Biology Exam Review

CHAPTER 1: General Introduction to Nutrition

<u>What are Nutrients?</u>

- A nutrient is a substance found in food that is required by the body and used for energy, maintenance of body structure, and/or regulation of chemical processes
- Six classes:
  - Carbohydrates
  - Lipids
  - Proteins
  - Vitamins
  - Minerals
  - Water (MOST ESSENTIAL NUTRIENT)
- **Essential nutrient:** Must be obtained from the diet
- **Nonessential nutrient:** Body can produce
- **Conditionally essential:** A nutrient that becomes essential under certain circumstances
- **Organic compounds:** Contains carbon and hydrogen
- **Inorganic compounds:** Do not contain carbon
- **Certified organic:** Must meet strict Canadian production regulations, including prohibition of most synthetic pesticides, herbicides, fertilizers, drugs and preservatives as well as genetic engineering and irradiation
- **Macronutrients:**
  - Required in large amounts (grams)
  - Includes
    - Carbohydrates
    - Lipids (fats)
    - Proteins
    - Water
- **Micronutrients**
  - Required in small amounts (milligrams or micrograms)
  - Includes
    - Vitamins
    - Minerals

<u>Non-nutrients</u>

- Substances contained in some foods that are not essential nutrients, yet have healthful benefits
  - Phytochemicals: Health promoting compounds made by plants. They may reduce risks of heart disease and certain cancers
  - Zoochemical: A health-promoting compound found in animal-based food
  - Fiber
  - Functional food: A food or product that likely promotes optimal health beyond simply helping the body meet its basic nutritional needs. Functional foods contain either
    - A high concentration of traditional nutrients
    - Phytonutrients
    - And/or Zoonutrients

Dietary Supplements

- Products that contain vitamins, minerals, and/or phytochemicals
    - Provided in capsule, tabled, powder, or formula
- Your best bet is to eat real food

Scientific Method:

1. Making an observation
2. Proposing a hypothesis
3. Experimentation (collecting data)
    a. Epidemiologic studies
        i. Determine whether a variable is simply correlated with another variable
        ii. Researchers do not actually ask people to change their behaviors, alter their food intake patterns, or undergo any sort of treatment
    b. Intervention studies
        i. Requires participants – regardless of whether they are humans, animals, or cell culture systems – to undergo a treatment or intervention.
        ii. In most studies, some of the participants receive the treatment, while others do not

CHAPTER 2: Dietary Reference Intakes & The Four Major Food Groups

DRIs

- A set of four dietary assessment standards used to assess and plan dietary intake
    - In other words, DRIs are a yardstick for measuring what healthy people must consume
    - They allow comprehensive assessments of individuals and populations
- The four reference values that comprise the DRIs are:
    - Estimated Average Requirement (EAR)
        - Used to examine likelihood that intake is adequate in a population
        - The average daily nutrient intake level that meets the needs of 50% of the healthy individuals who are in a particular life stage and gender group
        - EARs are set only once scientists determine a marker in the body that indicates adequate amounts of the nutrient
            - Without such markers, EARs cannot be set

    - Recommended Dietary Allowance (RDA)
        - Used as a goal to help ensure adequate intake in an individual
        - Daily nutrient intake level that meets the needs of nearly all the healthy individuals (97-98%) in a particular life stage and gender group
        - RDA = EAR x 1.2

    - Adequate Intake Level (AI)
        - Used to examine likelihood that intake is adequate when no RDA is set for a nutrient

        - Based on intakes of healthy people (either experimentally or by simple observation) in a particular life stage and gender group
        - Ideally meets more than RDA

    - Tolerable Upper Intake Level (UL)
        - Used to examine likelihood of excess toxicity

- Because nutrient requirements differ by sex and stage of life, we have DIFFERENT DRI VALUES FOR DIFFERENT GROUPS OF PEOPLE
    - THERE ARE 16 LIFE-STAGE GROUPS FOR FEMALES AND 10 LIFE-STAGE FROUPS FOR MALES

- If your intake of a nutrient is much less than the EAR, then it is likely to be inadequate, increasing your risk of nutrient deficiency
- If your intake is between the EAR and the RDA, then you should probably increase your intake
- If your intake is between the RDA and the UL, then it is probably adequate
- If your intake is above the UL then it is probably too high

- It is also important to determine the right amount of calorie intake and whether these calories are coming from the right mix of foods
    - Estimated Energy Requirements
        - EER = average energy intake that is predicted to maintain a healthy weight
        - EER takes into account
            - Physical activity level
            - Height
            - Weight
            - Age
            - Gender
        - To calculate EER (must know variables included in equation)
            - AGE = age in years
            - PA = physical activity estimate
            - WT = weight in kg (lb/2.2)
            - HT = height in meters (in/39.4)
    - Acceptable Macronutrient Distribution Ranges
        - AMDRs indicate ranges of carbohydrate, fat and protein intakes that provide adequate amounts of energy AND may reduce the risk of a diet-related chronic disease
        - AMDR values are expressed as *percentages of the total caloric intake*
            - Carbs: 45-65% of total energy intake
            - Fat: 20-35% of total energy intake
            - Protein: 10-35% of total energy intake

Major Food Groups

Order: Vegetables and Fruits, Grain Products, Milk and Alternatives, Meat and Alternatives

1. Grains
   a. Seeds from plants
   b. Contain fiber-rich carbohydrates and several vitamins and minerals
      i. Fiber-rich only when the grain is whole
   c. **The bran:** fiber-rich outer layer; multi-layered outer skin of the edible seed
   d. **The endosperm:** middle part; provides the essential energy to the germ so it can sprout; it is by far the largest portion of the seed and contains mostly starch
   e. **The germ:** nutrient-rich inner part; the embryo, it has the potential to sprout into a new plant and it contains vitamins
   f. Wheat, Oats, Rice, Corn
   g. Grain foods are often enriched or fortified
      i. **Enrichment:** addition of vitamins and minerals to food products to replace those lost during processing or refinement
      ii. **Fortification:** addition of supplementary nutrients to food
2. Milk and alternatives
   a. Includes milk and milk products made form milk that *retain* their content of the mineral calcium
   b. Fortified with vitamin A and D in Canada
3. Meat and alternatives
   a. Meat: poultry, beef, pork and fish
   b. Alternatives: tofu, legumes, eggs and nuts
      i. Beans, peas, lentils and peanuts belong to the legume family
4. Fruits and vegetables
   a. Includes vegetables, fruits, 100% fruit juice ad 100% vegetable juice
   b. Can be fresh, frozen, or canned

CHAPTER 3: Basic Chemistry and Body Basics

What are Atoms?

