Module 1 - Characteristics of Life

Characteristic	Example
Growth and Development	cell growth and cell division
Maintain Homeostasis	maintain appropriate concentrations of different chemicals, pH level, optimum temperature
Reproduction	succeeding generations thruough sexual or asexual processes
Response to Environment or Stimuli	adaptation to environment
Energy Processing	photosynthetic process
Organized	highly organized and coordinated cell structures

Life Processes

Movement	transfer places with the use of specialized structures like flagella, cilia and pseudopodia
Respiration	exhibits a metabolic pathway that breaks down glucose and produces adenosine triphosphate (ATP)
Sensitivity	act on sensing a stimulus and at the same time responding to it
Growth	increase the size of each individual cell or increase of the number of cells
Reproduction	formation of new cells by the process of cell division to replace or repair old cells
Excretion	get rid of by-products due to metabolic processes which maybe toxic

Life Processes (cont)

Nutrition	break down food, into simple molecules that can be absorbed and be utilized

Terms

Specialization	**adaptation** of an organ or part to serve a special function
Meristhematic Tissue	includes undifferentiated cells that are capable of **specialization**; most action takes place here
Cytokinesis	physical separation of the two daughter cells; where cell division ends
Hibernation	state of minimal activity and metabolic depression
Torpor	**involuntary** and lasts for just a few hours during the daytime; not as heavy as hibernation
Piloerection	or **goosebumps**; modification of the heat exchange, contraction of the **musculi arrectores pilorumor (MAP)**
Autotrophs	organisms that can make their own food
Photosynthetic process	+ Oxygenic photosynthesis - Light energy transfers electrons from **water to carbon dioxide** in order to produce carbohydrates; seen in algae, cynobacteria, plants
	+ Anoxygenic photosynthesis - light energy is captured and converted to ATP, **without the production of oxygen**; doesn't have water as electron donor

Terms (cont)

Epithelial tissues	line the cavities and surfaces of the body such as the inside of the stomach and the outermost skin layer
Connective tissue	supports, protects and binds certain parts of the body such as muscles, together
Muscular tissues	produce movement by contraction and expansion
Nervous tissue	receive stimuli and conduct electrical impulses
Dermal tissue	forms outer covering of plants
Vascular tissue	moves water and nutrients through the plant
Ground tissue	makes up most of plants' bodies and performs majority of bodily functions
Vegetative organs	help sustain plant life; roots and leaves
Reprod-uctive organs	facilitate either sexual or asexual reproduction; cones, flowers and fruits
Shoot system	parts above the ground; leaves, and stems
Root system	parts below the ground; roots and tubers
Diurnality	behavior characterized by activity during daytime, highly variable temperature
Crepuscul-arity	active primarily during the twilight period, coldest temperature is at dawn

Terms (cont)

Noctu rnality	behavior in animals characterized by being active during the night and sleeping during the day, constant temper-ature

Human body has 11 systems, while plants only have 2 (shoot and root)

Module 2 - Cell Theory

Development of Microscope

Zachrias Janssen	Dutch spectacle-maker who discovered the first compound microscope which was later disputed
Galileo Galilei	able to make his own microscope because of his knowledge about glass and focal lengths
Antony van Leeuwe-nhoek	“Father of Microbiology”, able to discover bacteria and protozoa; called bacteria "animacules"
Robert Hooke	coined the term "cell"; published "Micrographia" in 1665

Formation of Postulates

Matthias Schleiden	German botanist, noticed that plants are made up of cells
Robert Schwann	concluded that animals are made up of cells; coined "-Schwann cells", which myelinates the axons of the peripheral nervous system
Rudolf Virchow	"Father of Modern Pathology", published "Virchow's archives" and the aphorism "every cell stems from another cell"

Postulates of Cell Theory

1. All known living things are made up of cells.
2. The cell is a structural and functional unit of all living things.
3. All cells come from pre-existing cells by division.

Additional:

1. All cells contain hereditary information which is passed from cell to cell
during division.
2. All cells are basically the same in chemical composition.
3. All energy flow of life occurs within cells.

