CASE 1

Monday, May 12, 2014 8:33 PM

LEARNING OBJECTIVES

- □ describe the broad hierarchical organisation of the human body, identifying the major levels of structural organisation
- □ describe the necessary functions of life
- □ define and briefly describe the concept of homeostasis
- □ describe the major components of a homeostatic regulatory system/mechanism
- □ describe the generic/common features of feedback control and identify the key differences between negative and positive feedback control
- □ identify the endocrine and nervous systems as the two major body systems involved in homeostasis
- □ list the systems of the body and the major organs in each system
- □ describe the "broad" major function(s) of each body system
- □ begin to identify the organ systems most central to the control of "regulated variables" of body function. For example the organ system(s) directly involved in controlling blood flow at a superficial level appears to only involve the cardiovascular system – but maybe an argument could be substantiated to include the lymph system and even musculoskeletal system?

Organ Systems

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1.1 Identify the organ systems of the human body. Most commonly eleven (11) systems are identified. Identify and list the organ systems of the human body.

1.2 List the **major** functions of each of the organ systems.

1.3 Identify the **major** discrete organs that form each of the organ systems. You might find it useful to construct a table or chart to display the organs that belong to each of the systems.

ORGAN SYSTEMS BRIEF OUTLINE

Organ System	Organs Involved	Basic Function	Necessary Life Functions
Integumentary System	- Skin - Hair - Nails	- Forms the external body covering and protects deeper tissues from injury - Synthesizes vitamin D and houses **cutaneous** (pain, pressure etc.) receptors and sweat and oil glands	**Maintaining Boundaries** - Skin protects internal organs from dying out - Bacteria/chemicals entering - Damaging heat
Skeletal System	- Bones (206) - Joints	- Protects and supports body organs, and provides framework muscles use to cause movement - Blood cells are formed within bone marrow - Bones store minerals	**Movement** - Provides bony framework that muscles pull on as they work
Muscular System	- Muscles	- Allows manipulation of the environment, locomotion, facial expression - Maintains posture and produces heat	**Movement** - Propelling ourselves from one place to another - Manipulating external environment with fingers
Nervous System	- Brain - Nerves - Spinal cord	- Fast-acting control system of body - Responds to internal and external changes by activating appropriate muscles and glands	**Responsiveness** - Because nerve cells are highly excitable and communicate via electrical impulses → nervous system responsible for responsiveness - Involuntary actions e.g. pulling your hand from hot stove
Endocrine System	- Pineal gland - Pituitary gland - Thyroid gland - Thymus - Adrenal gland - Pancreas - Ovary / Testis	- Glands secrete hormones that regulate growth, reproduction and nutrient use (metabolism) by body cells	**Metabolism** - Regulated largely by hormones secreted by endocrine glands **Reproduction** - Hormones (testosterone/estrogen) are produced by endocrine system

Cardiovascular System	- Heart - Blood vessels	- Vessels transport blood → carries oxygen, carbon dioxide, nutrients, waste - Heart pumps blood	
Lymphatic System/Immunity	- Red bone marrow - Thymus - Lymphatic vessels - Thoracic duct - Spleen - Lymph nodes	- Picks up fluid leaked from blood vessels and returns it to blood. - Disposes of debris in lymphatic stream - Houses white blood cells (lymphocytes) involved in immunity	
Respiratory System	- Nasal cavity - Pharynx - Larynx - Trachea - Lungs - Bronchus	- Keeps blood constantly supplied with oxygen and removes carbon dioxide - Gaseous exchanges occur through the walls of the air sacs of lungs	**Metabolism** - Make oxygen available to the blood
Digestive System	- Oral cavity - Esophagus - Liver - Stomach - Small intestine - Large intestine - Rectum / Anus	- Breaks down food into absorbable units that enter the blood for distribution to body cells - Indigestible foodstuffs are eliminated as feces	**Digestion** - Break up of foods **Metabolism** - Make nutrients available to the blood **Excretion** - Gets rid of indigestible food residues in feces
Urinary System	- Kidney - Ureter - Urinary bladder - Urethra	- Eliminates nitrogenous wastes from body - Regulates water, electrolyte and acid-base balance of blood	**Excretion** - Disposes of nitrogen-containing metabolic wastes e.g. urea in urine
Reproductive System	**Male:** - Prostate gland - Penis - Testis - Scrotum - Ductus deferens **Female:** - Mammary glands (in breast) - Ovary - Uterine tube - Uterus - Vagina	- Overall function to produce offspring - Testes produce sperm and male sex hormone - Male ducts and glands aid in delivery of sperm to female reproductive tract - Ovaries produce eggs and female sex hormone - Uterus is site for fertilization and development of fetus - Mammary glands produce milk to nourish newborn	

1.4 Have some fun and try and identify the organ systems centrally involved in each of the eight (8) functions necessary to maintain life.

