An outline of the cell theory

Science, Biology

Chapter 2 IB Biology 2. 1 Cell Theory 2. 1. 1 Outline the cell theory (2). •All organisms are composed of one or more cells •Cells are the smallest units of life •All cells come from preexisting cells •TOK: cell theory replaces the former ideas of spontaneous generation or abiogenesis in which inanimate matter assembles itself into living forms •Exception: muscle cells- more than 1 nucleus, very long; (fungal cells) hyphae roots- not a single unit; protoctista- not specialized to single function; subcellular things like organelles 2. 1. Discuss the evidence for the cell theory (3). •Robert Hooke first described cells in 1665 while observing cork with a microscope he built. Coined the term " cell"

Antoine van Leeuwenhoek observed the 1st living cells and referred to them as animalcules. " microscope" •In 1838, botanist Mathias Schleiden stated that plants are made of independent separate being called cells. Later, Theoder Schwann made a similar statement about animals. •The 2nd principle continues to gain support because we have not been able to find any living entity that is not made of at least one cell. Louis Pasteur in the 1860s performed experiments to support the last principle. After sterilizing chicken broth by boiling, Pasteur showed that living organisms would not ' spontaneously' reappear. " biogenesis" •Only after exposure to preexisting cells was life able to re-establish itself in the chicken broth. •Eukaryotes- mitosis; prokaryotes- binary fission; thus all cells have a common ancestor- original ancestral form 2. 1. 3

State that unicellular organisms carry out all the functions of life (1). •Functions include: Metabolism- chemical reactions that occur within an

organism •Growth- may be limited but is always evident in some way •Reproduction- hereditary molecules that can be passed to offspring •Response- toenvironmentis imperative to survival •Homeostasis- maintain a constant internal environment ex: temp •Nutrition- provide a source of compounds with many chemical bonds which can be broken to provide the organism with the NRG and the nutrients necessary to maintain life CHNOPS 2. 1. 4 Compare the relative sizes of molecules, cell membrane thickness, viruses, bacteria, organelles and cells, using the appropriate SI unit (3). Cells- 100 micrometers (plant) •Organelles- < 10 micrometers •Bacteria- 1 micrometer •Viruses- 100 nanometers

•Membranes- 10 nanometers thick •Molecules- 1 nanometer •Animal cell- 10 micrometers •cm = 10-2 m •mm = 10-3 m •um = 10-6 m •nm = 10-9 m •A = 10-10 m 2. 1. 5 Calculate the linear magnification of drawings and the actual size of specimens in images of known magnification (2). •Magnification = size of image divided by the size of specimen •Magnification = measured length / scale bar level •Actual size = measured length / magnification 2. 1. Explain the importance of the surface area to volume ratio as a factor limiting cell size (3). •In the cell, the rate of heat and waste production and rate of resource consumption are functions that depend of its volume. •Most of the chemical reactions occur in the interior of the cell and its size affects the rate of these reactions.

•The surface of the cell, the membrane, controls what materials move in and out of the cell. •Cells with more surface are per unit volume are able to move materials in and out of the cell, for each unit volume of the cell. As the

width of the object increases, the surface area also increases but at a much slower rate than the volume. •This means that a large cell has less surface area to bring in needed materials and to rid the cell of waste than a small cell. •Because of this, cells are limited to the size they can attain and still be able to carry out the functions of life. Large animals have more cells not larger ones. •A large surface area to volume ratio means the cell can act more efficiently: for every unit of volume that requires nutrients or produces waste, there is more membrane to serve it. But this is not always an advantage- cell can lose heat quickly.

•As organisms grow, cells divide. 2 small cells are more efficient than one. •Alveoli in lungs maximize surface for gas exchange. 2. 1. 7 State that multicellular organisms show emergent properties (1). •Different things come together to make process •Cells-tissues-organs-etc. •Ability to reproduce themselves. Allows possibility of growth and for replacement of damaged or dead cells. 2. 1. 8 Explain that cells in multicellular organisms differentiate to carry out specialized functions by expressing some of their genes but not others (3). Start out as single cell that reproduces at a rapid rate then the resulting cells go through a differentiation (different cells- different functions- to run an organism) process to produce all required cell types that are necessary for organism. •Every cell in a multicellular organism contains all the genes of that organism. However, the genes that are activated vary from cell to cell. •Differentiation- when we break something complex into its component pieces, they each appear to be simple. Combined, they can perform a whole new function.

