Biology 112
Study Notes Exam 1

Chapter 1: Introduction to Human Anatomy & Physiology

Anatomy - the study of the *structure* of body parts & their relationship to one another
- *gross anatomy*: studies large, visible structures (organs, tissues)
- *microanatomy*: studies microscopic structures (cells, tissues)
  - *cytology* & *histology*
- other fields: regional anatomy; developmental anatomy

Physiology - the study of the *function* of the body's structures
- fields: *renal physiology* is the study of kidney function; *neurophysiology* is the study of nervous system function…

Principle of complementarity of structure & function: the function of structure depends on its structural form

Levels of Organization in Organisms:
Chemical Level:
- atoms/elements (carbon, hydrogen, oxygen, sodium…)
- molecules/compounds (sugar, salt, water…)
- macromolecules (proteins, lipids, carbohydrates, nucleic acids)
- organelles (mitochondrion, nucleus, plasma membrane…)

Cellular Level: molecules, macromolecules & organelles combine to form cells
- whole greater than sum of its parts
- **cells**: basic structural & functional units of organism

Tissue Level: cells combine to form tissues
- **tissue**: group of cells & surrounding structures that together perform a specific function
- **4** basic tissue types: *epithelial tissue, connective tissue, muscle tissue, nervous tissue*

Organ Level: different kinds of tissues combine to form organs
- **organ**: a group of 2 or more different tissues that together perform a specific function
- examples of organs: stomach, heart, liver, lungs, brain

Organ System Level: a group of organs that together form an organ system
- **organ systems** in the body: integumentary system; skeletal system; muscular system; nervous system; endocrine system; cardiovascular system; lymphatic system; immune system; respiratory system; digestive system; urinary system; reproductive system

Organism Level: the whole organism; all parts of the body functioning together

Characteristics of Life:
- ability to move & respond to our surroundings
- growth & reproduction
- ingestion & digestion of food; absorption of nutrients

- circulation of absorbed nutrients & oxygen from respiration to body cells; together they are used by cells to make energy through cellular respiration
- excretion of wastes
- **metabolism**: all the chemical reactions in the body that break down substances & build them up

Requirements of Organisms:
- **water** – most abundant chemical in body; many functions; required for metabolism & transport of substances
- **nutrients** (food) – for energy, structural support, cellular reactions
- **oxygen** – for cellular respiration to create energy, which drives metabolism
- **heat** – to maintain normal body temperature (~98˚F or 37˚C) – helps to maintain normal reaction rates
- **pressure** – normal atmospheric pressure required for proper breathing; normal *hydrostatic pressure* maintained in blood

Homeostasis – the maintenance of internal conditions within normal limits
Homeostatic Control Mechanisms: receptor senses changes or stimuli in the environment (alteration in ***set point*** for a controlled value) & sends information along an afferent pathway to a ***control center*** (central nervous system). The control center determines the appropriate response & sends information along an efferent pathway to an ***effector*** that produces a response.

Negative Feedback: the product or response shuts off or reduces the level of the original stimulus; the variable then changes in a direction opposite the initial change
Examples of negative feedback mechanisms: regulation of body temperature, regulation of blood pressure, the withdrawal reflex, regulation of blood glucose levels by the hormones insulin & glucagons

Positive Feedback – the product or response enhances or exaggerates he original stimulus such that the response is continued
Examples of positive feedback mechanisms: blood clotting, labor contractions during birth

Homeostatic Imbalance – some lack of ability to activate/carry out control mechanisms – age is one factor

Know the location of each of the following. Also know the subdivisions where appropriate (for example: the pleural cavity is within the thoracic cavity, which in turn is within the ventral body cavity).
Dorsal Body Cavity
- Cranial cavity
- Vertebral or Spinal cavity

Ventral Body Cavity
- Thoracic cavity
  - Pleural cavity

    - Mediastinum
    - Pericardial cavity
- Abdominopelvic cavity
    - Abdominal cavity
    - Pelvic cavity

Other Body Cavities: (smaller cavities... most in the head & open to body exterior)
- oral & digestive cavities
- nasal cavity
- orbital cavities
- middle ear cavities
- synovial cavities

Serous membranes: thin 2-layered membranes with fluid-filled space that covers the viscera within thoracic & abdominal cavities and lines walls of thorax & abdomen
- 2 layers:
    - ***visceral layer***: covers & adheres to organs within cavity
    - ***parietal layer***: lines walls of cavity
- **Pleura**: covers lungs within pleural cavities
- **Pericardium**: covers heart within pericardial cavity
- **Peritoneum**: covers abdominal viscera within abdominal cavity

