CHAPTER 18: NUTRITION AND METABOLISM

OBJECTIVES:

1. Define the terms *nutrition, nutrients,* and, *essential nutrients.*

2. Review (from Chapter 2) the three major macromolecules (polymers) that humans ingest, name the building blocks (monomers) that compose each, & give a general function for each.

3. List the major dietary sources for carbohydrates, lipids, and proteins.

4. Compare and contrast the two major divisions of metabolism in terms of: (see Chapter 4)

    1. Name of division
    2. Descriptive sentence for division
    3. Other descriptive terms
    4. Whether bonds are broken or formed
    5. Whether energy is required or released; name that term
    6. Whether water is required or released; name that term

    and write an equation illustrating each division.

5. Review (from chapter 4) the process of cellular respiration in terms of major steps, location of each step in the cell, end-product(s) from each step and finally, explain the significance of cellular respiration.

6. Describe how human cells utilize lipids (i.e. the process of beta-oxidation).

7. Compare the ATP yield obtained from an 18-Carbon lipid with that of an 18-Carbon carbohydrate.

8. Explain how cells utilize amino acids and name the two major metabolic wastes that result.

9. Define the term *nitrogen balance.*

10. Define the term *calorie, kilocalorie,* and *heat.*

11. Explain how the energy values of foods are determined.

12. Discuss the factors that determine an individual_s energy requirements.

13. Define the term *energy balance.*

14. Explain what is meant by the term *desirable weight.*

CHAPTER 18: NUTRITION AND METABOLISM

OBJECTIVES:

15. Distinguish between fat-soluble and water-soluble vitamins and explain which enters cells more easily.

16. Make a list of fat-soluble vitamins and give a function for each.

17. Make a list of water-soluble vitamins and give a function for each.

18. Distinguish between a vitamin and mineral in terms of size and function.

19. Explain what is meant by the term *trace mineral.*

20. List the major minerals and trace minerals and give a function for each.

21. Discuss the major disorders/diseases that result from an insufficiency of the above listed vitamin/mineral.

22. Discuss the components of an adequate diet.

23. Distinguish between primary and secondary malnutrition.

CHAPTER 18: NUTRITION AND METABOLISM

I. INTRODUCTION

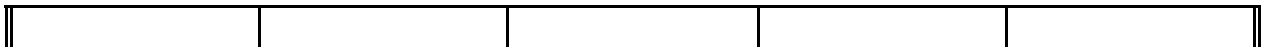
We eat to obtain the nutrients that power the activities of life. The macronutrients that are needed in large amounts includes carbohydrates, proteins and lipids, while micronutrients include vitamins and minerals. Metabolism refers to the ways that nutrients are chemically altered and used in anabolism (synthesis reactions) and catabolism (breakdown reactions) to support the activities of life.

II REVIEW

-15 Major Macromolecules:

MACROMOLECULE SUMMARY TABLE (key on page 398 of outline)

Organic Molecule				
Composed of what atoms?				
Building Blocks (monomers)				
Specific types & functions of monomers				
Specific types and functions of polymers				



II REVIEW

2. Review of Metabolism

METABOLISM SUMMARY TABLE (Keyed on page 399 of this outline)

	ANABOLIC REACTIONS CONSTRUCTIVE RXN'S	**CATABOLIC RXNS DEGRADATION RXNS**
GENERAL DESCRIPTION		
DESCRIPTIVE TERMS		
BOND FORMATION OR BREAKING?		
IS ENERGY REQUIRED OR RELEASED? NAME THAT TERM.		
HOW IS WATER INVOLVED? NAME THAT TERM		

III MACRONUTRIENTS

-15 **Carbohydrates:**

Carbohydrates are organic compounds and include sugars and starches. The energy held in their chemical bonds is used to power cellular processes.

-14 **Carbohydrate Sources**:

1. Complex carbohydrates:
   - starch from grains and vegetables;
   - glycogen from meats;
   - These foods usually contain rich vitamins and minerals.