- Atoms are composed of protons, neutrons and electrons
- In this course we only care about electrons
  - Why? The chemical behavior of an atom is determined by its electrons
- **Golden Rule**
  - Atoms with *incomplete* shells can *share* or *transfer* electrons with certain other atoms
    - These interactions usually result in atoms staying close together, held by attractions called chemical bonds
  - Thus, atoms may join in order to fill their outer shell with the maximum number of electrons
  - The outer shell is full when there are 8 orbiting electrons (except for hydrogen needing only 2)
- For some atoms, like sodium, it would require 7 chemical bonds in order to fill its shell. Instead, what this atom does is give away its outer electron. Sodium now carries a net *positive* charge and becomes ion
  - Sodium has 3 shells. The 3^{rd} shell contains 1 electron and it needs to be 8. So, instead of gaining 7, it gives one away.

- **Electrolytes** are molecules that separate into ions when added to water
    - NaCl (salt)
        - Salt dissolves in water. So when it dissolves, NaCl becomes sodium and chlorine, not sodium chloride
- **Free radical:** A compound that finds itself with an *unpaired* electron. These free radicals cause damage to your cells. They go around stealing electrons from other compounds. Compounds with stolen electrons then become free radicals
    - Free radicals are like robbers that are deficient in electrons. Free radicals attack and snatch electrons from the other cells to satisfy themselves
    - Antioxidants have extra electrons that they can donate to free radicals
    - Can cause
        - Cancer
        - Heart attack
        - Trauma
        - Aging
        - Arthritis
        - Asthma
        - Stroke
        - And more

What are Molecules and Compounds?

- Atoms come together to form chemical bonds
- When two or more atoms interact, a molecule is formed
    - CO2
    - O2
    - H2O
    - C6H12O6 (Glucose)
- Molecules that contain two or more *different* elements are also called compounds
    - H2O
    - Glucose
    - Omega-3 fatty acid
    - Cholesterol
- **Ions** form when atoms lose or gain 1 or more electrons
    - This gives the atom a net charge: (+) if it loses electrons, or a negative charge if it gains electrons

How about Solutions?

- A solution is an evenly distributed mixture of two or more compounds
- Water is a universal solvent – the *primary* component of solutions
    - Your body, for example, is about 60% water
- The lesser the component in a solution is the solute
- Many beverages and foods are solutions that have water as the solvent

5 KEY THINGS TO UNDERSTAND AND MEMORIZE

1. Electrons that are shared between 2 atoms in a chemical bond are *not always shared equally*

2. The oxygen atom is very selfish
    a. It *pulls* on the electrons much more than do the hydrogen atoms
    b. As a result, in a water molecule, the electrons shared between hydrogen and oxygen spend more time orbiting the oxygen atom
3. This causes a *partial negative* charge around the oxygen atom and a *partial positive* charge around the hydrogen atoms
4. Molecules that behave this way are called polar molecules
    a. Each molecule with a *partial* charge acts like a magnet to bond weakly to another polar molecule
    b. The partial positively charged end is attracted to the partial negatively charged end of another molecule
    c. Water molecules are polar and can form hydrogen bonds with each other
    d. These hydrogen bonds are weak

<u>Solubility</u>

- The solubility of a compound describes how easily it dissolves, that is, forms a solution, in a liquid solvent
- Simple carbohydrates such as sugar dissolve in water
- Other substances, such as fat, are insoluble and will not dissolve in water
    - Lipids are insoluble
    - Starch: partially soluble in water

<u>The pH Scale: Acids and Bases</u>

- A hydrogen atom in a hydrogen bond between two water molecules *shift* from one to the other
    - The hydrogen atom leaves its electron behind and is transferred as a proton, or hydrogen ion (H+)
- Water is in a state of dynamic equilibrium in which water molecules dissociate at the same rate at which they are being reformed
    - Concentrations of H+ and OH- are equal in pure water
- Adding certain solutes, called **acids** and **bases**, modifies the concentrations of H+ and OH-
- **Acids** are substances that lose H+ when dissolved in water
- **Bases** are substances that *remove* and *accept* H+ when dissolved in water
    - Bases *remove* H+ from solutions by dropping OH-. These bind with H+ to from water
    - Bases *accept* H+ by binding to H+
- pH is important because your body must maintain its *acid-base balance* to function properly. Under normal conditions, the pH of your blood ranges from 7.35 to 7.45
- Digestion, is tightly regulated by controlling pH
- Chemists measure the concentration of hydrogen ions in a water solution by using the pH scale. The scale ranges from 0-14
- With each whole number increase within the scale, the H+ concentration decreases 10 times
    - Black coffee has a pH of 5.0 and tomatoes 4.0. Thus, tomatoes are 10 times more acidic than black coffee

And Finally… Chemical Reactions

- Chemical reactions change the arrangement of atoms in the molecules
    - **Digestion:** is a chemical reaction. Large molecules in food are broken down into smaller ones that can be absorbed
    - **Metabolism:** refers to the sum of all chemical reactions that occur in living cells. When cells receive a nutrient they metabolize it
        - **Catabolic reactions** involve breaking down molecules. Catabolism, for example, occurs during digestion
        - **Anabolic reactions** involve synthesizing new compounds. Repairing damaged muscle tissue after injury or exercise is an example of anabolism. This requires energy

- Enzymes are crucial for chemical reactions. However, many of these reactions occur slowly or simply do not occur spontaneously
- To solve this problem, living cells produce **enzymes**
    - **Enzymes** *are* proteins that initiate or facilitate (catalyze) chemical reactions
    - **Enzymes** are recyclable; they do not become part of the products of a reaction and as a result, one enzyme can catalyze many reactions
- Most enzymes end in "ase"… Sucrase

Body Basics: From Cells to Organ Systems

Atoms → Molecules → Macromolecules → Cells and Organelles → Tissues → Organs → Organ Systems

- **Tissues** are a *collection* of cells. The tissue that we care most about in this course is the **epithelial tissue**
    - The **epithelial tissue** includes the sheet of cells that
        - Cover the exterior of the body and organs of the body
        - Line the entire **gastrointestinal tract (GI)**
    - The epithelial cells of the small intestine absorb nutrients, store some nutrients and secrete important substances to aid digestion
- 4 types of tissue
    1. Epithelial
        a. Skin and inner lining of organs
    2. Connective
        a. Supports, connects, and anchors body structures – it is the glue that holds the body together
    3. Muscle
        a. Skeletal muscle and smooth muscle
    4. Neural
        a. Makes up the brain, spinal cord, and nerves

- Organs and organ systems
    - Organs are a collection of tissues that perform a specific function
        - More than 40 organs
    - Organ systems are groups of organs that work together for similar purpose
        - 11 organ systems

