Human Bioscience Notes

HUBS1401

Course Learning Outcomes:

1. Develop strategies for self-learning and critical reasoning.
2. Identify and apply the correct terminology in relation to human anatomy and physiology.
3. Define the major aspects of biochemistry relating to reactivity and the formation of chemical bonds.
4. Identify and explain the levels of biological organisation.
5. Explain homeostasis and negative feedback.
6. Develop an understanding of the organ systems and how they contribute to life.

I. WEEK 1

Lecture one. Introduction to HUBS1401

Provide an overview of body structure and organisation.

- Anatomy is the study of body structures.
- Physiology is the study of the function of the body structures.
- Physiological processes are performed by anatomical structures.
- Levels of organisation allows us to understand the composition of large structures.
- The six levels of organisation allow understanding of the body from atoms (chemical) to whole organism (organismal).

Identify the 6 levels of organisation.

- Chemical, Cellular, Tissue, Organ, Organ system, Organismal

Identify the 11 organ systems.

- An organ system is a collection or organs that perform a specific task. All organ systems work together to maintain life and produce offspring.
- Integumentary, Skeletal, Muscular, Nervous, Endocrine, Cardiovascular, Lymphatic, Respiratory, Digestive, Urinary, Reproductive (Male and Female)

Determine how these combine to create a living organism.

- Integumentary System forms external body covering, provides mechanical and chemical protection, synthesis of Vitamin D, sensory neurons and sebaceous and sudoriferous glands.
- Skeletal System forms framework for muscle attachment, protection of organs, blood cells formed within bone and mineral deposit (Magnesium).
- Muscular System maintains posture, thermoregulates (shivering) and allows for manipulation of environment and locomotion.
- Nervous System forms fast-acting control centre, responds to internal and external changes by activating muscles and glands.
- Endocrine System secretes hormones from glands for regulation of growth, reproductive and metabolic processes.
- Cardiovascular System involves transportation of blood (oxygen, carbon dioxide, nutrients and waste)via blood vessels and via pumping of heart.
- Lymphatic System picks up fluid leaked from blood vessels, disposes debris in the lymphatic stream, houses white blood cells as part of immune response.
- Respiratory System supplies blood with oxygen and removes carbon dioxide. Gaseous exchanges occur through the wall of the air sacs of the lungs.
- Digestive System breaks down food into absorbable units (bolus and chyme) that enter blood for distribution to body cells.
- Urinary System eliminates nitrogenous wastes from body, regulation of water, electrolyte and acid-base balance of blood.
- Reproductive System (Male and Female)
- These systems are in constant communication and work together to achieve normal function.
- Healthy normal function is characterised by systems providing movement, detecting and processing sensory information, strong immunity from disease and allowing for the production of offspring.

Lecture two. The Cell

Discuss the background to the discovery of cells.

- In 1865, Robert Hooke discovered ‘cells’ as small compartments of cork slices under the microscope.

Identify the elements of Cell Theory.

- 1. All known living things are made up of one or more cells.
- 2. All living cells arise from pre-existing cells by division.
- 3. The cell is the fundamental unit of structure and function in all living organisms.
- 4. The activity of an organism depends of the total activity of independent cells.
- 5. Energy flow (metabolism and biochemistry) occurs within cells.
- 6. Cells contain DNA which is found specifically in the chromosome and RNA found in the cell nucleus and cytoplasm.
- 7. All cells are basically the same in chemical composition in organisms of similar species.

Describe the basic structures of a eukaryotic (animal) cell.

- Eukaryotic cells characteristics include complex structure (cell membrane, nucleus, cytoplasm (organelles and cytosol), DNA located in nucleus, occurring in single/multi-celled organisms (e.g. animals, plants, fungi etc.)
- Eukaryotic cells can include cells that connect body parts, form linings and transport gases (fibroblasts, epithelial and erythrocytes), cells that move organs and body parts (smooth muscle cell, skeletal muscle cell), cells that store

nutrients (fat cell), cells that fight disease (macrophage), cells that gather information and control body functions (nerve cell) and cell of reproduction (sperm cell).