Module 3 - Prokaryotic vs. Eukaryotic cells

All known life are classified into 3 domains: Archea, Bacteria, Eukarya. The organisms in **Archea and Bacteria are prokaryotes** while the organisms in **Eukarya have eukaryotic cells.**

Prokaryotic cells - simpler and lack the membrane-bound organelles and nucleus; more primitive than eukaryotes, single-celled.

Eukaryotic cells - single or multicelllar

Major Difference in Cell Structure

Eukaryotes store their DNA as chromosomes within the nucleus but prokaryotes lack the nucleus. Instead, the majority of their DNA is in the **nucleoid**. Additional DNA pieces, called **plasmids**, are shaped like rings and reside outside the nucleoid in the cytoplasm.

Differences in Organization

Eukaryotic cells use a specific cell division process called **mitosis**, while prokaryotic cells use **binary fission**.

-Prokaryotes create an exact copy of themselves; though genetic variance occur through **transduction**, which is when virus transmit plasmid containing DNA to bacterial cells (host).

-Eukaryotes sexually reproduce through **meiosis**, which maximizes genetic diversity and minimizes mutation.

Similarities between Prokaryotes and Eukaryotes

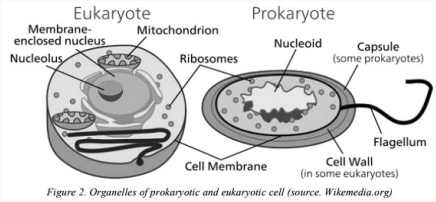


Figure 2. Organelles of prokaryotic and eukaryotic cell (source. Wikemedia.org)

Both have DNA, plasma membrane, ribosomes for protein synthesis, and cytoplasm

Other Differences

Features	Prokaryotic	Eukaryotic
Protective layers	Capsule, cell wall and cell membrane	Cell membrane (animal cells), cell wall and cell membrane (plant cells)
Cell type	Usually unicellular (some cyanobacteria maybe multicellular)	Usually multicellular
Complexity	Simple	Complex organization
Nucleus location	Free in the cytoplasm, attached to mesosomes	Contained in membrane bound structure
Chromosome	Usually single circular without histones	Multiple linear with histones
Genes	Expressed in groups called operons	Expressed individually
Genome	DNA haploid genome	DNA diploid genome
Genome nature	Efficient and compact with little repetitive DNA	With large amounts of non-coding repetitive DNA
Movement	Simple flagellum, if present	Complex flagellum, if present
Respiration	Via cytoplasmic membrane	Via mitochondria
Energy production site	Electron transport chain located in the cell membrane	Within membrane bound mitochondria
Metabolic mechanism	Wide variation	Glycolysis, electron transport chain, Krebs cycle
DNA replication	Occurs in cytoplasm	Occurs in the nucleus
Transcription and translation	Occurs simultaneously	Transcription occurs in nucleus and then translation occurs in cytoplasm

Module 4 - Membrane-bound Organelles

Nucleus	consists of nuclear envelope, chromatin and nucleolus; largest and contains genome
Endoplasmic Reticulum	**major site of synthesis**, flattened sac network (cisternae). Its function is closely linked to that of the golgi apparatus and together they form the cell's secretory route
Rough Endoplasmic Reticulum	takes proteins from the cytosol and continues its production in the golgi apparatus until completion
Smooth Endoplasmic Reticulum	lipid, phospholipid and steroid synthesis
Golgi Apparatus	packages macromolecules into vesicles; modifies proteins and lipids from endoplasmic reticulum

Module 4 - Membrane-bound Organelles (cont)

Mitochondria	site of ATP synthesis; helps maintain the intracellular environment, has inner and outer membrane with an intermembrane space in between
Lysosomes	acidic; contain numerous hydrolytic enzymes which catalyze hydrolysis reactions
Perixosomes	contain the enzyme catalase which decomposes hydrogen peroxide
Vacuoles	acts as a storage for nutrients as well as waste materials to protect the cell from toxicity; helps in maintaining an **acidic internal pH**
Vesicles	facilitate the storage and transport of materials in and outside the cell
Chloroplast	produces amino acids and lipids required for the production of chloroplast membrane; has two distinct regions- grana and stroma