Digestive System

- Hollow tube form mouth to anus
    - Lumen
- Organs:
    - Mouth
    - Esophagus
    - Stomach
    - Small intestine
    - Large intestine
- Transit time
    - 24-72 hours
- Accessory organs
    - Gallbladder
    - Pancreas
    - Liver
- Functions
    - Digestion
    - Absorption
    - Elimination

- Digestion is highly regulated
    - Powerful muscular contraction called peristalsis propels the food from one region of the GI tract to the next
    - At certain points we find sphincters that regulate the flow of food
    - The innermost lining of the digestive tract, the **mucosa**, consists mainly of epithelial tissue that produces and releases substances that facilitate digestion. Substances released include:
        - Enzymes
        - Hormones that regulate the rate at which food moves through the GI tract
        - Mucus, which keeps the inner lining of the GI tract moist and provides protection from irritating (and sometimes harmful) substances

Accessory Organs	**Organs of the Gastrointestinal Tract**
Salivary glands	Mouth
Liver: Processes and stores nutrients, produces cholesterol, makes bile	Pharynx
Gallbladder: Releases bile into the duodenum when fatty foods are present	Esophagus
Pancreas: Secretes enzymes that break down carbohydrates, protein, and fat. Also neutralizes HCl in chyme when it enters duodenum	Stomach
	Small intestine
	Large intestine

Digestion, Absorption and Excretion

1. **Digestion:** The physical and chemical breakdown of food into a form that allows nutrients to be absorbed
    a. Digestion begins in the mouth
        i. Begins by biting and grinding actions of teeth
        ii. Chewing increases surface area
        iii. **Saliva** from glands mixes with food and begins digestion of starch and fat
        iv. **Saliva** contains
            1. Enzymes that breakdown bacteria
            2. Mucus to lubricate and hold food together
            3. **Salivary amylase** breaks down starch
            4. **Lipase** breaks down some fat
            5. Enhances perception of flavor
2. **Absorption:** The transfer of nutrients from the GI tract into the blood or lymph
3. **Elimination:** The process whereby solid waste is removed from the body

- **Peristalsis** moves the bolus toward the stomach
    - A wave of powerful muscular contractions called **peristalsis** move small amounts of food and beverages through the gastrointestinal tract
    - The esophagus is lubricated with mucus that is secreted from the epithelial cells that line the inside
    - The trip from mouth to stomach takes less than 10 seconds
- Now the bolus reaches the stomach
    - Stomach is a large J-shaped muscular sac that holds and churns food
    - Can hold food for 3-5 hours
    - Mixed with stomach secretions food becomes **chyme**
        - Chyme stays in the stomach for about 2 hours and then released in periodic spurts into the duodenum. The first part of the small intestine
        - **Pyloric sphincter** controls the rate that chyme is released into the small intestine

Small Intestine

- Small intestine has 3 sections
    - Duodenum
    - Jejenum
    - Ileum
- Most digestion and absorption occurs in the small intestine
- Carbs, lipids, and proteins are broken down here into smaller components. These molecules are then ready to be absorbed
- Works as a team with the gallbladder, liver and pancreas

The Cardiovascular System Circulates Nutrients and Gases

- Includes heart, blood, and blood vessels
- Upon absorption, water-soluble nutrients enter the bloodstream through capillaries contained within each villus
- Once in the bloodstream, directed to the liver, giving it first access to the nutrient-rich blood as it leaves the small intestine. The liver then regulates the

use of the nutrients to suit the body's needs. Small amounts of some nutrients are stored in the liver, but most either undergo chemical modification or are released directly into blood, whereby they are delivered to other parts of the body

- **Blood vessels:** A network of tubes through which the blood moves. Beginning from the heart, the blood flows through
  - Arteries
  - Arterioles
    - RED IS OXYGENATED
  - Capillaries: this is where gas + nutrient exchange between blood and cells occurs
  - Venules
  - Veins
    - BLUE IS DEOXIGINATED

The Lymphatic System Circulates Fat-Soluble Nutrients

- Plays an important role in the circulation of fat-soluble nutrients (mostly lipids and some vitamins) away from the GI tract
- Each villus contains a lymphatic vessel – a lacteal – through which the nutrients are absorbed
- Each lacteal connects to a larger network of lymphatic vessels that circulate a translucent liquid called lymph
- Through the circulatory route of the lymphatic system initially bypasses the liver, it eventually empties into the bloodstream where nutrients can be taken up and used by cells

Large Intestine

- Primary role is absorption of water and minerals, and dehydration of chyme before it is expelled
- Rectum: lower part of the large intestine where feces are stored
- Housing of bacteria (microbiota)
  - Bacteria break down some fiber and make vitamin K and biotin available to the host
  - The bacterial species varies from one person to the next
  - A **probiotic** food contains live bacterial cultures, some of which thrive in the colon
    - Yogurt and fermented dairy products are examples
  - A **prebiotic** food is typically fiber-rich and may stimulate the growth of the microbial population in the large intestine

CHAPTER 4: CARBOHYDRATES

- Carbohydrates are energy yielding nutrients
- Where do we get our carbohydrates?
  - All plant food
    - Because of photosynthesis!
    - Plants *make* carbohydrates by using the sun's energy
    - They take carbon dioxide (CO_2) from the air and water (H_2O) from the ground and synthesize glucose
    - This chemical reaction is powered by the sun

            - The energy from the sun is then transferred to the glucose molecule, where it remains stored
            - More specifically, the energy is stored in the carbon-hydrogen bonds. We break these bonds to release energy. We are in a sense, solar powered
    - Milk
- Carbohydrates are not all equal. Plants produce:
    - **Simple carbohydrates**
        - Sugars
    - **Complex carbohydrates**
        - Starch
        - Fiber
            - Plant material that we cannot break down. It enters the large intestine virtually unchanged
- So, we eat plants and use these carbohydrates to then power the chemical reactions within our cells

<u>Energy in Food is Measured in Calories</u>

- Energy is the capacity of a physical system to do work
    - In other words, if something has energy, it can cause something else to happen
- Energy is NOT a nutrient, but in terms of nutrition, the body uses energy found in foods to grow, develop, move, and fuel the many chemical reactions required for life
- Carbohydrates, proteins, and lipids all contain energy
- How do we measure energy in food?
    - The standard unit of energy is the joule but biologists measure the *energy of metabolism* in calories
    - So, calories tell us how much energy there is in food
        - 1000 **c**alories = 1 **C**alorie = 1 **kcal**
        - 1 **kcal** = 1 **C**alorie (with a capital C)