- Plasma (Cell) membrane/fluid mosaic is 6-10nm and functions include forming barrier to extracellular area, support of cell, regulation of in/out and communication between cells. Phospholipid bilayer convers most of cell surface with hydrophilic heads forming interior and exterior of membrane and hydrophobic tails forming centre of membrane. Membrane proteins can be integral or peripheral, channel and carrier proteins permit material in/out, anchor cells are linkers, and glycoproteins are recognition system, receptor proteins and enzymes. Carbohydrates usually form glycoproteins and glycolipids and functions include recognition and binding sites. Cholesterol function includes preventing membrane rigidity and fluidity.
- Nucleus contains deoxyriboneucleic acid (DNA, DNA contains approximately 21 000 genes, genes contain code for proteins), nuclear envelope and small spherical nucleoli (DNA, RNA, proteins and ribosome production).
- Cytoplasm includes organelles and cytosol.

Define organelles and explain their role within the cell.

- Organelles (membranous and non-membranous) are structures that perform cellular tasks.
- Non membranous organelles include cytoskeleton, microvilli, cilia, centrioles and ribosomes. Cytoskeleton (Microfilaments (actin and myosin) determine contractile ability, intermediate filaments determine stability of cell and components, microtubules determine cell shape and movement (cilia, flagella)) provides structural support and movement. Microvilli are small projections to increase surface area of cell and cilia are long extensions and beat in rhythm to move content through canals. Centrioles are short section of microtubule surrounded by centrosome to form spindle structure during cell division. Ribosome occurs in cytoplasm, rough endoplasmic reticulum, mitochondria to synthesis proteins.
- Membranous organelles include mitochondria, endoplasmic reticulum, golgi complex, lysosomes and peroxisomes. Mitochondria contain mDNA (37 genes) and functions include site of ATP production. Endoplasmic reticulum occurs attached to nuclear envelope, comprised of flattened sacs and tubules. Rough endoplasmic reticulum occurs continuous with nuclear membrane, comprised of ribosome surface; functions include manufacture of proteins and enclosure of proteins for transfer to golgi complex. Smooth endoplasmic reticulum occurs continuous with rough ER, comprised of membrane tubules, functions include synthesis of fatty acids and steroids, enzymes involved in detoxification of drugs, alcohol, pesticides, carcinogens and breakdown of glycogen to glucose in liver. Golgi complex is comprised of cisternae (flattened sacs), functions include modifying (glycoprotein/lipoprotein), sorting and packaging (secretory vesicles for delivery outside of cell, membrane vesicles for cell membrane, transport vesicles for delivery within cell). Lysosomes are small vesicles, comprised of powerful digestive enzymes; functions include garbage disposal (unwanted components ejected from cell) and recycling. Peroxisomes are small bodies, comprised of powerful oxidising enzymes, functions include detoxifying harmful substances (by-product is hydrogen peroxide and superoxide which are degraded by catalase and superoxide dismutase respectively).

Lecture three. The Plasma Membrane

Explain the functions of the plasma (cell) membrane.

- Cell membrane is selectively permeable. Selection is based on size, polarity, molecular shape and solubility etc.
- Passage through membrane can be passive (no energy input required) or active (ATP energy input required).
- Plasma membrane is highly permeable to oxygen, carbon dioxide, fatty acids, alcohol and steroids.
- Provides protection as ions cannot enter due to hydrophobic tails in centre of membrane. Large molecules such as glucose cannot enter. Water molecules pass through small gaps in the membrane.

Define osmosis.

- Osmosis is the diffusion of a solvent across a selectively permeable membrane.
- Water is the solvent in living systems. Water molecules travel across the membrane from low solute concentration to high solute concentration.

Describe concentration gradients and tonicity.

- The concentration gradient is the difference between high concentration area and low concentration area.
- Tonicity is the effects of osmotic pressure on cells. Isotonic solution describes no net flow of water in or out of cell. Hypotonic solution describes water flow into cell because of higher concentration of solute in cell. Hypertonic solution describes water flow out of cell because of lower concentration of solute in cell.

Identify the mechanisms of transport through the membrane.

- Passive transport includes diffusion and filtration. Diffusion is important for every cell in our body. Filtration –covered in later lectures-.
- Diffusion occurs as material will move from high concentration area to low concentration area and is dependent on concentration gradient. The concentration gradient is the difference between high concentration area and low concentration area. Particles are dynamic and will eventually distribute evenly. Factors affecting diffusion rate include distance (faster if shorter), molecular size (faster if smaller), temperature (faster if higher), steepness of concentration (faster if larger gradient), surface areas (faster if larger).