Terms

Cell compartmentalization	process of selectively permeable nuclear envelope (separates the contents of the nucleus from the cytoplasm)
Gene expression	involves first transcription, which is the mechanism by which **DNA is transcribed to mRNA**

Terms (cont)

pre-mRNA	undergoes a process known as post-transcriptional modification where molecules are added or removed
Cytochrome p450	enzyme in SER; essential to some drugs and toxins, such as alcohol and barbiturates, in the metabolism
Exocytosis	form of active transport and bulk transport in which a cell transports molecules out of the cell
Protein processing	carbohydrate regions of glycoproteins are altered by addition, removal or modification of carbohydrates
Lipid processing	adds phosphate groups and glycoproteins to lipids from ER (like cholesterol) to create the phospholipids that make up the cell membrane
Mannose 6-phosphate receptor	lysosomal protein; binds newly synthesized lysosomal hydrolases in the trans-Golgi network and deliver them to pre-lysosomal compartments
Secretory proteins	hormones; requires ATP, as it is necessary to fuse two negatively charged membranes to allow its release

Terms (cont)

Cell-surface proteins	phospholipids; primary route of communication among the cells and the external environment
Porins	protein in the outer membrane of nucleus; enable ion movement to and from mitochondrion
Phagocytosis	important in killing mechanisms which are independent of oxygen
Tonoplast	membrane which bounds the vacuole of a plant cell
Lamellar phase	similar to plasma membrane; outer layer enclosing the liquid in vesicle
Grana	made up of thylakoids; sight for the process of light-dependent reactions of the photosynthesis process
Stroma	contains grana and is similar to the cytoplasm in cells in which all the organelles are embedded
Stroma Lamellae	flat membranous tubules; connects the thylakoids of the different grana

Module 5 - Non-Membrane-bound Organelles

Ribosomes - produces protein; attached to rough ER within the cytoplasm. consist of ribosomal RNA (rRNA) and ribosomal protein *(Humans and other eukaryotes have 3 rRNA strands, while bacteria have 4 rRNA strands)*. Prokaryotes consist of 60% rRNA and 40% protein

+ serves as a line of assembly and starts to “read” the mRNA, identifies the corresponding tRNA and binds the amino acid to a binding spot.

Module 5 - Non-Membrane-bound Organelles (cont)

+ Svedberg units - defined in a centrifugal field as the sedimentation rate of subunits; when placed in centrifugal chamber, the time it takes for each subunit to reform. The smaller subunits are forming faster than the bigger ones. *(Eukaryotes: 40s and 60s while Prokaryotes: 30s and 50s)*

Centrioles - helps cell divide or make copies of themselves; made up of protein strands called microtubules. Involved in the formation of the spindle apparatus which functions during cell division.

+ Microtubules - mitotic apparatus during mitosis or meiosis and sometimes get arranged just beneath the plasma membrane to form and bear flagella or cilia in flagellated or ciliated cells.

A single centriole forms the anchor point or basal body for each individual cilium or flagellum. Basal bodies direct the formation of cilia and flagella as well.

Cytoskeleton - network of microscopic molecular filaments found in the cytoplasm of all nucleated eukaryotic cells. Responsible for locomotion and preserving the shape of a cell, chromosome movement during cell division and cytokinesis.

Structural components of the cytoplasm that help divide chromosomes in cell division;

+ Mitotic spindle - array of microtubular proteins formed in late G-2 following duplication of the centrosomes.

+ Contractile ring - overlapping array of actin/myosin proteins; responsible for cytokinesis, becomes smaller, finally dissecting the cell’s cytoplasm into two separate domains.

Terms

Proteins	comprise hundreds or thousands of smaller units called amino acids (20 types)
Carbohydrates	provide energy, structural support and cellular communication; plant and fungal cell walls have carbohydrate cell walls
Lipids	made up of fatty acids that can either be saturated or unsaturated
Nucleic Acids	DNA and RNA
Archea	single-celled microorganisms living in environments low in oxygen (extremophiles)
Flagellum	specialized part used for movement

Terms (cont)

Cytoplasm	jelly-like fluid within in a cell that is composed primarily of water, salts and proteins
Ribosome	organelle used to synthesize proteins
Bacteria	organelle used to synthesize proteins
Operon	a functioning unit of DNA containing a cluster of genes under the control of a single promoter

Module 6 - Cell Modifications

Animal Tissue

Epithelial Tissue - consists of closely packed sheets of cells covering surfaces- including the outside of the body- and cavities of the body wall *(outer layer of skin and lining of small intestine)*.