Cells within a multi cellular organism specialize their function. •Examples: muscles cells, cardiac cells •This differentiation process is the result of the expression of certain specific genes but not others •Genes allow for the production of all different cells in the organism •Each cell contains all the genetic info for the production of the complete organism •Each cell becomes a specific type of cell dependent of which DNA segment becomes active 2. 1. 9 State that stem cells retain the capacity to divide and have the ability to differentiate along different pathways (1). Retain ability to divide and differentiate into various cell types •Embryonic stem cells retain the ability to form any type of cell in an organism and can even form a complete organism •When stem cells divide to form a specific type of tissue, they also produce some cells that remain as stem cells. This allows for the continual production of a particular type of tissue.

•Pluripotent- give rise to any type of cell •Treating diseases? 2. 1. 10 Outline one therapeutic use of stem cells (2). •Replace differentiated cells lost due to injury Therapeutic cloning- implanted stem cells replace lost cells •Tissue-specific stem cells- these cells reside in certain tissue types and can only produce new cells of that particular tissue •For example, stem cells have been introduced to humans to replace the damaged bone marrow of some leukemia patients •Bone marrow transplants are one of the many therapeutic uses of stem cells. Stem cells found in the bone marrow give rise to the red blood cells, white blood cells and platelets in the body. These stem cells can be used in bone marrow transplants to treat people who have certain types of cancer.

When a patient has cancer and is given high doses of chemotherapy, the chemotherapy kills the cancer cells but also the normal cells in the bone marrow. This means that the patient cannot produce blood cells. So before the patient is treated with chemotherapy, he or she can undergo a bone marrow harvest in which stem cells are removed from the bone marrow by using a needle which is inserted into the pelvis (hip bone). Alternatively, if stem cells cannot be used from the patient then they can be harvested from a matching donor.

After the chemotherapy treatment the patient will have a bone marrow transplant in which the stem cells are transplanted back into the patient through a drip, usually via a vein in the chest or the arm. These transplanted stem cells will then find their way back to the bone marrow and start to produce healthy blood cells in the patient. Therefore the therapeutic use of stem cells in bone marrow transplants is very important as it allows some patients with cancer to undergo high chemotherapy treatment.

Without this therapeutic use of stem cells, patients would only be able to take low doses of chemotherapy which could lower their chances of curing the disease. •Ethical issues- embryonic stem cells come from embryos obtained from labs doing IVF. involves death of embryo. 2. 2 Prokaryotic Cells 2. 2. 1 Draw and label a diagram of the ultrastructure of Escherichia coli (E. coli) as an example of a prokaryote (1). •Plasmid is circular thing not on diagram. Refer to book. •Size of cell: 1-2 um •Absence of membrane bound organelles Prokaryote examples: (look at notes for pictures) •straight rod- Escherichia •Club shaped rod- corynebacterium •Spore forming rods-

bacillus •Coccus Staphylococcus 2. 2. 2 Annotate the diagram with the functions of each named structure. •Cell wall: Protects the cell from the outside environment and maintains the shape of the cell. It also prevents the cell from bursting if internal pressure rises. ?? •Plasma membrane: Semi-permeable membrane that controls the substances moving into and out of the cell. It contains integral and peripheral proteins.

Substances pass through by either active or passive transport.?? •Cytoplasm: Contains many enzymes used to catalyze chemical reactions of metabolism and it also contains the DNA in a region called the nucleoid. Ribosomes are also found in the cytoplasm. ?? •Pili: Help bacteria adhere to each other for the exchange of genetic material. Involved in transfer of DNA in a process called conjugation (direct contact between bacterial cells in which plasma DNA is transferred between a donor and a recipient cell) •Flagella (singular flagellum): Made of a protein called flagellin.