- Diffusion includes simple diffusion (material diffuse without transport protein aid) and facilitated diffusion (material diffuse with protein channels and protein carriers' aid). Small ions use protein channels and sugars use protein carriers.
- Active transport includes ion pumps and vesicles.
- Active transport occurs as material is transported using energy (ATP) and is not dependent on concentration gradient. Ion pumps transport ions (e.g. sodium ions, potassium ions and calcium ions) across the cell membrane. The sodium-potassium pump is located on the cell membrane to maintain concentration of the key ions in cell and body fluid. One molecule of ATP results in 3 sodium ions pumped out of cell and 2 potassium ions pumped into the cell.
- Vesicular transport is the movement in and out of cell in sacs. Vesicle and cell membranes fuse and contents are dispersed. Endocytosis is entry into cell and exocytosis is exit from cell.

II. WEEK 2

Lecture four. Atomic and Molecular Structure

Define the structure of an atom.

- There are 92 naturally occurring elements on earth. The human body contains 26 elements. Elements are made up of atoms.
- Atoms are the smallest stable units of matter. The specific atoms and their arrangement dictate the characteristics of the element. Atoms include three subatomic particles (proton, neutrons and electrons). Protons and neutrons form the nucleus; electrons (2000x smaller in size) orbit the nucleus in vast energy levels/shells.

Understand atomic stability and reactivity.

- Atoms are electrically neutral. Electrons must fill inner shells before occupying another shell. The valence shell electrons determine the reactivity of the atom.
- Atoms are stable/unreactive if valence shell is full of electrons.
- Atom is unstable/reactive if valence shell is not full of electrons. Unstable atoms react with other atoms to fill its outer shell by gaining electrons, losing electrons or sharing electrons.

Describe an ion and how it is formed.

- Ions are atoms carrying an electrical charge. Ions have an unequal number of protons and electrons. A cation is a positively charged ion. An anion is a negatively charged ion.
- Gaining, losing or sharing electrons create ions (charged particles) and the formation of molecules and compounds.

Detail the differences between the three main types of chemical bonds.

- Chemical bonds hold ions and atoms together to form a molecule or compound.
- Ionic/electrovalent bonds form between ions and are held together by electrical attraction.
- Covalent bonds form between atoms, sharing of electrons. Single and double covalent bonds are the most strongest and common bond found in biological organisms. Non-polar covalent bonds is the equal sharing of electrons (one atom does not have stronger electronegativity than other atom). Polar covalent bonds is the uneven sharing of electrons (one atom does have a stronger electronegativity than other atom, electrons spend more time around nucleus of stronger electronegative atom, creates positive and negative regions in molecule).
- Hydrogen bond/force form between molecules (between hydrogen atom of one molecule and oxygen/nitrogen atom of nearby molecule). Hydrogen has slightly positive charge and oxygen/nitrogen has slightly negative charge.

Understand why reactivity is essential for life.

- Atoms constantly bond with other atoms to form molecules and compounds essential for life.
- Hydrogen bond/force is essential for life influencing 2D/3D protein shape, creating surface tension in water and holding DNA bases together.

Lecture five. Molecules of Life

Define an organic compound.

- Organic compounds always contain carbon. They are responsible for chemical reactions essential to life. Organic compounds include carbohydrates, lipids, proteins, nucleic acids and adenosine triphosphate.

Explain the importance of carbon.

- Carbon is the chief component of organic compounds.
- Carbon is a useful building material being able to form long chains (2-1000 atoms long via covalent bonding), can adopt various shapes and does not dissolve in water.

Describe the basis of polymerisation.

- Macromolecules are large organic molecules. Most macromolecules are polymers.
- Polymers are constructed from identical subunits called monomers.

Identify the structure of carbohydrates, lipids, proteins and nucleic acids.

- Carbohydrates contain hydrogen, carbon and oxygen (CHO). It makes 2-3% of body mass. It is a major source of energy for ATP production. Dehydration synthesis process is two monosaccharides joining together via covalent bonding releasing water molecule. Carbohydrates include monosaccharides (simple sugar, glucose, fructose, galactose, deoxyribose and ribose), disaccharides (simple sugar, sucrose is glucose and fructose, lactose is glucose and

galactose and maltose is glucose and glucose) and polysaccharides (complex sugar, not sweet, straight or branched, insoluble, glycogen, starch and cellulose).