2. Simple carbohydrates:
   - disaccharides from cane sugar, beet sugar, molasses;
   - monosaccharides from honey and fruits.

3. Cellulose is a structural polysaccharide in plants:
   - Humans do not possess enzymes to digest cellulose;
   - important in providing bulk fiber (roughage) to aid in movement of intestinal contents.

2. **Carbohydrate Utilization**:

1. Monosaccharidesabsorbed from small intestine and transported to the liver via the hepatic portal vein include:
   - fructose,
   - galactose,
   - glucose.

2. Liver enzymes:
   - convert fructose and galactose into glucose (for cellular respiration);
   - polymerize excess glucose as glycogen (glycogenesis).

3. The body can only store a certain amount of glycogen, so further excesses of glucose are converted to fat and stored in adipose tissue.

CHAPTER 18: NUTRITION AND METABOLISM

III MACRONUTRIENTS

0 Carbohydrates:

1 **Carbohydrate Utilization**:

0 **SUMMARY OF CELLULAR RESPIRATION**:
Keyed on page 400 of this outline.

	GLYCOLYSIS	CONVERSION STEP	KREBS CYCLE	ELECTRON TRANSPORT CHAIN
LOCATION in cell				
Is Oxygen Required?				
Starting Product(s)				
End-Products				
TOTAL				

0. **Carbohydrate Requirements**:

0. Varies with activity of individual
1. Some cells need continuous glucose supply to survive.
2. Amino acids may be converted to glucose if necessary.
3. Average diet includes 200-300 grams carbohydrates daily.
4. Poor nutrition status usually not related to insufficient carbohydrate intake.

CHAPTER 18: NUTRITION AND METABOLISM

III. MACRONUTRIENTS (continued)

2 Lipids:

Lipids are organic molecules that include fats, phospholipids, and cholesterol. They supply energy for cellular processes and building blocks for cell membranes, steroid hormones, etc. The most common dietary lipids are the fats called triglycerides.

0 Lipid Sources:

0 Triglycerides:

· Saturated fats are found in foods from:
0 Mainly animal origin: Meats, Egg, Milk, Lard.
1 Some plant origin: palm & coconut oil.

· Unsaturated fats are contained in:
0 Seeds
1 Nuts
2 Plant oils.

1. Cholesterol:

· from foods of animal origin only;
· abundant in liver and egg yolk;
· trace in whole milk, butter, cheese, and meats.

1. Lipid Utilization:

0. Fatty acids and glycerol absorbed by lacteals in the small intestine are transported to:

· tissues:

0. Beta Oxidation breaks fatty acids into 2-carbon units;

0. Citric acid cycle releases energy in their bonds.

1. Glycerol becomes intermediate in glycolysis.

CHAPTER 18: NUTRITION AND METABOLISM

III. MACRONUTRIENTS (continued)

3 Lipids:

1. Lipid Utilization:

- Liver: See Fig 18.3, page 707.

0 Converts fatty acids from one form to another, except it cannot synthesize linoleic acid (i.e. essential F.A.):
  0 Required for the synthesis of phospholipids;
  1 Needed for the formation of cell membranes;
  2 Needed for the transport of circulating lipids.
  3 Good sources include corn, cottenseed & soy oils.
  4 Other essential FA_s:
    - linolenic acid
    - arachadonic acid;

1 Uses free FA_s to synthesize a variety of lipids that are then released into the blood (i.e. regulates circulating lipid concentration)
  0. Triglycerides,
  1. Phospholipids,
  2. Lipoproteins.

2 Controls the total amount of cholesterol in the body by:
  0 synthesizing cholesterol and releasing it into blood;
  1 removing cholesterol from the blood and excreting it into the bile.
  2 The liver uses cholesterol to make bile salts:
    - not used for energy;
    - used for construction of:
      0. cell components
      1. hormones.

