Cell

Definition of a cell: fundamental structural and functional unit of all living organisms **Characteristics of cells**: ☐ Contain highly organized molecular and biochemical systems and are used to store information ☐ Use energy ☐ Capable of movement ☐ Sense environmental changes ☐ Can duplicate (transfer genetic information to offspring) ☐ Capable of self-regulation Most cells are microscopic (invisible to the naked eye) and thus, a microscope is needed to view most cells. **Cell Theory states**: (Note – viruses are not living because they require a host cell to replicate) ☐ All living organisms are composed of cells ☐ Cells are the functional units of living organisms ☐ Cells arise from preexisting cells via division **Cell Structure**: ☐ Most cells are microscopic and cannot be seen by the naked eye. ☐ Microscopes were developed to visualize cells. ☐ Resolution is the minimum distance where 2 objects can be visually separated Depends on:-Wavelength of light & Refractive index of the medium of the light The naked eye can resolve two separate objects separated by 200 um

Prokaryotic Cells- small and primitive bacteria and blue-green algae (cyanobacteria) Greek: Pro=before karyon=nucleus ☐ Lacks specialized internal membrane--bound compartments known as organelles. **Eukaryotic Cell**- (eu=true karyon=nucleus) o Possesses a complex membrane system o Has a true nucleus o Distinct membrane--bound intracellular compartments called organelles

Energy

Energy (cont)

GLYCOLYSIS - or Sugar Breaking Reactions 👇 Both Aerobic and Anaerobic Respiration begin by breaking down a six carbon sugar (glucose) into two molecules of a three carbon compound called pyruvate 👇 Initial step(s) - energy requiring (2 ATP) 👇 Subsequent steps ☐ Two - substrate-level phosphorylations (4 ATP) ☐ One - reduction of NAD to NADH (2 NADH) 👇 Yield - 2 ATP & 2 NADH 👇 Final product - 2 pyruvates

Regulating Cell Cycle

Fluid Mosaic

Fluid Mosaic Model ☐ For 30 years, the fluid mosaic model of Singer and Nicolson has provided the foundation for our understanding of the structure of cellular membranes.

Lipid Rafts ☐ There is structure within this sea of lipids that in turn imposes organization on the distribution of proteins in the bilayer. The lipid “structures” within the membrane ocean are called lipid rafts ☐ The plasma membranes of cells contain combinations of glycosphingolipids and protein receptors organized in glycolipoprotein microdomains termed lipid rafts. o These specialized membrane microdomains compartmentalize cellular processes by serving as organizing centers for the **assembly of signaling molecules**, influencing membrane fluidity and membrane protein trafficking, and regulating neurotransmission and receptor trafficking. o Lipid rafts are more ordered and tightly packed than the surrounding bilayer, but float freely in the membrane bilayer. o Although more common in plasma membrane, lipid rafts have also been reported in other parts of the cell, such as **Golgi and lysosomes**.

Cell membrane with lipid rafts ☐ Functions of the lipid rafts o Lipid rafts appear to exert both positive and negative control on signal transduction. o In their positive role, rafts containing different signaling proteins may cluster or fuse upon agonist stimulation, leading to the mixing of components and resulting in the activation of signaling pathways. o In their negative role, rafts may spatially segregate interacting components to block nonspecific pathway activation, or may directly suppress the activity of signaling proteins present in rafts.

Energy ☐ Sunlight contains energy – under the right conditions it can be converted into other forms of energy as chemical bond energy, electricity, kinetic energy, heat, etc. ☐ **Light** has both wave-like and particle-like properties. o Packets of energy are called **photons** o Wavelengths of light are measured in units called **nanometers** (very small units) o The shorter the **wavelength** of light, the more energy it contains photon ☐ **Plants** contain the pigment chlorophyll (a & b) in the thylakoids of the chloroplast ☐ When sunlight hits a leaf, the light is absorbed – some of the light is transmitted through the leaf like a filter and the rest is reflected away ☐ The green in the photosynthesis causes red and blue to be absorbed while green and yellow are reflected away **Importance of ATP** ☐ Chemical storage battery for cells – major energy currency for the cell ☐ **Production of much ATP** requires membranes to generate current to make ATP ☐ **ATP cell functions** o *Transport work* – moving substances across the cell in active transport o *Mechanical work* – supplying energy for muscle contraction, chromosomes, and flagella o *On-off switch* to control chemical reactions and send messages. ☐ Plants carry out both photosynthesis and cellular respiration ☐ Almost all of ATP produced in photosynthesis is used in photosynthesis to provide the energy to produce the bonds for the *glucose molecules* ☐ Amount of ATP produced in cellular respiration varies from cell to cell; emphasize quantitative aspects; **most of ATP is produced via electron transport chain.** ☐ Main reason that cells need oxygen: to allow them to make lots of ATP. Oxygen cannot be stored, so it must be constantly supplied.