- Polarized, have a top and bottom face; closely packed and this helps them to serve as barriers to fluid movement and potentially harmful microbes.

- Can have distinct arrangements: **cuboidal** for secretion; **simple columnar** for secretion and active absorption; **simple squamous** for exchange of material through diffusion; **stratified squamous** for protection; and **pseudo-stratified columnar** for lining or respiratory tract usually lined with cilia.

Connective Tissue - made up of cells that are suspended in an extracellular matrix; **supports and binds** tissues together. *Most abundant and widely used; functions as protection.*

- Protein fibers such as **collagen** and **fibrin** form the matrix in a solid, liquid or jellylike ground material.

+ Loose Connective Tissue - protecting organs and blood vessels and connecting epithelial tissues to the underlying muscles.

+ Dense or Fibrous Connective Tissue - found in tendons and ligaments which connect muscles to bones and connect bones.

+ Adipose Tissue - specialized connective tissue like *body fat, bone, cartilage, and blood* in which the extracellular matrix is liquid called plasma.

Muscle Tissue - contain *actin and myosin* proteins which allow them to contract.

Module 6 - Cell Modifications (cont)

+ Skeletal Muscle - striated (striped) and attached by tendons to the bones, which helps to regulate movements consciously. **(In the quads or biceps)**

+ Smooth Muscle - not striated and involuntary. **(In blood vessel walls, digestive tract walls, uterus, urinary bladder, etc.)**

+ Cardiac Muscle - striated; individual fibers are bound by structures called intercalated disks, allowing them to contract synchronously. **(In the walls of the heart)**

Nervous Tissue - collects and transmits information through detecting stimuli. Has 2 cell types:

+ Neurons or Nerve cells - nervous system's main functioning structure; generates nerve impulses which allow neurons to transmit information.

+ Glia - promotes neuronal activity.

Plant Tissue

Dermal Tissue - covers and protects the plant and monitors exchange of gases and absorption of water in roots.

+ Stomata - specialized pores that allow exchange of gas through cuticular holes.

+ Root hairs - or root epidermal cell extensions; increase the root surface area, contributing significantly to the absorption of water and minerals.

Vascular Tissue - transports water, minerals, and sugars into different parts of the plant.

+ Xylem Tissue - brings water and nutrients from the roots throughout the plant; plays a role in stem structural support.

+ Phloem Tissue - brings organic compounds from the photosynthesis site throughout the plant.

Ground Tissue - performs different functions depending on the type and position of the cells in the plant, including:

+ Parenchyma - photosynthesis in the leaves and storage in the roots.

+ Collenchyma - adds flexibility and support in areas of active growth or young plants.

+ Schlerenchyma - adds rigidity and support in areas where growth has stopped or adult plants.

Cell Modification that Lead to Adaptation

Apical Modifications - surface or luminal; for secretion, absorption, and movement.

+ Microvilli - or brush/striated border; finger-like cytoplasmic extensions of the apical surface which **expands surface area that helps in absorption.** *(Found in absorptive epithelia).*

+ Cilia - for movement or motility. short hair-like structures or projections; its core is composed of microtubules, each cilium is connected to a basal body and extends from the free surface.

Cell Modification that Lead to Adaptation (cont)

+ Flagella - have the same axial structure with cilia but longer; also functions for movement. *(Present in the tail of spermatozoa).*

Basal Modifications - base; for structural support and barrier.

+ Basal Infoldings - support the epithelium and also functions as a **passive molecular sieve** or ultrafilter. *(Present in mitochondria).*

Lateral Modifications - sides of the tissue; provide barrier and cell-cell communication.

+ Tight Junctions - intercellular adhesion complexes in epithelia and endothelia that control paracellular permeability *(this paracellular diffusion barrier is semipermeable).*

- Form the **border between the apical and basolateral cell surface domains** in polarized epithelia and support the maintenance of cell polarity by restricting intermixing of apical and basolateral transmembrane components.