<u>Classification of Carbohydrates</u>

- Simple Carbohydrates
    - Monosaccharides: All have 6 carbons, 12 hydrogens and 6 oxygens; only the arrangement differs
        - Glucose
            - Most common sugar in our food and bodies
            - Found in fruit and vegetables
            - Has a mild sweet flavor
            - Found in *every* disaccharide and *poly*saccharide
        - Fructose
            - Sweeter than glucose. In fact, it is the sweetest tasting of all natural occurring sugars
            - Naturally found in many fruits and vegetables and honey
            - Not needed in the body. So the liver converts it into glucose or fat
        - Galactose

            - Does not occur in our food
            - Hardly tastes sweet
            - Galactose is a component of the disaccharide lactose that is found in milk
            - Breastfeeding mothers convert their glucose into Galactose in order to produce lactose
    - Disaccharides: Pairs of monosaccharides
        - Lactose
            - Consists of glucose and Galactose molecules, referred to as milk sugar
        - Sucrose (glucose and fructose)
            - Consists of glucose and fructose
            - Sweeter than lactose and maltose
            - Found in fruit, vegetables, grains
        - Maltose
            - Consists of two glucose molecules, referred to as malt sugar
            - It is not present in the food we eat. Rather, it is a by-product of our digestion of the food
                - When starch breaks down
- Nutritive vs. non-nutritive sweeteners
    - **Nutritive** are simple sugars that add calories in food
    - **Non-nutritive** are synthetic compounds that are intensely sweet tasting compared to sugar but supply no energy per serving
        - Splenda

- Complex Carbohydrates: made of *many* units of glucose linked together in straight or branched chains
    - Polysaccharides
        - Glycogen
            - Storage form of glucose in the *body*
            - Built entirely of glucose
            - Provides a rapid release of energy when needed
        - Starch
            - Storage form of glucose in *plants*
            - Built entirely of glucose
            - Our digestive systems break it down into glucose units
            - Plants convert the glucose to starch. Starch is the storage form of glucose
        - Dietary Fiber
            - Build from a variety of monosaccharides
            - Indigestible in the **small intestine**
                - **Soluble Fibers:** are digested by bacteria in the large intestine
                    - Dissolve in water where they swell and become viscous → has thickening abilites
                - **Insoluble Fibers:** are NOT digested by bacteria in the large intestine

                - Lignin is insoluble
                    - Found in the woody parts of plants (seeds, carrots, etc.)
                - Cellulose is insoluble
            - Both are important for good health
                - **Soluble Fiber** promotes bowel health, reduces obesity risk
                - **Insoluble Fiber** promotes bowel health by reducing/preventing constipation and hemorrhoids. Also prevents diverticula (bulging pockets that form on large intestine)
- **Amylopectin** is highly branched, leaving more surface area available for digestion. It's broken down quickly → produces a larger rise in blood sugar (glucose)
- **Amylose** is a straight chain, this limits the amount of surface area exposed for digestion
- Plants typically contain a mixture of these two types of starch

<u>Insulin</u>
- After a carb-rich meal, blood glucose levels quickly rise, leading to hyperglycemia
- Pancreas triggered to increase its release of insulin
- Insulin allows your cells to take in glucose from across their cell membranes
    - **Without insulin, glucose will not enter cells**
- Insulin is like a key that opens the door to allow glucose to enter the cell
- Also enhances energy storage by promoting
    - Fat production
    - Glycogen production
    - Protein production
- Also decreases hunger

<u>Glucagon</u>
- When you haven't eaten for some time, your blood glucose levels decline
- Now other specialized cells in your pancreas secrete glucagon into the blood stream
- Eventually, the glucagon will reach the liver and the cells will respond to the glucagon and break down glycogen to make glucose
- Now blood sugar levels rise

CHAPTER 5: Lipids
<u>Why Lipids are Good…</u>
1. Lipids enhance intestinal absorption of fat-soluble vitamins and phytochemicals. At lease 20 grams of fat to properly transport fat-soluble vitamins!
2. Lipids contribute to satiety. Gastric emptying is slowed
3. Lipids add flavor and texture to food
4. Cushion the body, example, the fatty apron that covers the abdomen
    a. Called **Visceral fat**

5. Insulates the body
    a. Called **Subcutaneous fat**
6. Maintain cell function
    a. The cell membrane is *made* of lipids
7. And o course for energy
    a. At rest, our cells need energy to carry out their work. Fat is what they use when we are at rest
    b. We have an *unlimited* capacity to store fat

<u>Types of Lipids</u>

<u>Fatty Acids</u>

- A **fatty acid** is a chain of carbon atoms attached to hydrogen atoms
- Most lipids have them in their chemical structure
- IMAGE
    - "Free" fatty acid symbol
        - Squiggly line (fatty acid)
    - Triglyceride symbol
        - Ball (glycerol molecule) with three squiggly lines (fatty acid)
    - Phospholipid symbol
        - Ball (red and grey) with two squiggly lines
        - Partially water soluble
            - They act as **emulsifiers**
                - A substance that keeps water-soluble compounds mixed together with non-water soluble compounds
- Fatty acids contain a hydrocarbon chain (carbon and hydrogen atoms) with a **methyl group (CH_3)** at one end and an **acid group ($COOH$) (carboxyl group)** at the other
- They differ in *length* and *shape* of they hydrocarbon tail
    - Short chain: 2 to 4 carbons long; short enough to be water soluble
    - Medium chain: 6 to 12 carbons long
    - Long chain: 14 to 24 carbons long
- The *shape* of a fatty acid is determined by the number of double bonds
    - A fatty acid with no double bonds is said to be **saturated**
    - A fatty acid with one or more double bonds is said to be **unsaturated**
        - **Monounsaturated Fatty Acids:** have one double bond with the carbon chain
            - More heat stable
        - **Polyunsaturated Fatty Acids:** have two or more double bonds within the carbon chain
            - Omega-3 fatty acid
            - Omega-6 fatty acid
- Cholesterol – the last of the lipids
    - A chemically complex lipid that DOES NOT PROVIDE ENERGY
    - Found in the fatty parts of animal food
        - Butter
        - Egg yolks
        - Whole milk
        - Poultry

Overview of Lipid Digestion

1. Mouth: Small amount of digestion of fat begins here. Warmth of mouth also melts some of the fat
2. Stomach: Minor fat digestion occurs (gastric lipase)
3. Liver: Produces bile that helps emulsify fat (bile stored in gallbladder)
4. Pancreas: Secretes lipase into small intestine
5. Small intestine: Main site for lipid digestion and absorption
6. Less than 5% of undigested fat is excreted in feces

Gallbladder

- Bile is produced in the liver and stored in the gallbladder
- When fatty foods enter the small intestine, gallbladder is triggered to squirt bile into the small intestine
- Bile contains:
    - Lecithin (a phospholipid)
    - Cholesterol
    - Salts (bile acid)
- Bile disperses large lipids into small globules called micelles
    - This increases the surface area upon which enzymes can work to break down the lipids