1. **Maintaining boundaries**
   a. Internal environment remains distinct from the external environment
   b. The body is protected by the integumentary system (skin)

2. **Movement**
   a. Activities that propel us forward
   b. Movement of blood, foodstuff and urine expelled from body

3. **Responsiveness**
   a. Ability to sense changes in the environment and then respond to them

4. **Digestion**
   a. Breaking down of ingested foodstuffs to simple molecules that can be absorbed into the blood.
   b. The nutrient rich blood is then distributed to all body cells by cardiovascular system

5. **Metabolism**
   a. Metabolism is all the chemical reactions that occur within body cells.
   b. Includes:
      i. breaking down substances into their simpler building blocks,
      ii. synthesizing complex cellular structures from simpler substances,

Structure and Function

Monday, May 12, 2014 9:05 PM

1.1 List the levels of structural organization of the body.

1. **Chemical Level**
   a. Atoms and molecules that form organelles in body

2. **Cellular Level**
   a. Cells that make up your body carrying out unique functions

3. **Tissue Level**
   a. *Tissues* are groups of similar cells that have a common function. The four basic types in the human body are:
      1) Epithelium
      2) Muscle
      3) Connective
      4) Nervous

4. **Organ Level**
   a. An *organ* is a discrete structure composed of at least two tissue types (four is more common) e.g. stomach --> epithelium lining, muscle wall, nerve fibers

   b. Each organ is a specialized functional center responsible for a necessary activity that no other organ can perform

5. **Organ System Level**
   a. Organs that work together to accomplish a common purpose e.g. heart and blood vessels

6. **Organismal Level**
   a. The living human being
   b. Sum total of all structural levels working together to keep us alive

1.2 Identify at least two specific examples of each level

Structural Level	Example
Chemical	Carbon, hydrogen and oxygen combine to form glucose $C_6H_{12}O_6$
Cellular	Mitochondria cell responsible for energy production Smooth muscle cells
Organ	Stomach: epithelium lining produces juices, bulk of wall is muscle tissue, connective tissue muscular walls, nerve fibers increase digestive activity

CASE 2

Saturday, May 17, 2014 6:40 PM

LEARNING OBJECTIVES

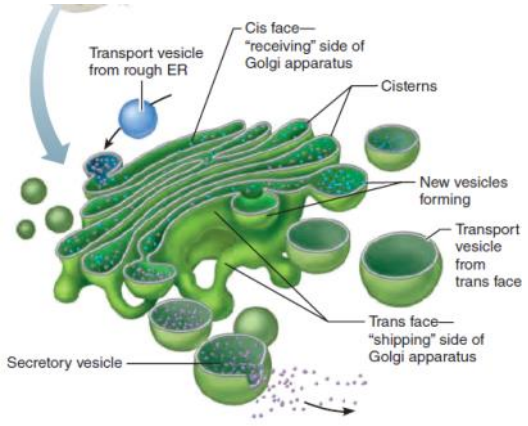
- □ identify the organelles and other structural elements of a typical human cell
- □ describe the major structural features of the organelles and other structural elements of a typical human cell
- □ begin to explain the major functions (at this stage it is really more the "types of functions" with the detail of specific functions explored in more detail as you progress through Year 1) of the organelles and other structural elements of a typical human cell
- □ begin to identify and explain the relationship(s) between the functions of tissues and organs with respect to the structural components of the cells that form the tissues and organs of the human body
- □ describe the broad properties of stem cells and their role in the formation of specialised cells

ENDOPLASMIC RETICULUM (ER) (MEMBRANOUS)