+ Adherence Junctions - element of the cell-cell junction in which **cadherin receptors bridge the neighboring plasma membranes** via their hemophilic reactions.

- The actin filaments which make up zonula adherens maintain integrity of the cell to better bind.

Module 7 - Cell Membrane: Phospholipid Bilayer

Cell Membrane - selectively permeable; barrier that separates the cytoplasm from the cell's outer surroundings, receive and respond to stimuli.

- Made up of 4 different molecules: phospholipid, proteins, cholesterol, and carbohydrates.

Phospholipids

+ Phospholipid Bilayer - two-layer of phospholipid oriented in opposite direction.

+ Phospholipid - consists of a glycerol molecule bonded to a phosphate "head" group and two fatty-acid "tails".

- Has two ends: **Phosphate head end** which is hydrophilic due to its polarity, and a **tail end of two chains of fatty acids** which is hydrophobic.

- It is **amphiphilic or amphipatic** since it has both hydrophobic and hydrophilic properties.

- Two layers of hydrophilic head face intracellular and extracellular fluid respectively; the hydrophobic end is in the middle, allowing the semipermeable membrane to work.

- This means that nonpolar molecules like oxygen gas, carbon dioxide, and lipids can pass freely, while large polar molecules like glucose are hindered.

Module 8 - Cell Membrane: Proteins and Others

Membrane Proteins - can further be classified based on location and function.

Based on Location

+ Integral Proteins - or intrinsic proteins are embedded entirely in the lipid bilayer; extends such that each end reaches the inside and outside of the cell respectively.

- Cannot easily be removed without the use of strong detergent .

+ Peripheral Proteins - less mobile; attached to either inner or outer layer of the phospholipid bilayer.

- They are easily separable from the lipid bilayer without harming it.

Based on Function

+ Ion Channels - very narrow tube-shaped protein that help establish a tiny pore in the cell membrane (open and close for Na^{+},K^{+}, Cl^{-}, Ca^{+2}.).

+ Transporter or Carrier Proteins - help transport too large molecules such as glucose and amino acids to go through ion channels.

- Enzymes are chemicals that catalyze and causes chemical reactions to occur.

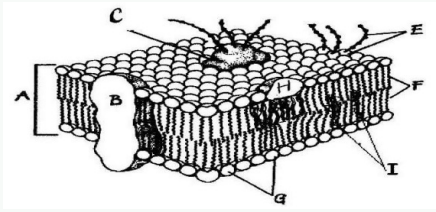
- Receptor Site Proteins help cells communicate with their external environment through the use of hormones, neurotransmitters, and other signaling molecules. *(Cells can have up to 20).*

- Recognition Sites or Cell Identity Markers are glycoproteins (carbohydrates attached to proteins); always on the outside surface and recognize foreign cells. (White Blood Cells for ex.)

+ Cholesterol - stable; helps the cell membrane maintain the appropriate level of fluidity by managing the space between phospholipids.

*The cell membrane is a **fluid mosaic model** because the structure of the membrane is flexible and fluid rather than a rigid solid barrier, and it is composed of different parts like a mosaic.

Parts of Cell Membrane



A - Phospholipid Bilayer
B - Integral Protein
C - Glycoprotein
E - Glycolipids
F - Fatty Acid Tails
G - Phosphate Heads
H - Peripheral Protein
I - Cholesterol

Module 9 - Membrane Transport: Passive Transport

Passive Transport - does not require the cell to exert any of itsenergy to accomplish the movement.

- Involves diffusion; substances simply move from an area of higher concentration to an area of lower concentration. *(Concentration is higher inside the cell).*

Factors Affecting Rate of Diffusion

Concentration Gradient - Direct proportion.

Temperature - Direct proportion.

Mass of Particles - Inverse proportion.

Solvent Properties - Inverse proportion; density and viscosity of solvent.

Types of Passive Transport - Simple Diffusion, Facilitated Diffusion, and Osmosis.

Simple Diffusion - substance moves down its concentration gradient without the use of transport proteins. *(Lipids and nonpolar molecules pass easily)*

Facilitated Diffusion - materials diffuse across the plasma membrane with the help of membrane proteins.

