safety of penicillin would not be compliant with current protocol on testing.
   - Compare allowable research risks of the past with those of the present.

6.3.U8 Viruses lack a metabolism and cannot therefore be treated with antibiotics. Some strains of bacteria have evolved with genes that confer resistance to antibiotics and some strains of bacteria have multiple resistance.
   - Explain why antibiotics are ineffective against viruses.
   - Describe one example of bacterial resistance and how it developed.
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Four processes were needed for the spontaneous origin of life on Earth.

#1 Non-living synthesis of simple organic molecules

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<tr>
<th>DESCRIBE</th>
<th>SKETCH</th>
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| Simple organic molecules can form naturally without a living thing. | ![Inorganic Organic Chart]

1. Evidence: Miller and Urey (1953) modeled early earth conditions in the lab.
   a. In a glass refluxing system, they recreated a miniature ocean-atmosphere system.
   b. Included hydrogen, methane, ammonia and water into the system to model pre-biotic atmosphere.
   c. The mixture was heated and circulated past an electric spark (to model lightning) before allowing to condense.

2. Results: Amino acids were formed from the inorganic compounds.

3. Other scientists repeated their work, eventually producing other amino acids, ATP, glucose and other sugars, lipids and the bases which form RNA and DNA, and adenine (the key component of ATP).

4. Conclusion: molecules of life can arise from non-living material.

5. TOK: We may be able to show that organic compounds could arise under certain conditions, but we can't determine with certainty whether they did in the past.
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#2 Assembly of the simple organic molecules into polymers (polymerization).

<table>
<thead>
<tr>
<th>DESCRIBE</th>
<th>monomers</th>
<th>SKETCH</th>
<th>polymers</th>
</tr>
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<tbody>
<tr>
<td>Simple organic molecules join together to form larger biological polymers.</td>
<td>amino acids</td>
<td><img src="image" alt="Amino Acid Polymerization" /></td>
<td>protein</td>
</tr>
<tr>
<td></td>
<td>fatty acids</td>
<td><img src="image" alt="Fatty Acid" /></td>
<td>phospholipids</td>
</tr>
<tr>
<td></td>
<td>nucleotides</td>
<td><img src="image" alt="Nucleotide" /></td>
<td>nucleic acid</td>
</tr>
</tbody>
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Evidence:

- Observable
  - hydrothermal vents
  - ocean-shore line
  - under ice
  - clay
  - heat/motion/radioactivity cause polymers to form

#3 Packaging of these molecules into membranes with an internal chemistry different from their surroundings.

<table>
<thead>
<tr>
<th>DESCRIBE</th>
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<tr>
<td>Lipids self-assemble into droplets that enclose a solution with an internal chemistry different from surroundings.</td>
<td><img src="image" alt="Like a cell membrane" /> form spheres in H&lt;sub&gt;2&lt;/sub&gt;O</td>
</tr>
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Evidence:

- Martin Hanczy P. TED Talk
  - formation of protocells that can move and interact with each other and the environment
#4 Origin of self-replicating molecules that made inheritance possible

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<tr>
<th>DESCRIBE</th>
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<tr>
<td>Formation of a molecule capable of making copies of itself without relying on other molecules.</td>
<td>![Self-replication diagram]</td>
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**RNA First Hypothesis:**

1. The first genetic information and enzymes were RNA molecules.
2. Why RNA? RNA can act as a catalyst to:
   a. Bind amino acids together to form proteins.
   b. Replicate itself to create more RNA.
3. **RNA** can be transcribed to **DNA** (using reverse transcriptase); this could have given rise to the first DNA.
4. DNA is more stable than RNA and eventually took over carrying the genetic information.

**Arguments in Support of the RNA First Hypothesis:**

- In Miller and Urey’s experiments, ribose was created and deoxyribose was harder to produce.
- **RNA** has a simpler structure than **DNA**.
- RNA exists in viruses (and no DNA).
- It has been proved experimentally that RNA has catalytic functions.
- The DNA-protein system cannot work without RNA.
Compare and contrast the DNA in each type of cell.

**PROKARYOTES**
- 1 chromosome
- Circular chromosomes
- DNA "naked"
- Attached to cell membrane
- Plasmids
- Replicate independently of cell

**EUARYOTES**
- Multiple chromosomes
- Linear chromosomes
- Chromosomes made of DNA
- DNA wrapped around histones
- DNA replication using same enzymes
- In nucleus
- No plasmids
Prokaryotic Cell Structures & Function

C = plasma membrane
D = ribosome
E = capsule

- Capsule
- Cell wall
- Cell membrane
- Capsule
- Nucleoid region
- Cytoplasm
- Pili
- Ribosomes
- Food granules
- Flagellum
- Plasmid DNA
Binary Fission

1. Prokaryotic chromosome duplicates

2. New chromosome attaches to cell membrane close to original

3. Cell membrane/wall grow causing cell to elongate

4. Cell membrane/wall pinch in, separating the cell into 2 daughter cells each with DNA and '1/2 cytoplasm

\[ \text{Plasmids replicate + move independently} \]