Organ Systems:
- **Integumentary System** (chapter 5): skin & accessory organs
- *Support & Movement*
    - **Skeletal System** (chapter 6)
    - **Muscular System** (chapter 7)
- *Integration & Coordination*
    - **Nervous System** (chapter 8)
    - **Sense Organs** (chapter 9)
    - **Endocrine System** (chapter 10)
- *Maintenance of the Body*
    - **Circulatory System** (chapter 12)
    - **Lymphatic System** (chapter 13)
    - **Respiratory System** (chapter 14)
    - **Digestive System** (chapter 15)
    - **Urinary System** (chapter 16)
- *Reproduction & Development*
    - **Reproductive System** (chapter 17)

Anatomical Terminology:
Anatomical Position: standing straight, facing forward with feet slightly apart, arms at sides & palms of the hands facing forward.

Know the definitions of & be able to apply:

Orientation & Directional Terms: (see textbook table for examples)
- **superior** (cephalic or cranial): above another part or toward the head
- **inferior** (caudal): below another part or toward the feet
- **anterior** (ventral): toward the front of the body
- **posterior** (dorsal): toward the back of the body
- **medial**: closer to midline
- **lateral**: further from midline
- **proximal**: nearer to trunk of body, origin or point of attachment (usually limbs)
- **distal**: further from trunk of body, origin or point of attachment (usually limbs)
- **superficial**: toward or at surface of body
- **deep**: away from surface of body

Planes of the body: (*sections* are cuts along body planes)
- **sagittal plane:** vertical plane that divides body or organ into left & right parts
    - ***midsagittal plane*** (median plane): divides into **equal** left & right parts
    - ***parasagittal plane***: divides into **unequal** left & right parts
- **frontal** (coronal) **plane**: divides body or organ into anterior & posterior parts
- **transverse plane:** divides body or organ into superior & inferior parts
- ***oblique plane:*** passes through body or organ at angle between transverse plane & sagittal or frontal plane

Abdominopelvic Regions
- right hypochondriac region; epigastric region; left hypochondriac region
- right lumbar region; umbilical region; left lumbar region
- right iliac (inguinal) region; hypogastric region; left iliac (inguinal) region

Abdominopelvic Quadrants
- right upper quadrant; left upper quadrant
- right lower quadrant; left lower quadrant

Chapter 2: Chemical Basis of Life

Basic Chemistry:
Matter: anything that has mass & takes up space
- matter is composed of **elements**
- states of matter: *solid*, *liquid* or *gas*

Elements are composed of ***atoms***
Atoms are composed of *subatomic particles*:
- ***protons*** (+ charge)
- ***neutrons*** (no charge)
- ***electrons*** (- charge)

The **atomic number** of an atom = the number of *protons* in its nucleus
- the periodic table is grouped according to atomic number (Hydrogen (H) has an atomic number of 1, Helium (He) has an atomic number of 2…)

The **atomic mass (mass number)** of an atom is the *number of protons + the number of neutrons* in its nucleus (the mass of electrons is negligible)
- Hydrogen (H) has a mass number of 1 (no neutrons), Helium (He) has a mass number of 4…
- the **atomic weight** of an element is the average of the relative weights of all the *isotopes* of that element (the atomic weight of Hydrogen is 1.008).

Isotopes are atoms of an element that have the same number of protons (atomic number) but different numbers of neutrons. (*examples*: ^{12}C, ^{13}C, ^{14}C)
- *radioactive isotopes* are unstable and spontaneously decay into more stable forms

Chemical Bonds:
Electrons of an atom differ in amount of ***potential*** (*stored*) **energy**
- electrons *closest* to the nucleus have the *least* potential energy (nonbonding electrons)
- electrons *farthest from* the nucleus have the *greatest* potential energy (**valence** or bonding electrons)

- *first energy level* can contain a maximum of **2** bonding electrons
- s*econd energy level*, and all additional energy levels, can contain a maximum of **8** bonding electrons
- **octet rule**: except for the first energy level, the outermost energy level is most stable when it has 8 bonding electrons (the first energy level is most stable with its maximum of 2 bonding electrons)

Bonding:
Ionic Bonding: ***transfer*** of *electrons* from one atom to another
- results in ions: charged particles resulting from charge imbalance (greater or fewer electrons than protons) due to electron transfer
- *Examples*: NaCl, $MgCl_2$, Na_2O

- chemical formulas of compounds based on # of *valence electrons* (example: from above: $MgCl_2$, Mg has 2 valence electrons to donate, while Cl can only accept 1, so two Cl atoms are needed to accept the 2 valence electrons donated by one Mg atom)