- With **channel proteins**, the transmembrane proteins present in the membrane act like a pore, in which it allows the transport of molecules.

- Molecules bind in **carrier proteins** which result in some conformational changes in the molecules, facilitating the movement across the membrane in the intracellular space.

Module 10 - Passive Transport: Osmosis

Osmosis - water molecules pass in a selectively permeable membrane; solution with higher concentration will attract or absorb the solvent from another solution.

Osmotic Pressure - causes the water to diffuse through selectively permeable membranes; directly proportional to the solute concetration.

Isotonic Solution - The concentration of solutions inside and outside of the cell is equal, thus the water movement is balanced. *(Iso - equal, tonicity - relative concentration of solutes in the water inside and outside the cell).*

Hypertonic Solution - The solute concentration on the outside is higher; causing **crenation** (water moves out of the cell, causing the cell to shrink and shrivel) of RBC. *(Hyper - above).*

Hypotonic Solution - the solute concentration is lower outside; which causes the cell to burst. *(Hypo - under).*

Module 10 - Passive Transport: Osmosis (cont)

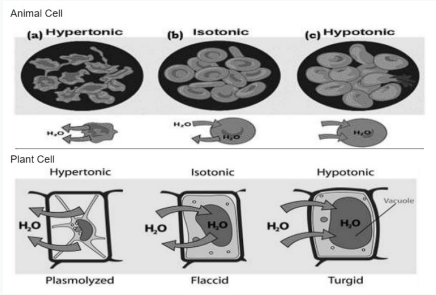
- Plants have rigid cell wall so it is ideal for hypotonic solution, causing it to become turgid or swollen.

Turgor pressure - or hydrostatic pressure is the resulting force of water against the cell wall; **prevents the further net intake of water.**

Plasmolysis - caused by hypertonic solution on plant cell, causing it to be flaccid or limp; can be reversed through deplasmolysis.

Incipient Plasmolysis - caused by isotonic solution on plant cell; not turgid nor flaccid causing the greens of the plant to droop. *(Incipient - about to be).*

Difference of Concentrations on Cells



Module 11 - Active Transport

Active Transport - uses transport protein to move a substance against its concentration gradient—from an area of lower concentration to an area of higher concentration.

Carrier Proteins:

Uniporters - transport a **single** type of molecule or ion. *(Ca^{2+} ATPase & H^{+} ATPase)*

Symporters - transport **two** molecules or ions in the **same** direction. *(Glucose – Na^{+} ATPase).*

Antiporters - transport **two** molecules or ions in the **opposite** directions.*(Na^{+} – K^{+} ATPase & H^{+} – K^{+} ATPase).*

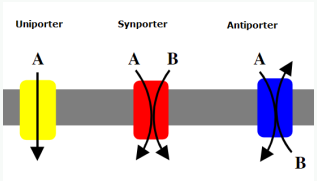
Electrical Gradient - Difference in the charge of molecules in the cell.

Membrane Potential - difference in the electrical potential (voltage) across their cell membrane.

- An **electrical potential difference** is present whenever there is a net separation of charges in space.

Cell membrane - separates negative and positive charges; the inside of the cell is more negative.

Carrier Proteins



Module 12 - Bulk Transport: Endo- & Exocytosis

Transport Vesicle - small sac that can pinch off or fuse with a cell membrane; used for larger molecules to enter or leave the cell.

Bulk Transport - mode of transport of large quantities of materials and food particles across the membrane. *(Endocytosis and Exocytosis).*

Endocytosis - cell membrane engulfs fluids or large molecules to bring them into the cell. The plasma membrane of the cell invaginates and pinches off into the cell.

+ Phagocytosis - **"cell eating"**; large particles, such as cells or relatively large particles, are taken in by a cell. Single-celled eukaryotes called **amoebas** also use phagocytosis to hunt and consume their prey. *(Phagein - to eat; cyto - cell).*

+ Pinocytosis - **"cell drinking"**; takes in molecules, including water, which the cell needs from the extracellular fluid. It results in a much **smaller vesicle** than does phagocytosis, and the vesicle does not need to merge with a lysosome.