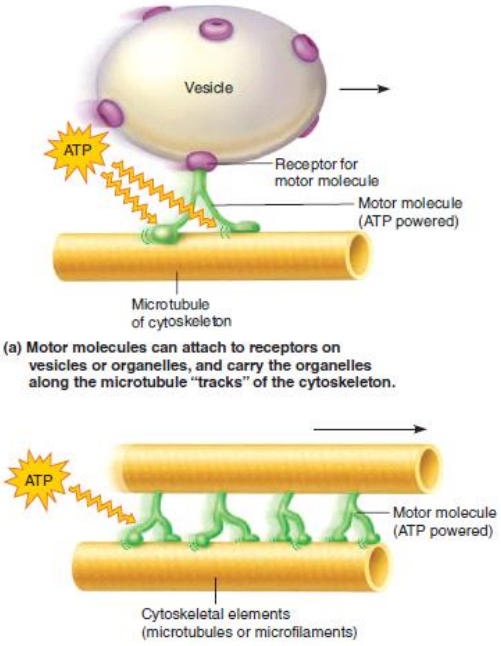
- Extensive system of interconnected tubes and parallel membranes enclosing fluid-filled cavities, or **cisterns.** Two types:
    - **Rough ER:** external surface studded with ribosomes, proteins assembled on these ribosomes thread their way into the fluid-filled interior of the ER cisterns --> newly made proteins are enclosed in vesicles --> go to Golgi apparatus. Also cell's **membrane factory** --> produces integral proteins and phospholipids that form part of plasma membrane.
    - **Smooth ER:** perform following tasks:
        - Metabolize lipids, synthesize cholesterol
        - Synthesize steroid-based hormones such as sex hormones (in testis)
        - Absorb, synthesize and transport fats (in intestinal cells)
        - Detoxify drugs, certain pesticides
        - Break down stored glycogen to form free glucose (in liver cells especially)

GOLGI APPARATUS (MEMBRANOUS)

- Principal "traffic director" for cellular proteins. Major function is to modify, concentrate, and package the proteins and lipids made at the rough ER and export it out of cell.
    - Transport vesicles from rough ER move to and fuse with the membranes at the **cis face** (receiving side) of the Golgi.
    - Inside the apparatus the proteins are modified
    - Various proteins are sorted and packaged into **three types of vesicles** that bud from the concave **trans face** (shipping side) of the Golgi:
        - Vesicles containing proteins destined for export pinch off into **secretory vesicles** or **granules** --> migrate to plasma membrane --> discharge their contents through exocytosis (PATHWAY A)
        - Pinches off vesicles containing lipids and transmembrane proteins destined for the plasma membrane or other organelles (PATHWAY B)
        - Packages digestive enzymes into lysosomes that remain in cell (PATHWAY C)



(a) Many vesicles in the process of pinching off from the Golgi apparatus.



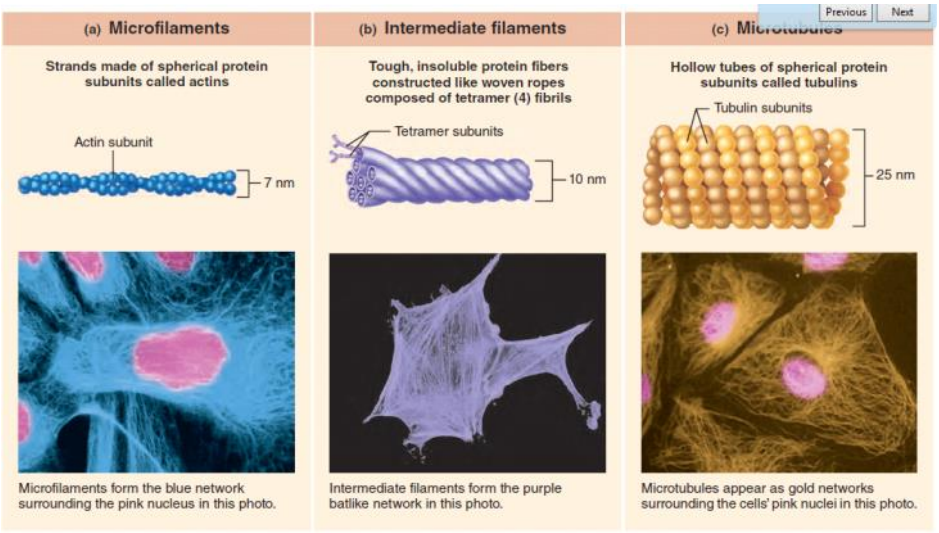


Figure 3.24 Microtubules and microfilaments function in cell motility by interacting with motor molecules powered by ATP.

- Microtubules are anchored at one end in a region called the **centrosome.** The centrosomes act as *microtubule-organizing centers.* It is surrounded in a matrix that contains paired **centrioles.** Best known for generating microtubules and organizing mitosis.

