Biology Lecture Chapter 4
Pages 85 - 101

<u>IN Question</u>: What does a CD, tires, rocks, and *you* all have in common?

<u>Section 4-1</u>: Matter Is Made of Atoms
I. Matter – anything that takes up space; made up of atoms.
<u>Element</u> – matter made-up of all the same kind of atoms. It cannot be broken down into simpler parts. (see periodic table on page 691)
e.g. copper atoms, gold atoms, hydrogen atoms.

II. Structure of an atom: (3 parts, or subatomic particles)
<u>Atoms</u> - all matter is composed of these small units (particles).
They are made of 3 smaller particles (subatomic particles):
1. *Electron*(-) = negative charge that orbits the nucleus in energy shells. Involved with forming chemical bonds between atoms.
2. (*)*Protons* - <u>positive</u> charge (+). Elements are different from one another due to the number of protons in their nucleus. e.g. the element gold has a different number of protons than oxygen.
3. (*)*Neutron* - <u>neutral</u> charge (0)
(*)<u>Nucleus</u> - the center region of the atom that contains protons & neutrons.

<u>Energy Levels</u> – the region around the nucleus where the e- orbit, aka. "electron shells"
- The 1^{st} shell holds 2 e- maximum.
- All other shells hold up to 8 e- maximum.

<u>Valence electrons</u> – electrons in the outer most energy level; *involved in forming chemical bonds* to form molecules and compounds.

<u>Section 4-2</u>: Chemical Bonds Hold Atoms Together "the Glue"
1. <u>Molecule/Compound</u> - 2 or more atoms bonded to one another. e.g. H_2O

2. <u>Ions</u> - a loss or gain of e^- creates *positively & negatively charged atoms*. eg, ions Na^+ or Cl^-

3. <u>Chemical bond</u> - the force(attraction) holding the atoms together to form a molecule.
"the Glue" [involves valence e^-].
- Chemical bonds have stored energy that is measured in calorie units.

<u>Section 4.3</u>: Chemical Rxns. Are Essential to Life

I. **Chemical reaction** - atoms <u>must collide</u> w/ one another and stick together like "GLUE"
<u>Catalysts</u> – are chems. help to speed up chem. rxns. (eg. enzymes)
A. 2 types of chemical rxns used in living orgs.

1. **<u>Synthesis rxn</u>** - a <u>build-up</u> of molecules; to make molecules Eg. building up muscle mass from the protein you eat.
Example rxn: Na^+ + Cl^- + *energy required* → NaCl
2. **<u>Decomposition rxn</u>** - <u>breaking down</u> of molecules.
Eg. digesting your food
Example rxn: NaCl → Na^+ + Cl^- + *energy released*

II. Water: * See figure 4.4; page 86

- Most common molecule in living things;
- 70-90% of your total body weight.
- It carries dissolved substances throughout the cells.
- Cells exist best in a water environment.
- The chemistry of life is really water chemistry.
- Helps the cell function (do its job).

WOW!
[Life's evolution as been largely determined by the properties of water]

A. Properties of water: (How it behaves)
1. It's the "universal solvent" - it dissolves and breaks down many substances. It is a "polar molecule"
2. It is "like a magnet" when dissolving substances.
3. It has the ability to store large amounts of heat energy (calories). ie, It resists temperature changes!
4. It has the ability to ionize (separate into ions) and aid in chem. rxns.

$$H_2O \rightarrow OH^- + H^+ \quad \text{(ionization)}$$

Section 4.4: Energy Makes Work and Order Possible
[energy does work or causes change; it is needed to maintain order or organization]
A. Living orgs. are complex, organized atoms which use energy to grow, reproduce & survive!
B. Matter(atoms) requires energy in order to move around (collide) and form chemical rxns. (see chemical rxns. above)
C. Matter has stored energy in its chemical bonds. ie. energy is released when the chem. bonds in food are broken.