Helps bacteria move around (mobility) •Ribosomes: They are the site of protein synthesis. Contributes to protein synthesis by translating messenger RNA.?? free in cytoplasm (70s) •Nucleoid: Region containing DNA; involved with cell control and reproduction •Plasmid- small, circular DNA not connected to main chromosome; replicate independently of chromosomal DNA; not required by cell under normal conditions but it may help the cell adapt to unusual circumstances; normal to find at least one anti-biotic resistance gene within a plasmid •Slime capsule- sticky layer outside of cell wall, sticks cells together . 2. 3 Identify structures from 2. 2. 1 in electron micrographs of liver cells (2). 2. 2. 4 State that prokaryotic cells divide by

binary fission (1). •Binary fission- simple division process in which DNA is copied and 2 daughter chromosomes become attached to different regions on plasma membrane and cell divides into 2 genetically identical daughter cells. Process elongation of cell 2. 3 Eukaryotic Cells 2. 3.

1 Draw and label a diagram of the ultrastructure of a liver cell as an example of an animal cell (1). . 3. 2 Annotate the diagram with the functions of each named structure. •Ribosomes: Found either floating free in the cytoplasm or attached to the surface of the rough endoplasmic reticulum and in mitochondria and chloroplast. Ribosomes are the site of protein synthesis as they translate messenger RNA to produce proteins. •Rough endoplasmic reticulum: Can modify proteins to alter their function and/or destination. Synthesizes proteins to be excreted from the cell. Lysosome: catalyze the breakdown of proteins, nucleic acids, lipids and carbs, fuse with old or damaged organelles so recycling can occur, breakdown of materials that are brought in by phagocytosis •Golgi apparatus: Receives proteins from the rough endoplasmic reticulum and may further modify them. It also packages proteins before the protein is sent to it’s final destination which may be intracellular or extracellular. •Mitochondrion: Is responsible for aerobic respiration. Converts chemical energy into ATP using oxygen. •Nucleus: Contains the chromosomes and therefore the hereditary material.

It is responsible for controlling the cell. Extra: •Smooth ER- production of membrane phospholipids can cellular lipids, production of sex hormones, detoxification of drugs in liver, storage of calcium ions needed for muscle contractions, transportation of lipid based compound, to aid in liver in

releasing glucose into bloodstream when needed •Centrosome- a pair of centrioles at right angles; involved in assembling microtubules which are important in providing structure and allowing movement and cell division •Vacuole- storage organelle; store potentialfoodto provide nutrition, metabolic wastes and toxins to be expelled, and ater; enables cells to have a higher surface area to volume ratios even at larger sizes; in plants, uptake of h2o provides rigidity 2. 3. 3 Identify structures from 2. 3. 1 in electron micrographs of liver cells (2). 2. 3. 4 Compare prokaryotic and eukaryotic cells (3). Prokaryote Eukaryote DNA in a ring form without proteinDNA with proteins as chromosomes/chromatin DNA free in the cytoplasm- no nucleusDNA enclosed within a nuclear envelope No mitochondriamitochondria 70S ribosomes80S ribosomes

No internal compartmentalization to form organellesinternal compartmentalization present to form many types of organelles Size less than 10 micrometersSize more than 10 micrometers •also: unicellular vs. multicellular •no membrane bound organelles vs. membrane bound organelles •binary fission vs. mitosis •asexual reproduction vs. asexual and sexual reproduction •similarities: both cells have some sort of outside boundary that always involves a plasma membrane, both carry out all functions of life, DNA is present in both . 3. 5 State 3 differences between plant and animal cells (1). Plant Animal Outer cell wall with a plasma membrane just insideOnly a plasma membrane Chloroplasts No chloroplasts Large centrally located vacuolesNo vacuoles/ or small ones Store carbs as starchStore carbs as glycogen Do not contain centrioles within a centrosome areaContain centrioles within a centrosome area Fixed, often angular, shape

because of a rigid cell wallCell is flexible and more likely to be a rounded shape . 3. 6 Outline 2 roles of extracellular components (3).

