Biology 102

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Note Card

• Name
• Goals
• Favorite Scientist
• Science education background.
• Something interesting (hobbies, favorite joke, celebrity you most resemble, etc.) Anything
Goals

• Gain a better understanding of biological systems

  1. Cell structure and function
  2. Cell division and inheritance
  3. Evolutionary processes

• Understand the scientific method (scientific inquiry)
Extra Credit

Read a chapter of a popular biology book and write a one page summary of it.

Digital format

2%
Suggestions

Genome
Diversity of life
The beak of the finch
The advance of the fungi
Darwin’s dream pond
The botany of desire
The Immortal Life of Henrietta Lacks
Biology 102

Class Structure

Grading: Percentage of final grade:

- 10 Labs, drop the lowest one = 10%
- Other in class Activities = 15%
- Online Homework = 10%
- 2 midterm exams = 40%
- Final Comprehensive exam = 25%
Expectations

• Respect towards instructor and fellow students

  • I respect you

• Interaction and participation with instructor and fellow students

• Sincere interest and enthusiasm for learning

• Effort
Policies

No Cell Phones

Lap tops are OK for class use

Emergency situations can have exceptions
Policies

Grading Scheme:

90 - 100%   A
80 – 89%     B
70 – 79%     C
60 – 69%     D
59.9 % and below   F
Biology: the study of life
What is Life?

Definition
What is Life?

• Growth
• Reproduction
• Adaptation
• Metabolism
• Cellular
Cells

- nucleus
- cell wall
- plasma membrane
- organelles
Tree of Life

BACTERIA

ARCHAEA

EUKARYA

animals

fungi

plants

protists

FIRST CELLS
The scientific method

- **Observation**: The car won't start.
- **Question**: Why won't the car start?
- **Hypothesis**: The car won't start because the battery is dead.
- **Prediction**: If the hypothesis is correct, then the car will start if the battery is replaced.
- **Experiment or Observation**: The battery is replaced.
- **Conclusion**: The dead battery hypothesis is supported.
The experiments of Francesco Redi

Observation: Flies swarm around meat left in the open; maggots appear on the meat.

Question: Where do maggots on the meat come from?

Hypothesis: Flies produce the maggots.

Prediction: IF the hypothesis is correct, THEN keeping the flies away from the meat will prevent the appearance of maggots.

Experiment:
- Obtain identical pieces of meat and two identical jars
- Place meat in each jar
- Leave the jar uncovered
- Leave exposed for several days
- Flies swarm around and maggots appear

Controlled variables: time, temperature, place

Experimental variable: gauze prevents the entry of flies
- Cover the jar with gauze
- Leave covered for several days
- Flies are kept from the meat; no maggots appear

Results

Control situation

Experimental situation

Conclusion: The experiment supports the hypothesis that flies are the source of maggots and that spontaneous generation of maggots does not occur.
A Petri dish contains solid growth medium.

Bacteria grow in a pattern created by streaking.

A substance from the mold diffuses outward and inhibits the growth of nearby bacteria.

A colony of the mold *Penicillium*. 