GEE WHIZ!
A frog causes disorder to a fly's body by eating it for energy.
Questions?
1. What does the frog need energy for?
2. What will happen to the energy in a frog's body when it dies?

Biology Lecture 4.5 - 4.7
Pages 88 - 91

Sect. 4.5: The Sun and Photosynthesis: How We Get Energy

Equation for Photosynthesis

$$6CO_2 + 12H_2O^* \xrightarrow[\text{(chloro.)}]{\text{(Sun)}} C_6H_{12}O_6 + 6H_2O + 6\,{}^*O_2$$

atmos. — water — (chloro.) — glucose — water — oxygen from original water

- Sun light. is the ultimate source of energy for organisms!

I. ***Photosynthesis*** **–** the process by which plants trap energy from the sun and make food (sugar)

- **Photons** - packets of light energy; measured in wavelength.
- Sunlight contains photons of various wavelengths (nm)
- Light Spectrum "a rainbow" **See Figure 19.2, page 505**

A. Pigments - molecules that absorb light (photons) energy used in photosynthesis.

- All organisms have pigments. eg. melanin in your skin

Chlorophylls – plant pigments in ***Chloroplasts*** that absorb photons of sunlight energy that are then used by the plant in photosynthesis to make ATP.

- **Chlorophyll** has a central atom of Mg^{2+} metal whose electrons get excited when sunlight is absorbed.

2 Types of chlorophylls: See Figure 19.3, page 505

- *chlorophyll a* & *chlorophyll b* absorb the violet/blues & the red wavelengths
- plants reflect light in the 500nm - 600nm range (the greens)

B. Other Plant pigments "accessory pigments" in leaves:

- they absorb wavelengths of light that chlorophyll can not absorb.

Carotene – orange
Xanthophyll – yellow
Anthocyanin - purple
*** See "Fall Colors" Figure 19.4, page 505-506**

Question?
All green plants have the yellows and oranges, so why do we not see these colors in the green leaf?

Chromatography – a technique used to separate out the components of a mixture. eg, separating out the various other plant pigments from chlorophyll.

Question? *See Demonstration*
Which colors of the rainbow [the visible light spectrum] would you expect to disappear from the spectrum when **chlorophyll is used**? Why?

D. Photosynthesis is a energy absorbing reaction:
[We can measure the amount of energy(calories) stored in the chemical bonds]. ***see graph on board***

- Photosynthesis is a reaction that requires energy "absorbs energy".
- The products (glucose) has more stored energy than the reactants (CO_2 & H_2O)

Question?
Where did the stored energy in glucose come from?

$$6CO_2 + 12H_2O \xrightarrow[\text{(chloro.)}]{\text{(Sun)}} C_6H_{12}O_6 + 6H_2O + 6O_2$$

glucose(chem.. energy)

- plants are *autotrophs*; they make their own food.

Question? **Photosynthesis is a synthesis rxn. Why is this so?**

Answer: energy is required (as a reactant). The products have more stored energy than the reactants. eg, glucose(lots of potential energy) vs. CO_2 (no potential energy)

Sect. 4.6: Energy Is Released as Food Is Broken Down
I. ***Cellular respiration*** - the process by which food(sugars from plants-"glucose") are used by plants themselves or eaten & broken down by animals for energy (ATP). ie. an energy releasing rxn.
* This occurs in the *mitochondria* of all your cells.
A. Food - made of C, H, O, N, (the building blocks of all orgs.)
Also, wood, coal, oil all release energy when burned(broken down).
B. Energy released in living orgs. occurs @ much lower temps.
Than burning wood, coal, oil, etc… [high temps. can kill cells]
ENZYMES - lower the temperature and the activation energy of biochemical reactions - Unlike the burning of wood. **See Figure 4.8, page 90**

Equation for Cellular Respiration

Enzymes in mitochondria

$$O_2 + {}^*C_6H_{12}O_6 \rightarrow {}^*CO_2 + H_2O + 38\ ATP$$

(glucose) **(carbon dioxide released from organisms)** **(energy used by the cell)**

II. Cellular respiration is a energy releasing reaction:
[We can measure the amount of energy (calories) stored in the chemical bonds]. ***see graph on board***

- Cellular respiration is a reaction that releases energy from food molecules, eg. glucose
- The reactants (glucose) has more stored energy than the products (CO_2 & H_2O)

?Question:
Cellular respiration is a decomposition rxn. Why is this so?