Pancreas

- Emulsification by itself does not complete lipid digestion; fatty acids still need to be chemically cleaved from those still attached to glycerol
- When fatty foods enter the duodenum, the epithelial cells release a hormone to signal the pancreas to release pancreatic lipase
- Pancreatic lipase completes triglyceride digestion by cleaving the remaining fatty acids from their glycerol molecules

Lipid Absorption

- Short and medium chain fatty acids enter directly into the blood stream via capillaries
- The rest of the products of lipid digestion are packaged together with protein to form **chylomicron**
- Chylomicron then passes into the lacteal vessel
- A chylomicron is a **lipoprotein**
    - A type of protein that helps the body transport lipids
- Everything inside the chylomicron is non-polar (insoluble-hydrophobic)
- It is a brilliant way to package lipids
- Chylomicron enters the lacteal vessel (part of the lymphatic system)
- Chylomicrons travel up the thoracic duct
- … And dropped into the right subclavian vein
- The chylomicron has now entered the cardiovascular system
- 10-12 hours after a meal, most chylomicrons have been reduced to small cholesterol-rich remnants
- The liver now clears these remnants from the blood stream

Lipoproteins

- There are 4 types of lipoproteins

- High-Density Lipoproteins (HDL)
  - "Good" cholesterol
  - Transports cholesterol away from dying cells including arterial plaques and brings it to the liver
  - The liver uses this cholesterol to make bile. Then you eat fiber and eliminate it from your body
- Very Low-Density Lipoproteins (VLDL)
  - The liver is the primary source of VLDLs
  - Carry triglycerides. Their load is ferried to cells throughout the body and delivered to muscle and adipose tissue
  - Once they release their triglyceride load, they become LDLs
- Low-Density Lipoproteins (LDL)
  - "Bad" cholesterol
  - Circulate in the blood and deliver cholesterol to cells with LDL receptors
  - These receptors are blocked by saturated fats

- Each carries a different proportion of
  - Cholesterol
  - Protein
  - Triglycerides
  - Phospholipids

<u>Embolus Formation</u>

- A clot that breaks away and travels through the blood is an **embolus**
  - If an embolus lodges in the heart → heart attack
  - If an embolus lodges in the brain → stroke

CHAPTER 6: Proteins

- Proteins are a string of many subunits called amino acids
- Proteins are *complex* organic molecules
  - Chemically similar to lipids and carbohydrates because they contain carbon, hydrogen, and oxygen atoms. **But protein is 16% nitrogen**
  - Plants, animals, bacteria, and even viruses contain hundreds of proteins
    - Human body contains 100,000 different proteins
- Although cells can use proteins for energy, normally they metabolize very little for energy
  - Instead, we conserve proteins for other important functions
- One major difference between proteins and other macronutrients is… **our DNA provides the blueprint on how to *build* proteins in our body**
- Unlike carbs and fat, the body can break down protein that is no longer needed and *recycle* them
  - Hemoglobin is a protein found inside red blood cells (RBCs). Hemoglobin carries oxygen. RBCs live for 3-4 months. Hemoglobin is broken down and recycled
  - The cells lining the small intestine have a 3-6 day life span
    - When cells are sloughed off, the digestive system breaks down protein just like in our food and absorbs the amino acids

<u>What *are* Amino Acids?</u>

- The **amino acid** is the basic building block of proteins. Proteins are long chains of amino acids
    - **Polypeptide:** A string of amino acids
- Amino acids are small molecules with a simple basic structure, a carbon atom to which 3 groups are added
    - An amino acid (-NH2)
    - A carboxyl group (-COOH)
    - A functional group (R)
- There are 20 different amino acids
    - **9 of the 20 amino acids are *ESSENTIAL***
- The functional group gives amino acids their chemical identity
- **Essential amino acids:** Body cannot synthesize them, therefore must be supplied by food
- **Nonessential amino acids:** Body can synthesize from other amino acids or compounds

- Changes to the environment of the protein may cause it to unfold or **denature**
    - A **denatured** protein is *inactive*; it no longer works
        - The protein in raw egg white
        - Wine is an alcohol → denatures proteins in meat, helping to tenderize the meat
        - Denaturation usually permanently alters the protein's shape and functions
            - Once an egg white has been cooked, the food cannot return to its original state
    - Increased temperature or lowering the pH affects hydrogen bonding,
    - Broken hydrogen bonds causes the protein to unfold

- The body makes protein by following information coded in DNA
- To make a protein, you would follow directions for connecting the different amino acids in a *specific order* and *length*
    - Your DNA tells your cells the *sequence* of amino acids to form a protein
- Protein synthesis begins with DNA in the cell's nucleus
- DNA is a twisted two-stranded molecule called the **double helix**
- A **gene** is a portion of DNA that contains information concerning the *order of amino acids* that comprise a specific protein
    - A=Adenine
    - T=Thymine
    - G=Guanine
    - C=Cytosine
- DNA NEVER leaves the nucleus. Only copies of the DNA are allowed to exit the nucleus
- The copy of the gene is **transcribed** form your DNA to *"messenger RNA" (mRNA)*. mRNA is chemically similar to DNA
- A healthy human body can make **11 of the 20 amino acids**
- The liver is the main site of *non-essential* amino acid production

Maintaining Fluid Balance

- **Albumin** is a protein that works to maintain the proper distribution of fluids in blood and body tissues
- Recall that blood capillaries are leaky tubes. Albumin is a large protein that is trapped inside the blood vessels (ie it does not leak out of the blood capillaries)
- **The presence of albumin, inside the blood capillaries, draws water back into the capillaries**
- Blood capillaries are leaky. Fluid, ie water, ends up in the extracellular spaces (interstitial space)
- Blood proteins attract this fluid, back into the bloodstream. This attraction works by **osmosis**
- **Edema:** swollen tissue
- Proteins can act as **buffers** because the have **acidic** and **basic** components

Proteins Maintain a Strong Immune System

- **Antibodies** are “soldier” proteins that are a key component of the immune system
- Antibodies bind to pathogens (bacteria, viruses). This flags them for destruction by other specialized cells of the immune system
- In a normal, healthy individual, antibodies are efficient in combating pathogens to prevent infection and disease
- However, without sufficient dietary protein, the immune system lacks the **material needed to build this defense**

Proteins Provide Structural Support and Movement

- The key structural proteins are **collagen and keratin**. Constitute more than a third of body protein
    - Bone is made mostly of collagen
    - Keratin is in outer layer of skin, hair and nails
- Muscle fibers are composed of protein

- Some proteins act as chemical messengers. Also known as **hormones**
    - **Insulin and glucagon are proteins that act as hormones**