- Adipose tissue

0 Excess is stored in adipose tissue;

1 During fasting, stored triglycerides may be :
0 hydrolyzed into glycerol and fatty acids and
1. released into blood.

CHAPTER 18: NUTRITION AND METABOLISM

III. MACRONUTRIENTS (continued)

4 Lipids:

2. Lipid requirements:

0. varies among individuals;
1. The amounts and types needed for health are unknown and are accordingly a "hot" research topic;
2. Intake must sustain production of fat-soluble vitamins;
3. American Heart Association: "Diet should not exceed 30% of total daily calories from fat."

3. PROTEINS:

Proteins are organic compounds that serve several functions in human cells. The most important proteins are **enzymes** that regulate metabolism, but others serve roles in structure (i.e. keratin), transport (i.e. hemoglobin), storage (i.e. albumin), movement (i.e. myosin), and energy. The building blocks of proteins are **amino acids.** During starvation (i.e. carbohydrate and lipid sources are depleted), tissue proteins may be used as energy source causing tissue wasting.

0 Protein Sources:

0 From meats, fish, poultry, dairy products, cereals and legumes;
1 During digestion, proteins are broken into amino acids:

· Nonessential amino acids can be synthesized by human cells;
· **Essential amino acids**:

0 Ten in growing children (8 in adults);
1 See Table 18.2 on page 708.

2 Classified as either complete or incomplete:
· Complete include those from meat, fish, & dairy:
0 contain adequate amounts of essential amino acids to maintain tissues and promote normal growth and

development;

- Incomplete include zein in corn:
  - 0 Contain inadequate essential amino acids tryptophan and lysine and therefore do not maintain tissues or promote growth or development.

CHAPTER 18: NUTRITION AND METABOLISM

III. MACRONUTRIENTS (continued)

3 Proteins:

4 Nitrogen balance

5 Catabolism and anabolism of proteins occur simultaneously, but at different rates in different tissues;
6 Overall gain of body proteins equals the overall loss = **dynamic equilibrium**;
7 Because proteins contain such a high content of nitrogen, dynamic equilibrium leads to **nitrogen balance**:

- Definition: Nitrogen balance (NB) is a condition when the nitrogen intake (via proteins) equals nitrogen excretion.
- Positive NB occurs in growing children, pregnant women and athletes;
- Negative NB occurs in starving individuals.

2 Protein /Amino acid requirements:

3 necessary to build enzymes, hormones, and other cellular proteins;
4 varies among individuals;
5 Nutritionists recommend that an average adult takes in 0.8g/kg body weight;
6 Protein deficiencies:
- tissue wasting
- decreased levels of plasma proteins:
  2 ↓ Albumin = osmotic pressure abnormalities; Nutritional edema.
  3 ↓ Globulins = ↓ immunity;
  4 ↓ Fibrinogen = ↓ clotting.

*** See Table 18.3 on page 709 to summarize nutrient sources, utilization and requirements!**

CHAPTER 18: NUTRITION AND METABOLISM

IV Energy Expenditures:

The amount of potential energy a food contains can be expressed as calories, which are units of heat.

1. Important definitions:

    1. **Calorie** = the amount of heat required to raise the temperature of one gram of water by 1 degree Celsius (°C);
    2. **Kilocalorie** = the amount of heat required to raise the temperature of a kilogram of water by 1 degree Celsius (°C);

        1. used to measure food energy;
        2. in nutritional studies, simply referred to as a calorie.

2. Energy Values of Foods:

    1. The caloric contents of food can be measured with a "bomb calorimeter" (See Fig 18.5, page 710);
    2. Energy yield via cellular oxidation:

        1. 1 gram of carbohydrate = 4.1 Calories;
        2. 1 gram of protein = 4.1 Calories;
        3. 1 gram of fat = 9.5 Calories.

3. Energy Requirements:

    The energy needs of individuals vary and are based on several factors including the individual's basal metabolic rate, degree of muscular activity, body temperature, and rate of growth.