•The plant cell wall gives the cell a lot of strength and prevents it from bursting under high pressure as it is made up of cellulose arranged in groups called microfibrils. It gives the cell its shape, prevents excessive water up take by osmosis and is the reason why the whole plant can hold itself up against gravity. Prevents entry of pathogens. Allows turgor pressure/ high pressure to develop inside the cell. The animal cell contains glycoproteins in their extracellular matrix (ECM) which are involved in the support, movement and adhesion of the cell. Cell to cell interaction, strengthens plasma membrane, allows attachment between adjacent cells, directs stem cells to differentiate 2. 4. 1 Draw and label a diagram to show the structure of membranes (1). 2. 4. 2 Explain how the hydrophilic and hydrophobic properties of phospholipids help to maintain the structure of cell membranes (3). One area of membrane is water soluble and polar and is hydrophilic •The other area isn’t water soluble and is non polar- hydrophobic

•These hydrophobic and hydrophilic regions cause phospholipids to always align as a bilayer if there is water present and there is a large number of phospholipid molecules •Membrane is flexible since fatty acid tail do not strongly attract one another •What maintains the overall structure of membrane is the tendency water has to form hydrogen bonds •In hydrophobic region (fatty acid tails) in animal cells these are cholesterol molecules- determine membrane fluidity (changes temp) •Proteins are embedded in fluid matrix of phospholipid bilayer (mosaic effect) •Integral

proteins have both hydrophobic and hydrophilic regions in the same protein •Hydrophobic region (mid section of phospholipid membrane) holds protein in place •Hydrophilic region is exposed to water solutions on either side of membrane •Peripheral proteins do not protrude into the middle hydrophobic region but remain bound to the surface of the membrane 2.

4. 3 List the functions of membrane proteins (1). •Hormone binding sites- have specific shapes that fit shape of specific hormone •Enzymatic action- catalyze chemical reactions •Cell adhesion- proteins hook together to form connections •Cell to cellcommunication- provide identification •Channels for passive transport- high to low concentration •Pumps for active transport- proteins shuttle a substance from one side of membrane to another by changing shape; ATP 2. 4. 4 Define osmosis and diffusion (1). •Diffusion is the passive movement of particles from a region of high concentration to a region of low concentration.

Osmosis is the passive movement of water molecules, across a partially permeable membrane, from a region of lower solute concentration to a region of higher solute concentration (hypo-osmotic solution to hyperosmotic solution). •Facilitated diffusion- involves a membrane with specific carrier proteins that are capable of combining with the substance to and its movement 2. 4. 5 Explain passive transport across membranes by simple diffusion and facilitated diffusion (3). •Simple diffusion- substances other than water move between phospholipids molecules or through proteins which possess channels •Facilitated diffusion- nonchannel protein carriers change shape to allow movement of substances other than water. No NRG.

Polar molecules need help. •Substances that move passively across membrane are influenced by size and shape •Small substances and nonpolar move with ease; large, polar, or both do not •Channel proteins- create a hydrophilic pore in membrane through which small changed particles (ions) can diffuse into cell •Transport proteins- help move substances (glucose) into cell. Substrate binds to protein which carries molecules across membrane and releases it inside cell 2. 4. 6 Explain the role of protein pumps and ATP in active transport across membranes (3). •Active transport involves the movement of substances through the membrane using NRG from ATP.

The advantage of active transport is that substances can be moved against the gradient, meaning from low to high concentration •This is possible because the cell membrane has protein pumps embedded it which are used in active transport to move substances using ATP •Each protein pump only transports certain substances so the cell can control what comes in and goes out •Transport or carrier proteins •Ex: Na +/ K + pump. Sodium moved out of cell, potassium moved in (important for nerve cells) 2. 4. 7 Explain how vesicles are used to transport materials within a cell between the rough ER, Golgi apparatus, and plasma membrane (3). •Materials are transmitted between rough ER, Golgi app, and plasma membrane •Nucleus contains chromosomes that contain genes for coding proteins.

RNA passes from nucleus to cytoplasm •Rough ER contains ribosomes which make proteins intended for export •Protein goes into lumen of Golgi app for processing before it leaves through the cell surface membrane by exocytosis

2. 4. 8 Describe how the fluidity of the membrane allows it to change shape, break and reform during endocytosis and exocytosis (2). •The phospholipids in the cell membrane are not solid but are in a fluid state allowing the membrane to change its shape and also vesicles to fuse with it. •This means substances can enter the cell via endocytosis and exit the cell via exocytosis. The membrane then returns to its original state. •In exocytosis the vesicles fuse with the membrane expelling their content outside the cell.