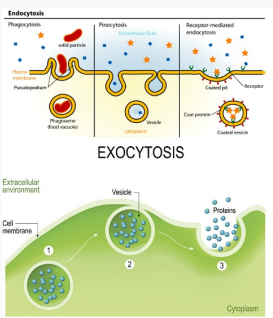
+ Receptor-mediated endocytosis - receptor proteins on the cell surface are used to capture a specific target molecule (mostly in low concentration).

- Might bring toxins to the cell *(Flu viruses, diphtheria, and cholera).*

Coat Protein - receptor found on the cytoplasmic side of the pit. *(Clathrin)*

Exocytosis - materials are transported from the inside to the outside of the cell in membrane-bound vesicles that fuse with the plasma membrane. *(Secretion of proteins and neurotransmitters).*

Bulk Transport



Module 13 - Cell Cycle

Interphase	longest event in the cell cycle; preparation of the cell for the successful cell division.
+ First Gap (G_1 phase)	cell is active; grows larger, duplicates the organelles, and makes the molecular building blocks needed for the next steps.
+Synthesis Phase (S phase)	DNA replication occurs; Duplication of centrosomes, needed in the separation of chromosomes in M phase. *(Takes a lot of time).*
+ Second Gap (G_2 phase)	cell grows continuously; making more proteins, duplicating the organelles.
Major Checkpoints	
+ Restriction Point	ensures that the cell size is large enough to divide; checks if the nutrients and proteins reserves are enough for the daughter cells.
+ Second Gap	ensures that the DNA have been accurately replicated without mistake or damage.
+ Metaphase	ensures that the chromosomes are attached to the spindle microtubules.

Gap 0 (G_0 phase) - resting phase where cells that would not undergo cell division rest and wait for a signal to divide or stay to preserve its physiologic function.

What Triggers Checkpoints?

p53 (Tumor Suppressor Gene)	"the guardian of the genome"; prevents gene mutation through **growth arrest, DNA repair and apoptosis (cell death).**
Kinases	regulators; enzymes that combine phosphate groups to other molecules like sugars and proteins.
+ Cyclins	activating proteins that bind to a kinase to form Cdk complex.
+ Cyclin-Dependent Kinases	activates or deactivates another protein through phosphorylating them.

Module 14 - Mitosis

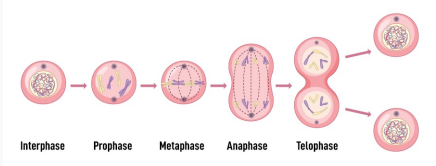
Mitosis	two new daughter cells are generated having the same number of chromosome (diploid) as the parent cell (2n).
+ Prophase	starts when chromatin is visible; mitotic spindle begins to form, and *kinetochore* microtubules start capturing the chromosomes.
+ Metaphase	chromosomes assemble at the metaphase plate; centromeres are at the center, and centrosomes are now at the opposite poles of the cell.
+ Anaphase	shortest stage; sister chromatids start to part because the kinetochore microtubules shorten.
+ Telophase	chromosomes become less dense; two daughter nuclei form in the cell.

Module 14 - Mitosis (cont)

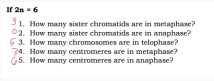
+ Cytokinesis	cytoplasm divides the two daughter cells; happens when cleavage furrow is visible.

Karyokinesis - division of a cell nucleus.
Kinetochore - proteins found in the centromere (regions of DNA where sister chromatids are connected).
- In a normal human; 2n = 46 (2n = diploid, 46 = chromosomes)
- **Plant cells skip cytokinesis** since cell plate is produced in the middle along the perimeter to divide.

Mitosis stages



No. of sister chromatids, centromeres, chromosomes



Metaphase - 23 sister chromatids, 23 centromeres
Anaphase - 0 sister chromatids, 46 centromeres
Telophase - 46 chromosomes

Module 15 - Significance of Mitosis

Gastrulation	blastula folds inward and enlarges to create a gastrula; for organ developing.
Cell Repair	wounds would be healed and be repaired.
Stem Cells	like clay that is ready to be molded to get a specific shape; replace dead cells.
Effects of Cell Division Error	
Cancer	caused by malfunction of p53 tumor suppressor gene where damaged daughter cells continuously divide.
Neurodegeneration	progressive damage in nerve cells from too much cell death by apoptosis (cell suicide).