Covalent bonding: ***sharing*** of electrons between 2 or more atoms
- each atom acquires an octet of valence electrons (electrons in outermost shell). Examples: CH_4, O_2, H_2, $C_6H_{12}O_6$
- **water (H_2O)** is formed by a ***polar*** covalent bond (unequal sharing of electrons)

Hydrogen Bonding:
- bond between a slightly positive hydrogen atom of one molecule, and a slightly negative atom (*usually* oxygen or nitrogen)of the same or another molecule
- **weak** bonding compared to ionic and covalent bonding, but many bonds increases strength
- good example is water molecules

Molecules: 2 or more *atoms* held together by chemical <u>bonds</u>
- when 2 or more <u>*different*</u> atoms bind, they form one *molecule* of a ***compound***

Chemical Reactions:
Synthesis (combination) reaction: atoms or molecules combine to form a larger molecule
- metabolic synthesis reactions are termed ***anabolic*** reactions

Decomposition reaction: a molecule is broken down into smaller molecules, or its constituent atoms
- metabolic decomposition reactions are termed ***catabolic*** reactions

Exchange (displacement) reaction: components of the reactant molecules change partners, resulting in different molecules as products
- example: neutralization reactions (strong acid + strong base -> salt + water) HCl + NaOH -> NaCl + H_2O

All chemical reactions are, in theory, reversible… however, many biological reactions show little or no tendency to go in the reverse direction
- **chemical equilibrium:** neither the forward nor the reverse reaction is reversible (for each product molecule formed, one product molecule breaks down)
- **catalysts**: increase rate of chemical reactions without themselves being changed in the reaction… ***enzymes*** are *biological catalysts*

Electrolytes: substances that ***ionize***, or break apart & release **<u>ions</u>**, when put into *water*
- **Acid**: molecules that release hydrogen ions (H^+) when dissolved in water
  - acids are hydrogen ion (proton) donors

- **Base**: molecules that release hydroxide (OH^-) ions , or increase the number of hydroxide ions available, when dissolved in water

    - bases are hydrogen ion (proton) acceptors

- **Salt**: ionically-bonded molecule that dissociates into cations & anions in solution
    - in the body, salts are electrolytes that conduct electricity (important for nerve & muscle cells) & provide essential chemical elements in body fluids (blood, lymph & interstitial fluids)

pH scale (power of hydrogen): indicates acidity or basicity of solution
- ranges from 0 (strong acid) to 14 (strong base)
- pH < 7 is acidic; pH > 7 is basic; pH = 7 is neutral
- water *ionizes* to release equal numbers of hydrogen ions and hydroxide ions (neutral)

Buffers: maintain stable pH of solution (resist changes in pH)
- Buffers have *acidic* and *basic* components, and can take up excess hydrogen or hydroxide ions

Chemical Constituents of Cells
Inorganic Molecules: molecules (usually ionic-bonding) that do not contain carbon and hydrogen (e.g.: salts, strong acids and bases, metal compounds)
- water
- oxygen
- carbon dioxide
- salts

Organic Molecules: ***carbon***-based molecules
- carbon atoms are bonded mainly to atoms of *hydrogen*, *oxygen*, and *nitrogen*, as well as some other atoms
- *always* contain carbon and hydrogen
- *always* covalent-bonding

Organic Substances:
Carbohydrates: (contain carbon, hydrogen, and oxygen atoms)
Monosaccharides: simple sugars with a backbone of 3 to 7 carbon atoms
- **glucose** (in the blood of animals) and **Fructose** (in fruits) are 6-carbon sugars
- **ribose** is a 5-carbon sugar found in *RNA* (in *DNA*, the sugar is **deoxy**ribose)

Disaccharides: 2 *monosaccharides* joined by **condensation**
- **maltose** (in the digestive tract), **lactose** (in milk), & **sucrose** (in fruits & vegetables)

Polysaccharides:
- **glycogen** is a highly branched *polymer* of ***glucose***, and is the storage form of carbohydrates in *animal cells* (stored in liver cells)
- **starch** & **cellulose** are polysaccharides in plants

Lipids:
In the form of **neutral fats (fats or oils)**

one **triglyceride = glycerol + 3 fatty acids**
- **glycerol** has 3 carbon atoms and 3 hydroxyl groups
- **fatty acids** have a long hydrocarbon (carbon + hydrogen) chain with a carboxylic acid group at one end; fatty acids are generally ***hydrophobic***
  - **s*aturated*** fatty acids: each carbon atom in the fatty acid molecules have the <u>maximum</u> number of bonded hydrogen atoms (each carbon is **saturated** with hydrogen atoms)
  - **u*nsaturated*** fatty acids: one or more carbon atoms in the fatty acid molecule has less than the <u>maximum</u> number of bonded hydrogen atoms