**Luck and observation**
Chemistry

- Atoms
  - Protons
  - Neutrons
  - Electrons
(a) Hydrogen (H)
(b) Helium (He)
<table>
<thead>
<tr>
<th>Element</th>
<th>Atomic Number(^1)</th>
<th>Atomic Mass(^2)</th>
<th>% by Weight in the Human Body(^3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oxygen (O)</td>
<td>8</td>
<td>16</td>
<td>65</td>
</tr>
<tr>
<td>Carbon (C)</td>
<td>6</td>
<td>12</td>
<td>18.5</td>
</tr>
<tr>
<td>Hydrogen (H)</td>
<td>1</td>
<td>1</td>
<td>9.5</td>
</tr>
<tr>
<td>Nitrogen (N)</td>
<td>7</td>
<td>14</td>
<td>3.0</td>
</tr>
<tr>
<td>Calcium (Ca)</td>
<td>20</td>
<td>40</td>
<td>1.5</td>
</tr>
<tr>
<td>Phosphorus (P)</td>
<td>15</td>
<td>31</td>
<td>1.0</td>
</tr>
<tr>
<td>Potassium (K)</td>
<td>19</td>
<td>39</td>
<td>0.35</td>
</tr>
<tr>
<td>Sulfur (S)</td>
<td>16</td>
<td>32</td>
<td>0.25</td>
</tr>
<tr>
<td>Sodium (Na)</td>
<td>11</td>
<td>23</td>
<td>0.15</td>
</tr>
<tr>
<td>Chlorine (Cl)</td>
<td>17</td>
<td>35</td>
<td>0.15</td>
</tr>
<tr>
<td>Magnesium (Mg)</td>
<td>12</td>
<td>24</td>
<td>0.05</td>
</tr>
<tr>
<td>Iron (Fe)</td>
<td>26</td>
<td>56</td>
<td>Trace</td>
</tr>
<tr>
<td>Fluorine (F)</td>
<td>9</td>
<td>19</td>
<td>Trace</td>
</tr>
<tr>
<td>Zinc (Zn)</td>
<td>30</td>
<td>65</td>
<td>Trace</td>
</tr>
</tbody>
</table>

\(^1\) Atomic number: number of protons in the atomic nucleus.

\(^2\) Atomic mass: total mass of protons, neutrons, and electrons (negligible); numbers are rounded.

\(^3\) Approximate percentage of this element, by weight, in the human body.
An electron absorbs energy. The energy boosts the electron to a higher-energy shell. The electron drops back into a lower-energy shell, releasing energy as light.
Bonds

• Covalent
  • Polar
  • Nonpolar
• Ionic
• Hydrogen
Hydrogen gas (H$_2$)

(a) Nonpolar covalent bonding in hydrogen gas (H$_2$)

- (hydrogens: uncharged)
- Electrons spend equal time near each nucleus
- Same charge on both nuclei
(b) Polar covalent bonding in water (H₂O)

- Oxygen: slightly negative
- Hydrogens: slightly positive

Electrons spend more time near the larger nucleus.

Larger positive charge

Smaller positive charge
Macromolecules
Macromolecules

• Carbohydrates
• Lipids
• Proteins
• Nucleic acids
Monosaccharides

fructose

galactose
Dehydration synthesis
Hydrolysis
Disaccharide
Starch polysaccharide

(a) Potato cells
(b) A starch molecule
(c) Detail of a starch molecule
(a) Potato cells
Cellulose

(a) Wood is mostly cellulose

(b) A plant cell with a cell wall

(c) A close-up of cellulose fibers in a cell wall

Hydrogen bonds cross-linking cellulose molecules

(d) Detail of a cellulose molecule

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Wood is mostly cellulose and lignin.
Lignin
Chitin
Lipids

(a) Fat

(b) Wax
Triglyceride

Glycerol + Fatty Acids → Triglyceride
A fat and an oil
Phospholipids
Steroids

(a) Cholesterol

(b) Estrogen

(c) Testosterone
Protein
Amino acid structure

variable group

amino group

hydrogen

carboxylic acid group
Protein synthesis

amino acid + carboxylic acid group → dehydration synthesis → peptide bond + water
Amino acid diversity

(a) Hydrophilic functional groups

- glutamic acid (glu)
- aspartic acid (asp)

(b) Hydrophobic functional groups

- phenylalanine (phe)
- leucine (leu)

(c) Sulfur-containing functional group

- cysteine (cys)
Sulfur-containing functional group

cysteine (cys)

(c) Sulfur-containing functional group
The four levels of protein structure

(a) Primary structure:
The sequence of amino acids linked by peptide bonds

(b) Secondary structure:
Usually maintained by hydrogen bonds, which shape this helix

(c) Tertiary structure:
Folding of the helix results from hydrogen bonds with surrounding water molecules and disulfide bridges between cysteine amino acids

(d) Quaternary structure:
Individual polypeptides are linked to one another by hydrogen bonds or disulfide bridges
Nucleic Acids

- Adenine
- Thymine (Uracil)
- Guanine
- Cytosine
Five-carbon monosaccharides

ribose

(deoxy)ribose

Note “missing” oxygen atom
Deoxyribose nucleotide
The energy-carrier molecule adenosine triphosphate (ATP)
Deoxyribonucleic acid (DNA)
What is a cell?