    1. Basal Metabolic Rate (BMR):

        1. BMR measures the rate at which the body expends energy under basal conditions (i.e. awake, at rest, comfortable, et cetera);
        2. Tests of thyroid function can be used to estimate a person's BMR.
        3. affected by sex, temperature, size, endocrine activity;
        4. represents the energy necessary to sustain activities of the brain, heart, lungs, kidneys & liver;

5. BMR maintenance requires the body's greatest energy expenditure.

2. Energy required to support muscular activity: See Table 18.4, page 711.

CHAPTER 18: NUTRITION AND METABOLISM

IV Energy Expenditures

4. Energy Balance

1. Definition: a state of energy balance (EB) exists when caloric intake in the form of food equals caloric output resulting from BMR and muscular activity.
2. Under these conditions, body weight would remain constant:

1. Positive EB = increases body weight
   - Excess of 3500 calories can be stored as a pound of fat.
2. Negative EB = decreases body weight
   - Stored materials are mobilized from tissues for oxidation.

5. Desirable Weight

See Clinical Application 18.1 on pages 712 and 713. This application addresses obesity, however a chart illustrating body mass index (BMI) is helpful in understanding what desirable weight really means.

5. MICRONUTRIENTS

Micronutrients include vitamins and minerals, which essentially aid our cells in metabolism. As discussed in Chapter 4 of this text, enzymes regulate metabolism however they are not always activated and may require a substance called a coenzyme or cofactor. Vitamins serve as coenzymes and minerals serve as cofactors. In addition, vitamins and minerals may themselves be necessary for important body functions (i.e. bone growth, nerve impulse transmission, muscle contraction, et cetera).

1. **VITAMINS**

1. General characteristics:

1. organic;
2. required in small amounts, but body cells cannot synthesize vitamins in adequate amounts and therefore they must be obtained from foods;

3. classified based on solubility:
   Fat soluble vitamins include A, D, E, and K;
   Water-soluble vitamins include the B vitamins and C.
4. fairly resistant to heating (i.e. not destroyed in cooking).

See Table 18.5 on page concerning vitamin fallacies.

CHAPTER 18: NUTRITION AND METABOLISM

5. MICRONUTRIENTS

1. VITAMINS

1. FAT-SOLUBLE VITAMINS

a. **VITAMIN A**
- occurs in several forms including retinol & retinal;
- synthesized from carotenes (See Fig 18.7, page 714);
- stored in liver;
- functions in the production of pigments necessary for **vision**.

2. **VITAMIN D**
- group of steroids in structure;
- found in foods such as dairy products;
- produced commercially;
- can be synthesized by skin (using sunlight);
- functions as hormone that promotes the intestine's **absorption of calcium and phosphorus** (i.e. bone growth and remodeling).
- Deficiency in children causes **rickets** (See Fig 18.8, page 716).

3. **VITAMIN E**
- antioxidants;
- stored in muscle and adipose;
- precise function unknown;
- seems to prevent polyunsaturated and vitamin A oxidation, and stabilize cell membranes;
- may play a role in **defense in aging**, and several other diseases.

4. **VITAMIN K**
- K_1 occurs in foods; K_2 occurs in intestinal bacterial flora;

- stored in the liver;
- functions in the production of prothrombin necessary for normal **blood clotting**.

See Table 18.6, page 717 for a summary of the fat-soluble vitamins.
See Clinical Application 18.2 on page 715, "Do Vitamins Protect Against Heart Disease and Cancer?"