Protein Digestion

- The process of digestion disassembles food proteins into amino acids that are then absorbed and carried to cells where they are used to make the proteins needed by the body
    - Analogous to disassembling someone else’s house and then using the materials to build another house that perfectly fits your needs
- Stomach
    1. Hydrochloric acid denature food proteins
    2. **Pepsin**, an enzyme, digests proteins into smaller polypeptides
- Small intestine
    1. Pancreas secretes more protein-splitting enzymes. These enzymes break down polypeptides into shorter peptides and amino acids
    2. Within the absorptive cells, di-and tri- peptides are broken down into amino acids

3. Amino acids are the end products of protein digestion

- After being absorbed
    - Amino acids enter the portal vein and travel to the liver where they may enter the general circulation
- Protein digestion and absorption is very efficient – very little dietary protein escapes digestion and is eliminated in feces
- The liver keeps some amino acids for its needs and releases the rest into the general circulation (ie into the cardiovascular system)
- By the time cells obtain amino acids from blood, they cannot distinguish the ones that were originally in oat proteins from those that were in milk proteins
- The cells of your body, however, now have all the amino acids they need to make *your* body's proteins

<u>How Much Protein Do You Need?</u>

- EAR = 0.66g of protein/kg of body weight
- RDA = 0.8 of protein/kg of body weight
- Note, the EAR for protein increases during
    - Pregnancy
    - Breast-feeding
    - Periods of rapid growth
    - *Recovery* from serious illnesses, blood losses, and burns

<u>Nitrogen Balance</u>

- The continual breaking down and recycling of protein is known as **protein turnover**
- **Protein turnove**r, allows the body to adapt to periods of growth (e.g. childhood) and maintain relatively stable amounts of nitrogen without requiring enormous amounts of protein from food
- Normally, an adult's body maintains **nitrogen balance**
    - A balance between nitrogen *intake* and nitrogen *losses*
- But sometimes, nitrogen intake and retention do not equal nitrogen losses
- When the body is in a state of
    - **Positive nitrogen balance** it *retains* more nitrogen than it loses
        - Resistance exercise
        - Lactating, pregnant
        - Recovery from illness
    - **Negative nitrogen balance**, the body *loses* more nitrogen than it retains and protein intake is less than what the body needs
        - Burns, severe injury
        - Starvation
        - Bed rest
        - Severe emotional trauma

- If you consume more protein than you need, what happens to the extra amino acids?
    - **The body DOES NOT STORE excess amino acids in muscle or other tissues**

- The unnecessary amino acids undergo deamination, and cells convert the carbon skeletons into glucose (gluconeogenesis) or fat, or metabolize them for energy

- **Protein complementation** is the process of mixing incomplete plant-based protein sources to provide all essential amino acids *without* adding animal proteins
    - To make dishes that contain complementary amino acid combinations, **you must know which plant foods are good protein sources and which essential amino acids are limiting or low in those plant foods**

- **Celiac disease** an autoimmune disorder that affects primarily the gastrointestinal tract

CHAPTER 7: Vitamins

- **Scurvy:** A deficiency disease caused by the absence of vitamin C in the diet
    - Cure: eating oranges and lemons
- **Beriberi:** A deficiency disease caused by eating polished rice (rice with the bran layer removed)
- Vitamins are **micronutrients**
    - Foods generally contain much smaller amounts of vitamins than macronutrients
        - Furthermore, the body requires vitamins in *milligram* (mg) or *microgram* (mcg) amounts, but it needs *grams* of macronutrients
- **Water-Soluble Vitamins**
    - **Thiamin (B1)**
        - Beriberi can occur with thiamin-deficiency
            - Weakness, memory loss, weigh loss, etc.
    - **Riboflavin (B2)**
        - If missing from diet
            - Fatigued easily
            - Inflamed tongue, sores on the edges of the lips
            - But deficiency is very rare
    - **Niacin (B3)**
        - If missing from diet
            - Pellagra disease
                - Dementia
                - Dermatitis
                - Diarrhea
                - Death
    - **B-6**
        - Needed for amino acid metabolism
            - **Without it, all amino acids become essential**
        - Required for synthesis of the **heme** in hemoglobin
            - **Hemoglobin:** oxygen carrying protein in our blood
    - **B-12**
        - Assists in DNA synthesis

        - Without it, segments of myelin sheath gradually undergo destruction that can lead to paralysis
        - Deficiency
            - **Pernicious Anemia**
                - Nerve damage
    - **Folate**
        - Name for a group of related compounds
            - **Folic acid** is the synthetic form found in supplements and added to fortify foods
        - Deficiency affects cells that rapidly divide
    - **C, Ascorbic Acid**
        - Collagen Synthesis
            - **Collagen** is a fibrous protein that gives strength to *connective tissue* (bone, teeth, skin, tendons, blood vessels)
        - Deficiency: scurvy
        - **Improves absorption of non-heme iron**
            - **Heme-iron** comes from animals
            - **Non-heme iron** comes from plants
    - **Pantothenic Acid**
        - Involved in energy metabolism
    - **Biotin**
        - Involved in energy metabolism
        - Bacteria in the large intestine synthesize biotin. Some of our biotin needs are met by the work of our friendly microbes
- **Fat-Soluble Vitamins**
    - **Vitamin A**
        - Includes a family of compounds
        - Retinol is *preformed* vitamin A. It is the most active form of the vitamin in the body
            - **Retinol and other forms of vitamin A are only in animal foods**
        - Plants contain hundreds of yellow-orange pigments called **carotenoids**
            - Beta-carotene is a *provitamin*. The body can use beta-carotene to make retinol
        - **It is crucial for production and maintenance of epithelial cells**
        - **Deficiency diseases**
            - Can reduce fertility, because the vitamin is required for maintaining the epithelial cells that line the reproductive tracts of men and women
            - Dry eye (xerophthalmia)
            - Keratinization – hard, scaly/bumpy skin
        - Stored in the liver
    - **Vitamin D**
        - The sunshine vitamin
        - Exposing children to sunlight could prevent or treat **rickets**
            - Bones that are soft and can become misshapen

        - Necessary for the production and maintenance of healthy pons
            - **Vitamin D *stimulates epithelial cells of the small intestine* to absorb more calcium and phosphorus from food**
        - Involved in controlling cell growth, thus may reduce the risk of certain cancers (very new research)
        - Excess vitamin D can cause the small intestine to absorb too much calcium from foods
    - **Vitamin E**
        - 8 forms of vitamin E, but **alpha-tocopherol** is the most active more
        - Easily destroyed by cooking
        - It is the *major fat-soluble antioxidant* found in cells
            - It donates an electron to free radicals
            - The vitamin protects polyunsaturated fatty acids in cell membranes from being damaged by radicals
    - **Vitamin K**
        - Important for the synthesis of blood clotting factors in the blood. Without it, you could bleed to death from a minor cut

What *is* a Vitamin?