The membrane then goes back to its original state. Endocytosis is a similar process which involves the pulling of the plasma membrane inward so that a vesicle is pinched off it and then this vesicle can carry its content anywhere in the cell. •Cell takes up substance by surrounding it with membrane, ATP •2 types: •pinocytosis (substance is liquid) •phagocytosis (substance is solid) •endocytosis and exocytosis- active transport that requires ATP; common in unicellular organisms Summary of processes: ATP requiredConcentration gradient Diffusion

NoDown (high to low) Facilitated diffusionNoDown OsmosisNoDown Active transport with carrier proteinsYesAgainst is possible EndocytosisYesAgainst is possible 2. 5 Cell Division 2. 5. Outline the stages in the cell cycle, including interphase (G1, S, G2), mitosis, and cytokinesis (2). •The first stage of cell division is interphase which is divided into 3 phases; G1, S and G2. The cell cycle starts with G1 (Gap phase 1) during which the cell grows larger. This is followed by phase S (synthesis) during which the DNA is replicated. Finally, G2 (gap phase 2) is the second growth phase in which organelles increase in number, cell grows and preps for mitosis, DNA begins

to condense form chromatin to chromosomes and microtubules begin to form. •? The fourth stage is mitosis, which is divided into prophase, metaphase, anaphase and telophase.

During mitosis the spindle fibers attach to the chromosomes and pull sister chromatids apart, providing the same genetic material to each of these locations. This stage separates the two daughter genomes. •Finally, cytokinesis is the last stage during which the cytoplasm divides to create two daughter cells. In animal cells the cell is pinched in two to form a cleavage furrow while plant cells form a plate between the dividing cells. 2. 5. 2 State that tumors (cancer) are the result of uncontrolled cell division and that these can occur in any organ or tissue (1). •Proto-oncogenes are genes that produce proteins, which stimulate growth (cell division). If mutation occurs, a tumor will form. Mutations: radiation, viruses, chemicals that are carcinogenic, EM radiation 2. 5.

3 States that interphase is an active period in the life of a cell when many metabolic reactions occur, including protein synthesis, DNA replication, and an increase in the # of mitochondria and/or chloroplasts (1). 2. 5. 4 Describe the events that occur in the 4 phases of mitosis (2). •During prophase, chromatin becomes chromosomes, nuclear envelope disintegrates, the spindle microtubules begin to form, centrosomes move toward opposite poles of cell due to lengthening microtubules. Each chromosome consists of 2 identical sister chromatids held together by a centromere. During metaphase, the chromatids move to the equator and the spindle microtubules from each pole attach to each centromere on opposite sides.

•During anaphase, the spindle microtubules pull the sister chromatids apart splitting the centromeres. This splits the sister chromatids into chromosomes. Each identical chromosome is pulled to opposite poles. Chromatids of each duplicated chromosome separate and become unduplicated chromosome

•During telophase, the spindle microtubules break down and the chromosomes uncoil and so are no longer individually visible. Also the nuclear membrane reforms. Chromosomes become chromatin (shapeless). Centrioles replicate in animal cells. The cell then divides by cytokinesis to form two daughter cells with identical genetic nuclei. 2. 5. Explain how mitosis produces 2 identical nuclei (3). •During prophase, the chromosomes become visible. The nuclear envelope disintegrates and the spindle microtubules grow and extend from each pole to the equator. •At metaphase the chromatids move to the equator. The sister chromatids are two DNA molecules formed by DNA replication and are therefore identical.

•These sister chromatids are then separated in anaphase as the spindle microtubules attaches to centromere and pulls the sister chromatids to opposite poles. As the sister chromatids separate they are called chromosomes. This means that each pole has the same chromosomes (same genetic material). Finally the microtubules break down, the chromosomes uncoil and the nuclear membrane reforms. The cell then divides into two daughter cells with genetically identical nuclei. •4 chromosomes in parent cell = 4 chromosomes in each daughter cell •duplicated chromosome with 2 strands connected by centromere and chromosome is 1 strand 2. 5. 6 State

that growth, embryonic development, tissue repair, and asexual reproduction involve mitosis (1). •Growth- production of similar cells •Embryonic development- allows zygote to grow into multicellular organism •Tissue repair- wounds need identical replacement cells •Asexual reproduction- allows for a rapid and significant increase in number of individuals