CHAPTER 18: NUTRITION AND METABOLISM

6. MICRONUTRIENTS
    1. VITAMINS
        1. WATER-SOLUBLE VITAMINS
            1. VITAMIN B-COMPLEX

- In general, the B vitamins:
    1. occur together in many foods (i.e. complex);
    2. function as coenzymes or a part of coenzymes that are necessary for the metabolism of proteins, lipids, or carbohydrates
    3. They either aid in the:
        1. synthesis of a macromolecule or
        2. the oxidization of a macromolecule.
- Include:
    1. **Thiamin** (B_1) aids in cellular respiration (required for pyruvic acid to enter the Krebs Cycle) and aids in the synthesis of the sugar ribose (RNA); See Fig 18.14, page 723; deficiency = **beriberi** (page 717);
    2. **Riboflavin** (B_2) includes FAD that transport electrons through the electron transport chain (ETC) & therefore aids in the oxidation of glucose & fatty acids.
    3. **Niacin** (Nicotinic Acid) includes NAD and NADP which are important electron carriers in glycolysis, Krebs Cycle and the ETC, as well as for the synthesis of proteins and fats; deficiency = **pellagra** (page 718);
    4. **Pantothenic Acid** (B_5) functions as part of coenzyme A (i.e. needed for formation of acetyl CoA that enters the Krebs Cycle in cellular respiration).
    5. **Vitamin B_6** aids in the synthesis of proteins, certain amino acids, antibodies, and nucleic acids; See Fig 18.11, page 719.
    6. **Cyanocobalamin** contains cobalt and is needed for the synthesis of nucleic acids and for the metabolism of carbohydrates and fats; See Fig 18.12, page 719.
    7. **Folacin** (Folic acid) aids in the metabolism of certain amino acids, the synthesis of DNA, and erythropoeisis; deficiencies have been linked to

neural tube defects during pregnancy.

8. **Biotin** is needed for the metabolism of amino acids and fatty acids and for the synthesis of nucleic acids; See Fig 18.14, page 723.

CHAPTER 18: NUTRITION AND METABOLISM

7. MICRONUTRIENTS

1. VITAMINS

1. WATER-SOLUBLE VITAMINS

2. **Ascorbic Acid (Vitamin C)**

- is closely related chemically to monosaccharides (i.e. contains 6 carbons; hexose);
- See Fig 18.13, page 720;
- is needed for the production of the connective tissue collagen (i.e. **bone matrix**, ligaments, tendons, others), the metabolism of certain amino acids, and iron absorption;
- prolonged deficiencies lead to **scurvy** (page 720).

See Table 18.7, page 721 for a summary of the water-soluble vitamins.

CHAPTER 18: NUTRITION AND METABOLISM

8. MICRONUTRIENTS

1. MINERALS

In contrast to carbohydrates, lipids, proteins, and vitamins which are organic molecules, minerals are very small **inorganic** elements. Human obtain these essential minerals by eating plants, or by eating herbivorous animals.

1. Characteristics of Minerals:

1. Compose 4% of body weight:

- concentrated in bones & teeth;
- Calcium and phosphorus are the most abundant.

2. Usually incorporated into organic molecules

- iron in hemoglobin;
- iodine in thyroxine.

3. Some compose of inorganic molecules

- calcium phosphate of bone.

4. Some are free ions in the blood:

- Sodium (Na^+);
- Chloride (Cl^-);
- Potassium (K^+).

5. Present in all body cells where they provide many functions:

- structure;
- cofactors for enzymes;
- maintain osmotic pressure (0.9%);
- are involved in transmission of nerve impulses;
- are involved in muscle contraction;
- are involved in blood clotting;
- maintain pH.

CHAPTER 18: NUTRITION AND METABOLISM

5. MICRONUTRIENTS

1. **MINERALS**

2. Summary Table of Minerals

Mineral	**Sym-bol**	**Major Trace**	**Primary Distribution**	**Major Function(s)**	**Major Sources**	**Conditions**	**Other**
Calcium	Ca	Major	Bones & Teeth	Structure of bone/teeth; nerve impulse conduction; muscle contraction	milk;	↑ kidney stones; ↓ stunted growth	
Phosphorus	P	Major	Bones & Teeth	Structure of bone/teeth; ATP; Nucleic acid & proteins	meats; cheese; milk	↑ none ↓ stunted growth	Fig 4.7
Potassium	K	Major	Intracellular Fluid	maintenance of resting membrane potential (RMP)	avocados; bananas; potatoes	↑ none ↓ muscular & cardiac problems	
Sulfur	S	Major	skin, hair, nails	essential part of amino acids, thiamine, insulin, biotin, and MPS	meats; milk; eggs	↑ none ↓ none	F 18.14 723
Sodium	Na	Major	Extracellular Fluid	maintenance of RMP, electrolyte, water, & pH balance	table salt; cured ham	↑ hyperten-sion; edema ↓ cramps; convulsions	
Chlorine	Cl	Major	Extracellular Fluid	maintenance of RMP, electrolyte, water, & pH balance	table salt; cured ham	↑ vomiting ↓ muscle cramps	
Magnesium	Mg	Major	Bones	needed in mitochondria for cellular respiration;	milk; dairy;	↑ diarrhea	