Regulating the Cell Cycle ☐ Normal cells divide and reproduce until they come in contact with other cells o In a multicellular organism, cell growth and cell division are carefully controlled. o Skin and bone cells grow and divide rapidly throughout life while nerve and muscle cells usually stop dividing once developed o For example, when an injury such as a cut in the skin occurs, cells at the edge of the cut divide rapidly o When the healing process is nearly complete, the rate of cell division slows and then returns to normal o The main components of cell cycle regulation are **CDKs (cyclin dependant kinases)** and **cyclins** o CKDs remain at a constant number throughout the cycle whereas cyclins fluxuate. o **Cyclins** – a group of proteins – regulate the timing of the cell cycle o Controls on cell growth can be turned on and off by the body 👇 The two main checkpoints are G1-S and G2-M. 👇 If there is no DNA damage in G1, then there will be enough cyclins produced to bind to the CDKs which allows the cell to enter S phase (DNA replication). 👇 The G2-M checkpoint ensures there is no DNA damage, and also that the chromosomes have successfully replicated. 👇 If everything is in order, then the M phase cyclins will be abundant enough to bind to the CDKs. This allows the cell to enter into mitosis. 👇 There are also other mechanisms, such as p53 and Rb that are activated when damage is detected. They will either hold the cell in G1 phase until the damage is repaired or induce apoptosis (cell suicide) if the damage is too overwhelming. 👇 The condition caused by irregular cell growth is cancer.

Light Reactions

☐ Photosynthesis is a reduction process, where hydrogen is reduced by a coenzyme. This is in contrast to respiration where glucose is oxidized. ☐ Two major parts of photosynthesis o **Light reactions**: (Photolysis) conversion of light energy into ATP and NADPH o **Dark reactions**: Calvin Cycle (the thermochemical stage) use of energy (ATP & NADPH) to form carbohydrates 👇 **Purpose of photosynthesis** 👇 Main biosynthetic pathway by which carbon and energy enter the web of life ☐ **Where it occurs** – in the Chloroplast 👇 Light reactions - granum (several thylakoids) and thylakoid membranes 👇 Dark reactions - stroma

Light Reactions (cont)

LIGHT REACTIONS (also light-dependent reactions) ☐ This part of photosynthesis occurs in the *granum* of a *chloroplast* where light is absorbed by *chlorophyll*; a type of photosynthetic pigment that converts the light to chemical energy. This reacts with water (H2O) and splits the oxygen and hydrogen molecules apart. ☐ From this dissection of water (**photolysis**), the oxygen is released as a by-product while the reduced hydrogen acceptor makes its way to the second stage of photosynthesis, the Calvin cycle. - water is oxidized (hydrogen is removed) and energy is gained in photolysis which is required in the Calvin Light-trapping molecule ☐ Chlorophyll (antenna chlorophyll pick up light) o Transmits green and absorbs red and blue o Right wavelength of energy excites an electron of chlorophyll o Inductive resonance carries excitation energy from molecule to molecule o Energy (P700 or P680) is transferred to an acceptor molecule ☐ Two options for **electron excitation energy** – electrons originate from the breakdown of water which liberates hydrogen ions and oxygen o **Non-cyclic photophosphorylation** (Photosystem II-P680 and then Photosystem I – P680) - long pathway - Occurs in eukaryotic plants – algae, mosses, ferns, conifers, & flowering plants Oxygen and NADP are generated o **Cyclic photophosphorylation** – (Photosystem I –P700) – short pathway Occurs in prokaryotes (Cyanobacteria) with electrons being used over and over again No oxygen or NADP are generated

Cell Death

Virus

Structure of Viruses ☐ Non-cellular infectious agent ☐ Composed of DNA or RNA and a protein coat ☐ Replicates only after its genetic material enters a host cell ☐ Subverts the host's metabolic machinery ***Viral Replication*** ☐ The process by which a virus reproduces itself within a living organism. ☐ Involves turning infected cells into virus factories, which manufacture copies of the virus's genetic code and expel them to spread into the host body. ☐ Turns the infected body against itself, using its own cells as tools of mass production and infection.