- Lipoids make up 12-18% body mass in males and 18-25% body mass in females. Lipids include fats, oils and waxes. Triglycerides (saturated is packed tightly, unsaturated is not packed tightly because of kink via double bond, and polyunsaturated is many kinks via many double bonds) is three fatty acids and glycerol. Functions of lipids include providing insulation, protection (excess energy is sored as triglycerides), source of vitamin A, D, E and K.
- Protein make up 12-18% body mass. It is constructed from amino acid monomers (1000-100 000) to form polypeptide chain. Amino acid monomer includes central carbon atom, hydrogen atom, amino group (NH2), carboxylic group (COOH) and variable group (R). Polypeptide chains include primary, secondary (twisting and folding of nearby amino acid monomers held together by hydrogen bonding/force), tertiary (3-D polypeptide chain) and quaternary (two or more polypeptide chains).
- Nucleic acid includes deoxyribonucleic acid (DNA) and ribonucleic acid (RNA). DNA is inherited gene material and RNA is copies of DNA for protein synthesis. Nucleotides monomer include pentose sugar (deoxyribose/ribose), phosphate group, nitrogenous base (Adenine, Guanine, Cytosine, Thymine, Uracil (RNA only replacing thymine)). DNA structure include double helix (two strands twisted), each strand consists of nucleotides bound together (nucleotide is deoxyribose sugar, phosphate group and ¼ nitrogenous base), nitrogenous base pair together via hydrogen bonding to form 'steps' (adenine pairs with thymine, guanine pairs with cytosine).

Describe the structure and function of ATP.

- Adenosine triphosphate structure includes adenosine and three phosphate groups. ATP is the principle source of cellular energy. Hydrolysis of ATP liberates energy (ATPase) producing adenosine diphosphate (ADP) and a free phosphate group. Functions include muscular contraction, transportation across cell membranes, molecule synthesis.

Lecture six. The Cell Cycle and Mitosis

Define the principles of cell division.

- The human body contains approximately 75 trillion cells. Most human cells have the ability to divide (parent cell dividing to create two identical daughter cells).
- New tissue is grown via cell division.
- Cell division includes mitosis (somatic cells) and meiosis (gamete cells).

Describe why cells divide.

- Cells divide to replace damaged or dead cells.
- Cells have variant life spans. Neutrophils is hours to a few days, stomach/intestinal cells is 3-5 days, skin cells is 2-3 weeks, red blood cells is 4 months, liver cells is 12-18 months and nerve/skeletal muscle cells is lifetime.
- The cell cycle includes interphase and mitotic phase.

Explain the process of DNA replication.

- The process of DNA replication include two strands of DNA separating, exposed nucleotides bases are templates, DNA polymerase adds complimentary nucleotide bases to each single strand sourced from nucleoplasm and two identical DNA molecules are created. Check points occur throughout cell cycle including DNA repair genes and tumour suppressant genes. Errors in replication of DNA can result in mutations/tumour.

List the stages of cell division.

- Interphase includes replication of cell contents (including DNA). Interphase include G1, S phase and G2 (G is gap and S is synthesis of DNA). G1 is the first and longest stage (8-10hrs) and is the replication of most organelles and beginning of centrosome replication. S phase (8 hours) is the synthesis of DNA. G2 is the shortest stage (4-6 hours) and is continued cell growth, enzyme and centrosome replication are completed and cell is prepared for division. It is characterised by cell growth and high activity level.
- Mitotic phase includes division of the nucleus. Mitotic phase include prophase, metaphase, anaphase and telophase. Prophase includes chromatin fibres condensing into chromosomes (each one is a chromatid and held together by centromere (surrounded by kinetochore)). Metaphase includes chromosomes migrating to centre of cell (metaphase plate). Anaphase includes chromatids pulled apart to opposite pole of cell by mitotic spindle fibres on kinetochores. Telophase includes chromosomes uncoiling, nuclear envelope forms around them, mitotic spindle fibres break down and cleavage furrow deepens.
- Cytokinesis include Cytokinesis phase includes division of cell. Cytokinesis includes the division of the cytoplasm and organelles creating two identical daughter cells. Each cell contains DNA and equal proportions of organelles and cytoplasm.
- 23 karyotypes (no. of chromosomes) taken at metaphase.