				ATP/ADP conversion	legumes	↓neuro-muscular problems	
Mineral	**Symbol**	**Major Trace**	**Primary Distribution**	**Major Function(s)**	**Sources**	**Conditions**	**Other**
Iron	Fe	Trace	Blood	part of hemoglobin	liver	↑liver damage ↓anemia	F 18.15 726
Manganese	Mn	Trace	liver, kidneys	occurs in many enzymes	nuts	↑none ↓none	F 13.18
Copper	Cu	Trace	liver, heart, brain	essential in synthesis of hemoglobin, bone, melanin, myelin	liver; oysters crabmeat	↑rare ↓rare	
Iodine	I	Trace	thyroid	essential in the synthesis of thyroid hormones	iodized table salt	↑thyroid hormone imbalance ↓goiter	
Cobalt	Co	Trace	widely distributed	component of cyanocobalamin (B_{12})	liver; lean meats	↑heart disease ↓perniciou s anemia	box on 720
Zinc	Zn	Trace	liver, kidneys, brain	wound healing; part of several enzymes	meats; cereals	↑slurred speech ↓decreased immunity	
Fluorine	F	Trace	bones & teeth	tooth structure	fluorida-ted water	↑mottled teeth ↓none	
elenium	Se	Trace	liver & kidney	occurs in enzymes	lean meats cereals	↑vomiting; fatigue ↓none	
			widely	essential for use in	liver;		

Chromium	Cr	Trace	distributed	carbohydrates	lean meats	↑ none ↓ none	

CHAPTER 18: NUTRITION AND METABOLISM

VI. HEALTHY EATING

1. An adequate diet provides sufficient energy and essential nutrients to support:
    1. optimal growth of tissues;
    2. maintenance of tissues;
    3. repair of tissues.

2. Individual dietary needs varies greatly:
    1. impossible to devise adequate diet for every human.

3. Devices to assist consumers in healthy eating include:
    1. Recommended Daily Allowances (RDA);
    2. Recommended Dietary Allowances;
    3. Food group plans;
    4. Food pyramid, See Fig 18.16 on page 728;
    5. Food labels, See Fig 18.17 on page 729.

4. Malnutrition:

    1. Poor nutrition may be due to either:
        1. Lack of foods or
        2. Failure to make best use of available foods.
    2. Is classified in two ways:
        1. Primary = poor diet;
        2. Secondary = some characteristic that makes a normal diet inadequate.

5. Starvation:

    1. A person can survive 50-70 days without food.
    2. A starving body digests itself:
        1. starts with carbohydrate stores in liver & muscle;
        2. continues with protein digestion in many tissues including muscle;

3. continues with fat digestion including adipose but also myelin that surrounds nerve fibers.

3. Starvation symptoms are numerous and progress in the following order:
    1. low blood pressure and pulse;
    2. chills, dry skin, hair loss;
    3. poor immunity;
    4. death due to malfunction of vital organ(s);
    5. See Fig 18.18, page 730.

CHAPTER 18: NUTRITION AND METABOLISM

VI. HEALTHY EATING (continued)

5. Starvation (continued)

    1. In the young, may be due to total vs. specific deficiencies:

        1. Marasmus is due to lack of all nutrients;
        2. Kwashiorkor is due to a protein deficiency.

        See Fig 18.19 on page 731 comparing these two deficiencies.