- A complex *organic* compound
- Vitamins generally meet the following criteria:
    - The body cannot synthesize it – or make enough to maintain good health
    - Naturally occurs in common foods
    - Deficiency condition occurs when the vitamin is missing from the diet
    - Good health is restored, if deficiency disorder is treated early by supplying the missing substance
- Vitamins are NOT A SOURCE OF ENERGY
    - Cells do not metabolize vitamins for energy
    - But, many vitamins *participate* in the chemical reactions that release energy from glucose, fatty acids, and protein
- **Provitamins** are vitamin precursors that do not function in the body until converted to active forms
    - **Beta-carotene is precursor to vitamin A**
    - **Tryptophan (amino acid) is a precursor to niacin**
- **Preformed** vitamins are found in food that are usable by the body – without chemical transformation

Vitamin Absorption

- Most absorption occurs in small intestine
    - Absorption is not 100% efficient
    - Absorption generally increases when more of the vitamin is needed
        - Growth (infancy and adolescence)
        - Pregnancy
        - Breast-feeding (milk production)
- There are several reasons why the amount of vitamin absorbed varies

  - Your body's physiological need for it. Mostly dictated by age and gender
  - How the food was prepared: raw vs. cooked
  - Synthetic vs. Non-synthetic vs. processed foods
  - The *combination* of the foods you ate

<u>Sources of Vitamins</u>

- Natural Sources
  - Plants, animals, fungi and bacteria
- Synthetic
  - Made in laboratories by chemists
  - Synthesized by microbes in laboratories and extracted for commercial use
- Enrichment
  - Addition of vitamins and minerals to food products to replace those lost during processing or refinement
- Fortification
  - Addition of supplementary nutrients to food

CHAPTER 8: Minerals

- Minerals cannot be synthesized by any organism
- Minerals come from Mother Earth
  - They are taken up by plants from the soil and water and incorporated into their tissue
    - In some parts of the world, soils have limited amounts of certain minerals
  - Animals eat plants and in turn incorporate it into their tissue (animals also take up minerals from water)

<u>Why are Minerals Necessary?</u>

1. Inorganic structural components of bones and teeth
2. Maintain fluid balance as inorganic ions
3. Maintain acid-base balance as inorganic ions
4. Critical in the transmission of nerve impulses throughout the body
5. Catalyzes chemical reactions working as **cofactors**

- Minerals are not metabolized for energy, but minerals serve as cofactors in chemical reactions that release energy from macronutrients…

<u>Sources of Minerals</u>

- Food
  - For some minerals, animal-based foods are the richest source and have the best **bioavailability**. For others, bioavailability is highest in plants
    - Dairy products are rich sources of bioavailable calcium
    - Meat is rich source of bioavailable iron and zinc
- Tap water
  - "Hard" water naturally contains calcium, sulfur, copper, iron and zinc
  - Additionally, fluoride is often added to public water supplies
  - Soft water is treated water with sodium (Na+) as the only mineral
  - Water with high mineral content often tastes and smells unpleasant

- Mineral supplements
  - Generally safe for healthy people
  - **BUT** many minerals have a narrow range of safe intake; therefore, it is easy to consume a toxic amount. Recall – the dose is poison
  - Additionally, an excess of one mineral can interfere with the absorption of another in the intestine

<u>Bioavailability of Minerals</u>

- The bioavailability of minerals depends on
  - The physiological need for a mineral at the time of consumption
  - The amount of other minerals consumed
  - Binding factors (compounds that bind to minerals preventing their absorption)

<u>Deficiency</u>

- The human body does not store large quantities of most minerals, and it loses small amounts of these essential elements every day
- Some common mineral deficiencies are
  - Iron: anemia
  - Iodide: goiter
  - Calcium: osteoporosis
  - Potassium: high blood pressure

<u>Water and Major Minerals</u>

- Water is a major component of
  - Intracellular fluid
    - Fluid inside the cell
  - Extracellular fluid
    - Fluid outside of the cell
      - Blood
      - Saliva
      - Sweat
      - Tears
      - Mucus
- Water participates directly in chemical reactions
  - In fact, some of the water in our cells is the *product* of chemical reactions. This is called **metabolic water**
    - **Metabolic water** refers to water created inside a living organism through their metabolism, by oxidizing energy-containing substances in their food
  - Amount of metabolic water produced per day depends on your physical activity level
    - Inactive people → 250-350 mL of water per day
    - Active people → 500-600 mL of water daily
- **Osmosis** is the *diffusion* of water through a *selectively permeable membrane*
  - This "selectively permeable membrane" is the membrane of your cells. Water must freely move from the intravascular compartments, to the interstitial space and into the intracellular compartment *freely*

    - **Substances like glucose, amino acids, and ions DO NOT MOVE FREELY ACROSS MEMBRANES**
- The body maintains the balance of compartmental fluids by controlling concentrations of ions in each compartment
- Water is attracted to ions, such as sodium, potassium, phosphate, magnesium and chloride ions
- **Where ions go, water follows**
- Intracellular water volume depends largely on intracellular concentration of potassium ions
- Extracellular water volume depends primarily on the extracellular concentration of sodium ions

<u>Sources of Water</u>

- **Total water intake** refers to our water intake from beverages *and* foods
    - 80% of our total intake is from water and other beverages
    - 20% from food
        - Especially fruits and vegetables
- **Metabolic water**

- Kidneys are major regulators of body water and electrolyte balance
    - Kidneys can control the *volume* of urine and the *amount of ions* in urine
- Water balance is controlled by hormones
    - **The Pituitary Gland** releases antidiuretic hormone (ADH)
        - ADH stimulates the kidneys produce less urine
        - **Diuretic** is a substance that *increases* urine production
    - **Adrenal Glands** secrete aldosterone
        - Aldosterone signals kidneys to reduce the elimination of sodium in urine
        - Because water follows sodium, it is conserved as well

<u>What are Minerals?</u>

- Inorganic substances other than water
- Micronutrients
- All are essential
- Cannot be created or destroyed
- Classification
    - Major minerals
        - Seven
    - Trance minerals
        - Eight
- These minerals are found
    - Within the bone matrix
    - Inside cells – intracellular fluid
    - Inside blood vessels – extracellular fluid
    - Intercellular spaces – extracellular fluid