Answer: energy is released (as a product). The reactants have more stored energy than the products. ie. glucose vs. CO_2

III. Comparing Photosynthesis and Cellular Respiration:
(see Figure 4.9, page 90)

Photosynthesis	Cellular Respiration
Food is made	Food is broken down
Synthesis reaction	Decomposition reaction
Energy from sun stored in glucose	Energy from glucose is released
CO_2 is used	CO_2 is released
O_2 is released	O_2 is taken in
Requires sun light	No sun light required
Occurs in photosynthetic organisms (needs chlorophyll)	Occurs in all living cells (plants, animals, etc)

Equation for Cellular Respiration

mitochondria

$$O_2 + {}^*C_6H_{12}O_6 + H_2O \rightarrow {}^*CO_2 + H_2O + 38\ ATP\ s$$

(from air) (glucose) (carbon dioxide released from organisms) (energy)

Equation for Photosynthesis

(Sun)

$$6CO_2 + 12H_2O^* \xrightarrow{\text{(Sun)}} C_6H_{12}O_6 + 6H_2O + 6\ {}^*O_2$$

from air water (chlorophyll) glucose water oxygen from original water

Sect. 4.7: ATP, the Cell's Currency for Energy Transfer

I. **Energy** is required for life in order to do **"biological work"**

Question? Where does the energy come from needed to move your pencil, breathe and think?

- large amounts of energy released from food molecules(glucose, fats & proteins) is released in "small packets" of energy that are easier for the cell to use.

A. ***ATP*** (**A**denosine **T**ri**p**hosphate) - a *high-energy* molecule used directly by the cell for energy **"cellular food"**.

- ATP has a lot of stored energy in its phosphate bonds that is released during a decomposition reaction!

NOTE: 1 glucose = many ATP molecules, or a one $100 bill(glucose) is equal to 100 $1.00 bills (ATP's)

***See ATP Molecule Figure 4.10, on page 91**

B. Importance of ATP:

- common in all living orgs.
- an energy transfer molecule
- energy from food is stored in ATP
- ATP releases energy when it loses a phosphate group
- the energy released from ATP is used to do work in a cell, eg. muscle contraction, nerves

C. ATP-ADP Cycle: *See Figure 4.11, on page 91

*Remember, there is a lot of energy stored in the phosphate bonds of ATP!

- AMP - one phosphate group is attached to adenosine.
- ADP - two phosphate groups are attached to adenosine.
- ATP - three phosphate groups are attached to adenosine.

NOTE: the 3rd phosphate bond is extremely energized and has a lot of stored potential energy to do work by the cell!

- ATP can be broken down into ADP by losing a phosphate group and can reform by adding a phosphate group to ADP
- When ATP is broken down into ADP the <u>energy is released</u> in small amounts, otherwise it is wasted. So to use the energy efficiently

<u>Question?</u>
What are <u>two differences</u> between how a **fire releases energy** and the way your **cells release energy**?
***See Figure 4.8, page 90**

Biology Lecture 4.8 - 4.13
Pages 92 – 98

<u>Section 4.8</u>: Carbon Is Found in All Living Things

- Carbon is the central element for molecules found in organisms.