    2. In teens or adults, may be self-inflicted as eating disorders:

        1. Anorexia Nervosa is self-starvation;

            · See introduction to chapter on page 704;
            · Read progression of disease on page 731-732.

        2. Bulimia nervosa:

            · characterized by binge eating followed by purging

                1. vomiting or
                2. use of laxatives or
                3. through excessive exercise.

            · See Box on page 731;
            · Read characteristics of disorder on page 731.

VII. OTHERS:

1. See Clinical Application 18.1 on pages 712 and 713 concerning **Obesity**.

2. See Clinical Application 18.2 on page 715 entitled "**Do vitamins protect against heart disease and cancer?"**

3. See Clinical Application 18.3 on page 732 entitles "**Nutrition and the Athlete**."

VIII. KEY TO MACROMOLECULE SUMMARY TABLE (outline page 380)

Organic Molecule	Carbohy-drates (sugars)	Lipids (Fats)	Proteins	Nucleic Acids
Composed of what atoms?	C, H, 0	C, H, O	C, H, O, N, S	C, H, O, N, P
Building Blocks (monomers)	Monosaccha-rides or hexoses	Triglycerides: glycerol and 3 fatty acids	amino acids	Nucleotides: pentose sugar, phosphate, nitrogen base
Specific types & functions of monomers	glucose, fructose, galactose: energy	TG = energy Phospholipid = cell membrane component Steroid = cell membrane component and chemical messenger (i.e. cholesterol)	20 different amino acids	N/A
Specific types and functions of polymers	Disaccharides: sucrose, lactose, maltose; energy _____ Polysaccharides: Starch (plant); Glycogen (animal); energy storage.	N/A	proteins (>100 amino acids); Many functions: ENZYMES, antibodies, struc-ture, transport, chemical messengers, storage	DNA = deoxyribo=nucleic acid; genetic material; RNA= Ribonucleic acid; aids DNA in protein synthesis.
Other		Saturated (only single bonds between C's in fa chain) vs. Unsaturated (at		DNA controls cellular activity by instructing our cells what proteins to

		least 1 double bond in fa chain)		make (i.e. Enzymes).

VIII. Key to Metabolism Comparison Table (outline page 381)

	Anabolism **SYNTHESIS REACTIONS**	**Catabolism** **DEGRADATION RXN'S**
GENERAL DESCRIPTION	Synthesis involves the building of a large molecule (polymer) from smaller building blocks (monomer).	Degradation involves the breakdown of polymer into individual monomers.
DESCRIPTIVE TERMS	Building Constructive Anabolic	breakdown digestive decomposition catabolic
BOND FORMATION OR BREAKING?	Bonds are formed.	Bonds are broken.
IS ENERGY REQUIRED OR RELEASED? **NAME THAT TERM.**	Energy is required to form the bond. Endergonic	Energy is released when the bond is broken. Exergonic
HOW IS WATER INVOLVED? **NAME THAT TERM.**	Water is released when he bond is formed. Dehydration	Water is required to break the bond. Hydrolysis
EXAMPLE	Building a protein from individual amino acids; Building a triglyceride from glycerol and 3 fatty acids, etc	Breaking a protein into individual amino acids; Breaking starch down into monosaccharides, etc.

VIII. KEY TO CELLULAR RESPIRATION SUMMARY TABLE (outline page 383)

	GLYCOLYSIS	**CONVERSION STEP**	**KREBS CYCLE**	**ELECTRON TRANSPORT CHAIN**
LOCATION	cytoplasm	Mitochondria	mito matrix	mito inner membrane
Oxygen Required?	no	Yes	yes	yes
Starting Product	glucose (6-C)	2 pyruvates (2 x 3C)	Acetyl CoA (2 x 2C)	10 NADH 2 $FADH_2$
End-Products	2 pyruvates (2 x 3-C) 2 ATP 2 NADH	2 Acetyl CoA 2 NADH 2 CO_2	6 NADH 2 $FADH_2$ 2 ATP 4 CO_2	30 ATP 4 ATP 4 ATP
TOTAL				38 ATP