Protein Functions

Transport Proteins – that move chemicals into and out of the cell o **Channel Proteins** that form small openings for molecules (electrolytes) to diffuse through by means of passive transport o **Carrier Proteins**- binding site on protein surface "grabs" certain molecules and pulls them into the cell (gated channels) – it involves active transport so energy is required 11 ☐ **Receptor Proteins** - molecular triggers that set off cell responses (such as release of hormones or opening of channel proteins) ☐ **Adhesion Proteins** – attach cells to other cells or fibrous extracellular material ☐ **Cell Recognition Proteins** - ID tags, to identify cells to the body's immune system ☐ **Enzymatic Proteins** - carry out metabolic reactions ☐ **Structural Proteins** – stabilize the cell

☐ **Stem Cells** are unspecialized that have the potential to differentiate into any type of cell o They are found in human embryos, umbilical cord blood and some adult cells o They are used to repair injuries as brain and spinal cord, cure some diseases as diabetes, and replace organs as liver tissue and heart valves **Death of Cells** – by injurious agents or by being induced to commit suicide **Apoptosis** - A form of cell death in which a programmed sequence of events leads to the elimination of cells without releasing harmful substances into the surrounding area **Necrosis** - The uncontrolled cell death that occurs as a response to lethal injury leading to a severe physical damage in the cell as well as the tissue containing it.

Protein Functions (cont)

Turgor Pressure: In plant cells, water moving into the cell pushes the cell membrane up against the cell wall. The large central vacuole stores liquids and aids in maintaining turgor pressure. Loss of water from the vacuole or cytoplasm causes shrinkage of cellular contents or **Plasmolysis**. In plants cells it results in wilted tissue – in animal cells it may cause cell to collapse as with RBC's.

Enzymes - ☐ Enzymes are specific in their activity; each enzyme catalyzes the reaction of a single type of molecule or a group of closely related molecules ☐ Enzymes are saturated by high substrate concentrations ☐ Enzymes are released unchanged after catalyzing the conversion of reactants to products because they do take part in the reaction. ☐ Enzymes are proteins (usually, some RNA molecules can act as enzymes); proteins are sensitive to changes in temperature and pH. They will change shape and become inactive. some enzymes are larger inactive molecule; activation involves enzymatic removal of some amino acids ☐ Many enzymes contain non-protein groups called cofactors ☐ Co-factors, usually metal or vitamin; others activated by addition/-removal of phosphate o Inorganic cofactors = metal ions o Organic cofactors = coenzymes (ex: vitamins) ☐ Competitive Inhibition has the molecule binding at active site; it resembles the substrate and is overcome by increase in substrate concentration while Non-competitive Inhibition has binding at a site other than the active site; its molecule is different than the substrate and it is not reversed by increased substrate but it may be irreversible if it covalently alters the enzyme. It binds only to enzyme substrate complex

Chemical Reactions

Introduction - Types of chemical reactions ☐ **Endergonic**: require energy ☐ **Exergoinc**: give off energy ☐ **Catabolism**: reactions breakdown large molecules and produce small molecules; Ex. Digestion of protein into amino acids ☐ **Anabolism**: reactions requiring energy to make large molecules from small molecules; Ex: the synthesis of a protein from amino acids

Acids and Bases: Lewis definition: ☐ **Acid**-a substance that can take up an electron pair to form a covalent bond ☐ **Base**-a substance that can donate an electron pair to form a covalent bond ☐ H2O dissociates into H+ ions and OH- ☐ [H+] + [OH-] = 1x10-14 moles/liter (M) ☐ pH = -log10 [H+] ☐ Acid pH is from 0 to 7 ☐ Base pH is from 7 to 14 ☐ **Condensation reaction**-when two molecules are combined into one molecule with the release of one water molecule A + B == C + H2O Ex: 2 amino acids are joined together to form a dipeptide molecule ☐ **Hydrolysis reaction**-when one molecule is broken into two molecules with the addition of water molecule C + H2O == A + B Ex: disaccharide maltose + water == 2 glucose molecules ☐ **Reactive Organic Molecules** o *Hydroxyl group* - strongly polar and highly reactive o *Carbonyl group* - weakly polar and highly reactive o *Aldehyde* o *Ketone* o *Carboxyl group* - strongly polar and acts as an acid o *Amino group* - polar and acts as a base o *Phosphate group* - acidic and polar o *Sulfhydral group* - readily oxidized-Two sulfhydral groups can bond together to form a disulfide bond