NUCLEUS

- Gene-containing control center of the cell. It is the genetic library --> contains instructions needed to build nearly all the body's proteins (kinds and amounts).
- Some cells (e.g. skeletal muscle cells, liver cells etc.) are **multinucleate** --> signifies a larger-than-usual cytoplasmic mass that need to be regulated.
- Except for **red blood cells** (nuclei ejected before entering bloodstream), all body cells are nucleated. **Anucleate** cells can't reproduce - only last for 3/4 months in the bloodstream. Cannot produce mRNA to make proteins.
- The nucleus has three recognizable regions or structures:
    1. **Nuclear Envelope:** nucleus bounded by the nuclear envelope (a **double membrane** barrier). Outer nuclear membrane is consistent with the rough ER and is studded with ribosomes. Envelope contains **nuclear pores** which form an aqueous transport channel for molecules e.g. mRNA an proteins.
    2. **Nucleoli:** the bodies found within the nucleus where ribosomal subunits are assembled. They are not membrane bounded. **Contains DNA** that issues genetic instructions for synthesizing ribosomal RNA (rRNA). As molecules of rRNA are synthesized --> combine with proteins to form two subunits of ribosomes. These are then exported to the cytoplasm.
    3. **Chromatin:** composed of 30% DNA, 60% histone proteins, 10% RNA chains (newly formed or forming).
        a) Fundamental unit of chromatin are **nucleosomes** which consist of flattened disk-like shaped clusters of **eight histone** proteins connected like beads on a string by a DNA molecule. The DNA winds twice around each nucleosome

Macromolecules & Water

Thursday, May 22, 2014 9:49 AM

The human body is **70% water** and **30% chemicals** (macromolecules, phospholipids, ions and small molecules).

MOLECULAR COMPOSITION OF CELLS

- Water (60-80%)
- Macromolecules
  - Carbohydrates, lipids, protein & nucleic acids & their building blocks
- Small molecules
  - Intermediates of metabolic pathways
- Ions & inorganic molecules
  - Na^+, K^+, phosphate, carbonate
- Miscellaneous organic molecules
  - Haem, vitamin derivatives

WATER

- Why is it vital for life?
  - Maintains body temperature: high heat capacity & heat of vaporization
- Transports nutrients & respiratory gases
  - Blood (we have 4-5 liters of blood)
- Carries away wastes
  - Blood & urine
- Ensures adequate blood volume
- Participates in chemical reactions
  - Hydrolysis/condensation
- Cushioning around body organs/lubricant around joints/surfaces
  - Hydrates eyes, mouth, nose

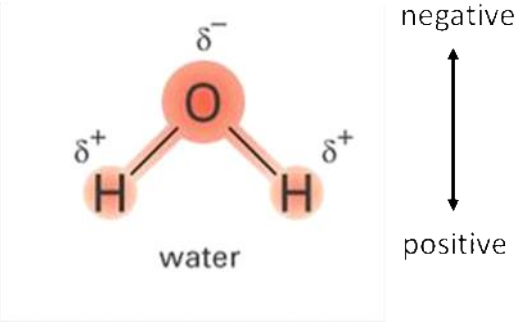
If volume of water drops, volume of blood drops, hence blood pressure drops

When hydrogen bonds are formed, it allows things to dissolve.

Ribosomes don't have a membrane.

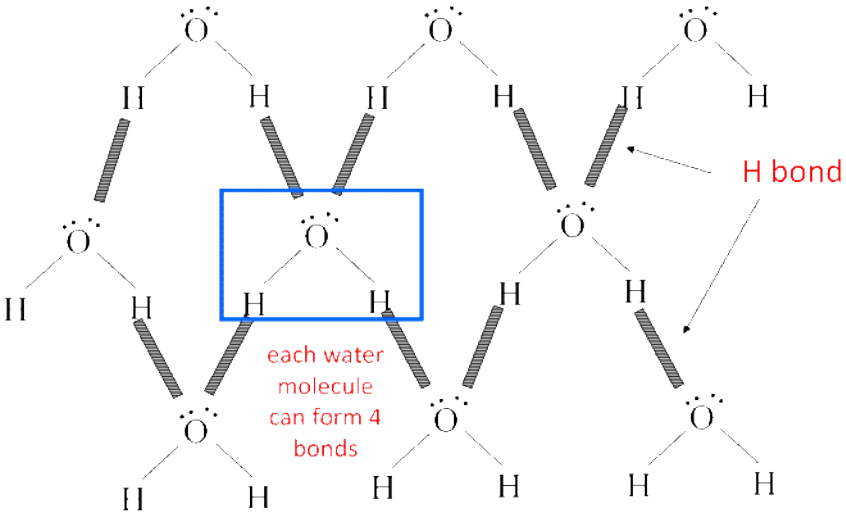
WATER IS A POLAR MOLECULE

- Unequal sharing of electrons between oxygen and hydrogen
- Oxygen is more electronegative than hydrogen
- The electrons in the covalent bond are more attracted to the oxygen nucleus & spend more time around it than H