- Smallest unit w/ property of life
  - Single-celled organisms
  - Make up multicellular organisms
The Cell Theory

1. All organisms composed of cells
2. Smallest unit of life
3. Division of preexisting cell
4. Possess heritable material (DNA)
Cytoplasm

- Aqueous material
Prokaryotic Cells

Capsule

Cell wall outside the plasma membrane

plasma membrane

cytoplasm, with ribosomes

DNA in nucleoid region

Fig 4.4
Eukaryotic cell

Fig 4.4

NUCLEUS

CYTOPLASM w/ RIBOSOMES

PLASMA MEMBRANE
How big are cells?

- Most cells can be seen with a light microscope.
Cell Membranes

• Fluid
• Composed of phospholipids, proteins, etc.
• Semipermeable
Triglyceride

glycerol + fatty acids → triglyceride
A fat and an oil
Phospholipids

variable functional group
phosphate group

polar head (hydrophilic)
glycerol backbone
fatty acid tails (hydrophobic)
phospholipid
hydrophilic heads
hydrophobic tails
hydrophilic heads
extracellular fluid (watery environment)
bilayer
cytoplasm (watery environment)
Kinks increase fluidity

more fluid

less fluid
Steroids

(a) Cholesterol

(b) Estrogen

(c) Testosterone
Endomembrane System

Food

Lysosome

Digestion

Damaged component
Exocytosis

Material is enclosed in a vesicle that fuses with the plasma membrane, allowing its contents to diffuse out.
Chloroplast

- Found in plants
- Sugar production
  - Photosynthesis

Central Vacuole
Storage of water and waste
Mitochondria

• Energy producer of cell (ATP)
• Two membranes – allows for gradient formation
• Where cellular respiration occurs
(b) An Amoeba engulfs a *Paramecium*
Cells and cell membranes

• Prokaryotic vs. Eukaryotic
• Nucleus and other organelles
A phospholipid bilayer helps to isolate the cell's contents.

Proteins help the cell communicate with its environment.

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Diffusion of a dye in water

1. A drop of dye is placed in water.
2. Dye molecules diffuse into the water; water molecules diffuse into the dye.
3. Both dye molecules and water molecules are evenly dispersed.
Diffusion and Osmosis

- Molecules move from high density to low density (diffusion)
- Diffusion across a membrane is Osmosis
- Some molecules can’t cross the cell membrane without active transport.
Types of diffusion through the plasma membrane

(a) Simple diffusion through the phospholipid bilayer
(b) Facilitated diffusion through channel proteins
(c) Osmosis through aquaporins or the phospholipid bilayer
(d) Facilitated diffusion through carrier proteins
The effect of solute concentration on osmosis

(a) A balloon in an isotonic solution
No net flow of water

(b) A balloon in a hypertonic solution
Water flows out; the balloon shrinks

(c) A balloon in a hypotonic solution
Water flows in; the balloon expands
The effects of osmosis on red blood cells

(a) Red blood cells in an isotonic solution
(b) Red blood cells in a hypertonic solution
(c) Red blood cells in a hypotonic solution
DNA vs. RNA

- DNA uses deoxyribose and RNA uses ribose
- RNA has the nucleotide urical instead of thymine
- DNA is much more stable than RNA
DNA to RNA

- DNA is the blueprint
- The code for individual genes gets copied to RNA
- RNA is used as a template to make protein
RNA to Protein

• Ribosomes
• The code for individual genes gets copied to RNA
• RNA is used as a template to make protein
Prokaryotic Cells

- Capsule
- Cell wall outside the plasma membrane
- Plasma membrane
- Cytoplasm, with ribosomes
- DNA in nucleoid region

Fig 4.4
(a) Turgor pressure provides support

When water is plentiful, it fills the central vacuole, pushes the cytoplasm against the cell wall, and helps maintain the cell's shape.

(b) Loss of turgor pressure causes the plant to wilt

When water is scarce, the central vacuole shrinks and the cell wall is unsupported. Deprived of the support from water, the plant wilts.