A. Carbon atoms can:
1) bond w/ H, O, N, S, P to form a *plethora* of molecules
2) form rings, straight chains & branched molecules
3) form a large variety of molecules [ensures the uniqueness of orgs. on this planet]
*** See figure 4.12, page 92**

- ***<u>Organic molecules</u>*** - building blocks of all life [cell parts], and the source of chemical energy "food"
- ***<u>Polymer</u>*** – a big molecule made of many repeating subunits.
- <u>4 major categories</u> of "polymers"

Carbohydrates, Lipids, Proteins, and Nucleic Acids(DNA/RNA)

<u>Section 4.9</u>: Carbohydrates Are Used for Energy Storage and Energy Production

A. Carbohydrates - "sugars" $\mathbf{C_1 H_2 O_1}$; a good energy molecule.
-saccharide – suffix means "sugar"
*** See figure 4.13; page 93**

- 4 calories/1 gram carbohydrate
- made of smaller subunits called *monosaccharides*, egs. glucose & fructose
- some are <u>complex carbos</u> and some are <u>simple carbohydrates</u> egs. polysaccharide vs. disaccharide & monosaccharide

Examples of some carbos.:
1. *Simple carbos* = monosaccharides & disaccharides
   egs. Glucose, sucrose, lactose, fructose, maltose

Note: 2 monosaccharides make one disaccharide:

Glucose	**+**	**Fructose**	**=**	**Sucrose**
(monosacc.)	**+**	**(monosacc.)**		**(disaccarhide)**

2. *Complex carbohydrates* = polysaccharides

egs. **Glycogen**(sugars stored in animals), **cellulose** (plant cell wall), **starch** (sugars stored in plants), **chitin**(exoskeleton of insects) , starch, glycogen & cellulose are all polysaccs. made of chains of glucose(monosaccs.), so how are they different from each other?

Question: Which type of carbohydrate [above] would release chemical energy (calories) for a longer period of time and WHY?

<u>Section 4.10</u>: Lipids Are Efficient Energy-Storage Molecules

A. Lipids "fats" - C, H, O; excellent energy molecule! *** See figure 4.14 and 4.15; page 93 - 94**

- 9 calories/1 gram fat
- made of smaller subunits: ***1 glycerol to 3 fatty acids***
- mammals store energy as fat (adipose tissue).. **WHY?**
- Examples. of lipids: fats, oils, waxes, cholesterol, steroids, hormones

Question: What is the <u>molecular</u> <u>difference</u> [in structure] between butter and olive oil?

***Coronary Heart Disease(CHD)–** leading cause of death in the U.S

- diets high in <u>saturated fats</u> cause arteries in the heart to clog!

<u>Section 4.11</u>: Proteins Function as Enzymes and Structural Components of Cells

A. Proteins - "polypeptides"- **C, H, O, N, S**; a <u>major building block</u> molecule of cell parts. Make up ENZYMES used by the cell! *** See figure 4.16 and 4.17; page 95**

- 60% of your dry body wt.
- 4 calories/1 gram protein
- made of smaller subunits: *amino acids*

ie, AA + AA + AA + AA + AA = **1 protein (polypeptide)**

- proteins vary in size from dipeptides to polypeptides

B. *Amino acids* - small subunits made of C, H, O, N, S

- 22 known a.a's; 11 are made by the body, and 9 are not
- plants can synthesize all 20 a.a's
- *Peptide bonds* - covalent bond that links 2 a.a's together
- *Polypeptide* - a long chain of a.a's
- your cells assemble a.a's into proteins needed by the body,

eg. muscle, hair, nails, elastin[in skin], antibodies & ENZYMES

<u>Section 4.12</u>: Enzymes Catalyze Chemical Reactions

A. <u>Enzymes</u> – a protein "catalyst" that speeds up reactions in the cell.

- they can be used over & over again.
- they are involved in <u>both synthesis & decomposition rxns.</u>
- enzymes end in the suffix ***"ase"***

* See figures 4.18 & 4.19; page 96 - 97

- enzymes bind to a molecule[substrate] to which it acts on.