PROPERTIES OF WATER

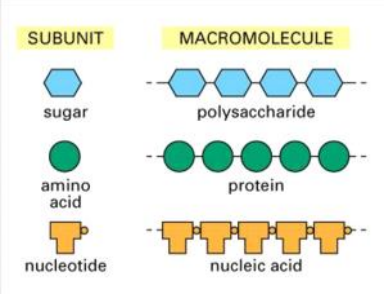
- Individual water molecules form **hydrogen (H) bonds** with their neighbors & with other polar molecules or charged particles
- H bonds are intramolecular attractions --> weaker than covalent bonds



MACROMOLECULES

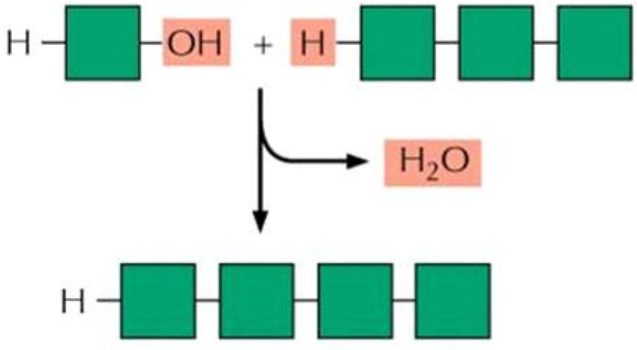
- Largely, highly organized molecules, made up of discrete building blocks chemically bonded
  - Contain carbon, hydrogen, oxygen (sometimes nitrogen)
- Many macromolecules are **polymers**. Four major categories:
  i. Carbohydrates
  ii. Lipids
  iii. Proteins
  iv. Nucleic acids

MACROMOLECULES ARE BUILT FROM SMALL MOLECULES



ADDITION OF SUBUNITS

- A **condensation reaction** involves loss of water molecule.



PROTEINS

- We depend on proteins to drive the reactions of metabolism. They are largely responsible for:
  - **Structure** of the body: like hair and fingernails, connective tissues such as tendons, to

carbohydrates. Three main polysaccharide:

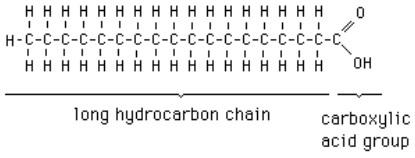
- **Starch**
- **Glycogen:** principal energy storage, made up of glucose polymers
- **Cellulose**

LIPIDS

- Includes fat, steroids, hormones etc. Main ones: triglyceride, phospholipids and steroids.
- Lipids are insoluble and are high forms of energy. They are thus stored in fat stores known as **adipose tissue** which we have in different parts of our body. They serve as reservoirs of energy, swelling and shrinking as fat is deposited and withdrawn.

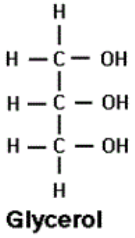
- **Triglycerides** are the major constituent of fats and oils. They are esters formed by condensation reactions between **glycerol** and **three fatty acids.**

- **Fatty acids** are long chain carboxylic acids, R-COOH.

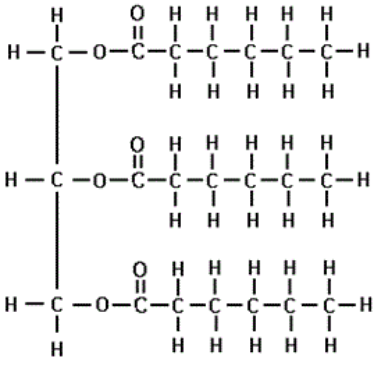


Essential features of a fatty acid

- An esterification reaction takes place between an acid -COOH group and each -OH group in glycerol, eliminating water as each ester link forms i.e. only glycerol condenses with three fatty acids to form the **triglyceride.**



Glycerol



Triglyceride-Saturated

- **Saturated** fatty acids contain all single carbon-carbon bonds. It allows them to pack together closely, van der Waal's forces increases, high melting point, solid at room temperature e.g. butter and lard.

- **Unsaturated** fatty acids contain some carbon-carbon double bonds. They have kinks in their hydrocarbon chains, not packed together, low melting point, liquid at room temperature e.g. oils. Phospholipid fatty acids are unsaturated.

- **Phospholipids** have two fatty acids attached to glycerol. The third -OH position in glycerol is condensed with a phosphate group.