Major Minerals

- **Calcium**
    - Most common mineral element in the human body
    - Structural component of bones and teeth
    - Remaining calcium in in *intravascular fluid* (blood) as Ca2+ (blood calcium)
    - Critical for nerve impulse transmission
        - Communication between neurons requires calcium
    - The **thyroid** and **parathyroid glands** help regulate blood calcium levels
        - They can control the activity of **osteoclast** and **osteoblast cells**
            - **Osteoclasts** are bone cells that *tear down* bone tissue
            - **Osteoblasts** are bone cells that *add* bone tissue
- **Phosphorus (P)**
    - 85% stored in bones
    - In everything we eat
    - Nearly impossible to be deficient
- **Magnesium (Mg)**
    - About 50-60% of the magnesium in the body is found in bones
    - Found in legumes
    - If intake is low, again your body will take it from your bones
- **Sodium (Na)**
    - "Table salt" or simply "salt" is sodium chloride (NaCl)
    - Salt is either mined from island salt deposits created by ancient seas or produced by the evaporation of sea water
    - Most of the sodium we consume doesn't come from the salt shaker at home
        - The majority – 75-80% – is added during food processing and at restaurants, either as salt or sodium containing food additives
    - The UL for sodium for adults is 2300 mg per day
        - AI = 1500 mg/day
        - Most people consume more than that! (3400 mg/day)
    - It is essential for
        - Water balance
        - Regulating blood pressure
        - Transmission of nerve signals
    - **VERY IMPORTANT**
        - Water is attracted to ions, such as sodium, potassium, phosphate and chloride ions
        - **Overall, where ions go, water follows**
- **Potassium (K)**
    - 95% of the body's potassium is found inside cells
    - Found in a large variety of *real* food
    - Necessary because, much like sodium
        - Maintains water balance and regulates blood pressure
        - Transmission of nerve signals
    - However unlike sodium, potassium is associated with **low blood pressure**
- **Chloride (Cl-)**
    - Important in nerve impulse transmission and fluid balance

- **Sulphur (sulphate)**
    - A component of the B-vitamins: thiamin and biotin
    - A component of the amino acids: methionine and cysteine
    - We have no EAR, RDA, AI or even UL

Trace Minerals

- Dietary sources
    - Plant-based foods
    - Animal-based goods
    - Bioavailability
- **Iron (Fe)**
    - Component of hemoglobin
        - Hemoglobin is the iron-containing protein in red blood cells that transports oxygen to tissues and some carbon dioxide away from tissues
    - Component of myoglobin
        - The oxygen-storing molecule in muscles
    - Bioavailability of iron depends on
        - Type of iron consumed
            - Heme iron and nonheme iron
        - Other dietary components
        - Individual's iron status
    - Absorption of iron
        - The epithelial cells of the small intestine produce **ferretin**
            - **Ferretin** *binds* and *stores* iron, thereby preventing it from entering the bloodstream
    - In meat is present as hemoglobin and myoglobin. Collectively referred to as **heme iron**
    - Iron in vegetables, grains, and supplements, is **nonheme iron**
    - Some iron is lost each day via the GI tract (as ferretin), urine and skin
        - Also any form of bleeding, including menstruation
    - Iron deficiency → **anemia**
- **Iodide (I)**
    - Found in rocks, plants, soil
    - Has a singular function – the synthesis of thyroid hormones
    - Iodide deficiency
        - Goiter and cretinism
            - **Goiter:** deficiency and toxicity both cause a condition called goiter to develop. It is the result of an enlarge thyroid gland (big bubble on throat)
            - **Cretinism:** fetal development impaired; stunted growth. Physical and mental abnormalities
- **Chromium**
    - *Possibly* enhances the ability of insulin to take in glucose into your cells
    - Does not increase muscle mass or melt fat
- **Zinc, Copper and Selenium**
    - Work as antioxidants
    - Component of enzymes

- **Selenium:**
    - Lowers probability of some cancers
    - Very powerful antioxidant; makes the job of vitamin E and C less hectic
- **Manganese**
  - Carbohydrate metabolism
- **Molybdenum**
  - Involved in protein metabolism
- **Fluoride**
  - Functions
    - Deposition of Ca and P in teeth and bones
      - Promotes bone and dental helath
  - Deficiency
    - Associated with an increase in dental caries
  - Toxicity
  - Mottling (fluorosis)

CHAPTER 9: Energy

What is Energy?

- Your body needs a constant supply of energy to function
- Metabolism is either anabolic or catabolic
  - **Anabolic** pathways use small, simpler compounds to build larger, more complex compounds
    - Glucose → glycogen
    - Amino acids → proteins
    - **Energy must be spent for anabolic pathways**
  - **Catabolic** pathways break down compounds into smaller units
    - The glycogen → glucose molecules
    - Proteins → amino acids
    - **Energy is released during catabolism**
- Cells *release* the energy stored in biological fuels by breaking bonds within the compounds' molecules
- The energy that is *released* can be *transferred* and *stored* in special compounds, such as **ATP** (adenosine triphosphate), until it is needed
  - **ATP** releases its energy onto the muscle fibers. The muscle fibers jerk causing movement

Energy Intake

- For humans, biological fuels are foods and beverages that contain **macronutrients**. These fuels coupled with oxygen give us energy
  - Cells obtain only about 40% of the energy that was in macronutrients by forming ATP
  - Cells release the remaining energy as heat
- Thermic effect of food (TEF)
  - Energy needed to digest, absorb, and metabolize nutrients from foods and beverages
  - Consumes about 5-10% of total caloric intake
- Nonexercise activity thermogenesis (NEAT)
  - Involuntary skeletal muscle activity

        - Shivering
        - Fidgeting
        - Maintaining muscle tone and posture
    - Consumes about 100-899 kcal/day

<u>Factors that Influence the Basal Metabolic Rate</u>

- **Basal metabolism** (expressed as **basal metabolic rate**) is the minimal number of calories the body uses for vital physiological activities after fasting and resting for 12 hours
    - It includes breathing, circulating blood, and maintaining constant liver, brain, and kidney functions
    - Does not include energy for physical activity, digestion of food, and absorption and processing of nutrients
    - For most adults, basal metabolism accounts for about 50% to 70% of the body's total energy use

1. Body composition
    a. Muscle tissue, is more metabolically active than fat tissue (thus greater muscle mass = greater metabolic rate)
2. Gender
    a. Males *generally* have higher metabolic rates than women because they tend to have more muscle tissue
3. Body surface area
    a. A tall slender person weight 140lbs has a higher metabolic rate than a shorter person who also weights 140lbs because the body constantly loses energy in the form of heat that moves to the skin's surface and then into the environment
4. Age
    a. Basal metabolism declines as one grows older
5. Calorie intake
    a. The body conserves energy use when calorie intakes are very low
        i. In one study, subjects who consumed 800 kcal per day for 10 days experienced about a 6% decline in their resting metabolic rates
6. Genes & environment
    a. Your BMR is largely genetically determined but… **Genes DO NOT control everything. The environment plays a role. Sometimes a significant role**