<u>Example reaction w/ an enzyme</u>:
Sucrose is broken down by the aid of an enzyme called *amylase* into two smaller sugars …glucose + fructose

Amylase(enzyme)

***Sucrose* → *glucose* + *fructose* + energy**

<u>Section 4.13</u>: Nucleic Acids Contain the Blueprint for Life

A. <u>Nucleic Acids:</u> "DNA & RNA"; made of **C, H, O, N, S, P**

- *DNA:* Deoxyribonucleic acid
- *RNA:* Ribonucleic acid

*** See figures 4.20 & 4.21; page 98**

- The hereditary molecule; your "genes" or "genetic blueprints"
- Found in every cell of your body
- GEE WHIZ! ~ 6 ft. of DNA/cell, but only ~1 inch is used!
- Made of repeating subunits(boxcars) = ***nucleotides***
- Nucleotides have 3 parts: **See figure 4.20, page 98**

1) five-carbon sugar
2) phosphate group.
3) one nitrogenous base (C, G, A, T, U)

<u>DNA</u>	**vs.**	**<u>RNA</u>**
*double stranded		*single stranded
*deoxyribose sugar		*ribose sugar
*thymine base		*uracil base

Biology Lecture 4.14 - 4.15
Pages 98 – 101

<u>Section 4.14</u>:Plants Make and Use Carbon-Containing Molecules

Remember:

- Photosynthesis is performed by ___?___

(Sunlight)

$$*CO_2 + H_2O \rightarrow *C_6H_{12}O_6 + H_2O + O_2$$

(chlorophyll & enzymes)

A. Plants take up carbon from the air (CO_2) & make up sugars.

* <u>The sugars are used 4 ways by plants</u>: ***See figure 4.22, page 99**

1. break down sugars for energy (ATP)
2. for growth & repair, eg. cellulose for plant cell walls.
3. convert the sugar into other organic molecules needed for life of the plant. ie. sugars can be converted to fats & proteins and vise versa.
4. store sugar for later use, eg. starch in a potato (a storage roots) – see reaction below!

<u>Synthesis rxn</u>:
glucose + glucose + glucose + glucose → starch

<u>Question</u>:
Which of the 4 plant uses does not add matter or materials to the plant body?

<u>Section 4.15</u>: Carbon Cycles Within an Ecosystem
(see fig. 4.23, page 101)

I. ***Carbon cycle*** – carbon is passed from org. to another via the abiotic environment.
[when orgs. are eaten the carbon from their body's is released into the atmosphere, and some is incorporated into the body of the consumer(the eater)]

A. <u>CO_2 is returned to the atmosphere(air) by</u>:
- consumers – *cellular respiration*
- producers – *cellular respiration*
- decomposers – *cellular respiration* (see below reaction)

O_2 + dead orgs. → *CO_2 + H_2O + ATP
(contain carbon) (atmosphere)

- burning fuel – *human activity*
- factories – *human activity*

<u>Note</u>: [Carbon is present in many atmospheric gases
- (CO_2 , CH_4 , CO); it determines climate changes & weather patterns.]
- CO_2 - released from orgs. & burning of fossil fuels.
- 25% ↑ of Carbon gasses since industrial revolution & clearing forests.

<u>Question</u>?
Why would <u>deforestation</u> cause an increase in atmospheric CO_2?

<u>Results of human activity</u>:
- ***Greenhouse Effect*** – atmospheric gases trap (like a blanket) the sun's heat energy in our atmosphere
- a delicate balance of greenhouse gases must be maintained in order for life to exist
- **See *Biology Today:*The Carbon Cycle and Global Warming, page 101**

B. <u>Human activity disrupts the carbon cycle in 2 ways</u>:
1. Burning of fossil fuels –
2. Destruction of rain forests & other plant communities –
3. Unharvested plant matter decays & releases CO_2

Results in …..
- Global Warming
- Changes in food production patterns; famine?
- Rise in sea levels