In *animal cells*, neutral fats are in the form of **<u>fats</u>**
In *plant cells*, neutral fats are in the form of **<u>oils</u>**

Phospholipids = Glycerol + **2** fatty acids + 1 polar (phosphate-containing) head group
- allows molecules to have **hydrophobic** end (2 fatty acids) and **hydrophilic** (phosphate) end
- these molecules are the *subunits* of **biological membranes** in cells (e.g.: plasma membrane)

Steroids are composed of **4** *fused* ***carbon rings*** plus some variable functional side group
- **cholesterol** is a structural component of the *plasma membrane* in animals, and is used in the synthesis of vitamin D and bile salts
- ***cholesterol*** is modified to produce several other types of steroids
- steroids function as **<u>hormones</u>** in animal cells
- accumulation of large amounts of these bulky molecules in animals can lead to reduced blood flow and hypertension (high blood pressure)

<u>Proteins:</u>
Proteins are composed of chains of **amino acid** monomers
- There are **20+** different amino acids in cells of living organisms
- Amino acids have a ***basic core structure*** plus an additional functional *side chain*
- Each amino acid has a central carbon bonded to an *amino group*, a *carboxylic acid group*, a *hydrogen atom*, and the remaining side chain (**R group**); it is the R group that differs in different amino acids
- **R groups** can be *nonpolar & hydrophobic*, **or** *polar & hydrophilic*, depending on the atoms present
- some proteins function as **enzymes** – organic catalysts that speed up chemical reactions

Polypeptide: a chain of many amino acids joined by peptide bonds
- a **protein** can be composed of one or several *polypeptide* chains
- *condensation* of two amino acids in a growing polypeptide chain results in the formation of a **peptide bond**
- *hydrolysis* of peptide bonds occurs between <u>specific</u> amino acids in a protein by the activity of <u>specific</u> **enzymes** (e.g.: ***pepsin***)

<u>Protein Structure</u>
- **primary structure:** the sequence of amino acids in a polypeptide chain

- **secondary structure:** the formation of discrete structures (*alpha helices* or *beta pleated sheets*) involving several amino acids within a polypeptide chain (held together by *hydrogen bonds*)
- **tertiary structure:** the conformation of the polypeptide chain following interactions of regions of *secondary structure*
  - if the protein only consists of 1 polypeptide, this is the final structure of the protein
- **quaternary structure:** structure following interaction and bonding between ***two or more*** (the same or different) polypeptide chains
  - hydrogen or ionic bonding between polypeptide chains

Denaturation: disruption of specific 3D structure of a protein by *increasing* **temperature** (boiling) or *changing* **pH**
- *may be* ***reversible*** (**remember**: the structure of a given polypeptide is specific as well as *consistent* and **reproducible**)

Nucleic Acids:

Nucleic Acids are polymers of **nucleotide** monomers
- a ***nucleotide*** = a pentose sugar + a phosphate + a nitrogenous (nitrogen-containing) base
- In ***RNA (Ribonucleic Acid)***, the pentose is **ribose**
- In ***DNA (Deoxyribonucleic Acid)***, the pentose is **deoxyribose** (missing a hydroxyl group at carbon # 2 relative to ribose)

DNA:

DNA is the ***genetic material*** of the cell (inherited from parents)
- composed of a sequence of four different nucleotides
- the 4 nucleotide subunits of DNA are named after the *nitrogenous base* each contains; the 4 bases are : **adenine** (A)
  cytosine (C)
  guanine (G)
  thymine (T)
- *DNA* forms a **double-helical** *structure* (***DNA is double-stranded***), in which two chains bond together; the sugar and phosphate groups are on the outside, and the nitrogenous bases interact by hydrogen bonding in the middle of the double helix
- the 2 **strands** (nucleotide chains) of the double helix are ***complementary***:

RNA:
- **RNA** is synthesized from 1 strand of DNA
- *RNA* does **not** form a double helix (no pairing of complementary bases between 2 strands); ***RNA is single-stranded***
- *RNA* also uses 4 nucleotide subunits; however, **uracil** (U) replaces *thymine* in RNA
- major forms of RNA in cells are: messenger RNA (mRNA), transfer RNA (tRNA) & ribosomal RNA (rRNA)
- **ATP** is an RNA nucleotide used for energy in cells

Genes in DNA code for polypeptides: the sequence of bases in DNA serves as a code for directing the sequence of bases in mRNA, and then the sequence of amino acids in a protein