Module 15 - Significance of Mitosis (cont)

+ Alzheimer's	most widespread and known; neurons are able to re-enter and cell cycle re-entry can lead to apoptosis.
+ Huntington's	inherited disorder characterized by neuronal dysfunction and degeneration in striatum and cerebral cortex.
	- Cell deaths are results of overexpression of huntingtin-interactive protein (HIP-1) that is said to be a proapoptotic protein.
+ Parkinson's	target neurons responsible for movements; misfolding of protein called alpha-synuclein in nerve cells leads to protein deposits that are toxic to neurons controlling voluntary movements.
Application of Mitosis in Other Disciplines	
Agriculture	cloning is used; **Horticulture** for example.
Medicine	**Tissue Culture** - fragments of tissue from an animal or plant are transferred to an artificial environment in which they can continue to survive and function, & **Stem Cells**

Module 14 - Meiosis

Meiosis I	or Reduction Division; number of chromosomes of the daughter cells are half of the parents' (haploid).

Module 14 - Meiosis (cont)

+ Prophase I	includes the disappearance of nucleoli, breaking down of nuclear membrane, formation of spindle fiber, and movement of centrosomes.	
	Leptonema	visible; chromosomes have coiled and condensed.
	Zygonema	chromosomes pair up with its homologue partner *(synapsis)*.
	Pachynema	crossing-over occurs; parts of the homologous chromosomes are recombined *(genetic recombination)*.
	Diplonema	tetrad begins to separate and chiasma becomes evident.
	Diakinesis	chromatids became more condensed and the chiasma move towards the ends of chromosomes *(terminalization)*.

Module 14 - Meiosis (cont)

+ Metaphase I	homologous pair at the center and facing both sides of the poles; kinetochore microtubules are attached to one of the kinetochores of the homologous pair.
+ Anaphase I	synaptonemal complex breaks down, causing the homologous chromosomes to start separating and move towards the opposite poles.
+ Telophase I	sister chromatids are already at the opposite poles; chromosomes start decondensing and the nuclear envelopes form.

The result of meiosis I is two daughter cells with only one set of chromosomes (haploid).

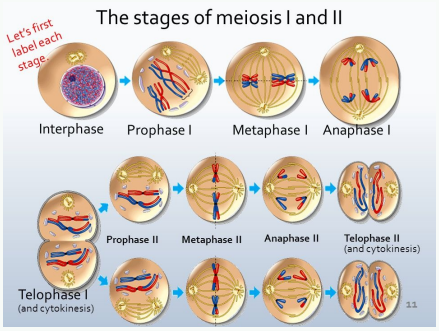
Meiosis II	sister chromatids separate, making haploid cells with non-duplicated chromosomes.
+ Prophase II	spindle apparatus forms from the centrosomes; chromosomes are still composed of two chromatids associated at the centromere (dyad).

Module 14 - Meiosis (cont)

+ Metaphase II	centromeres are at the metaphase plate; kinetochore microtubules are attached to the kinetochores of each sister chromatids.
+ Anaphase II	sister chromatids (monads) start separating from each other; individual chromosomes move towards the opposite poles.
+ Telophase II	chromosomes uncoil and extend; nuclear membrane starts to form together with cytokinesis where cleavage furrow happens.

Meiosis produces four (4) daughter cells that are distinct to each other and from the parent cell, n = 23.

Meiosis Stages



Mitosis vs Meiosis

MITOSIS	MEIOSIS
One nuclear division	Two nuclear divisions
No synapsis and crossing over	Has synapsis and crossing over
For growth and repairs of damaged and worn-out cells	For reproduction (produces sex cells)
2 daughter cells with same number of chromosomes as parents (2n)	4 daughter cells with haploid number of chromosomes (n)
Genetically the same with parents and other cells	Genetically different from parent and other cells
Asexual reproduction	Sexual reproduction

Module 17 - Gametogenesis

Gametogenesis - diploid (2n) cell undergoes a meiotic cell division to become haploid sex cells.

+ Spermatogenesis - production of millions of spermatozoa (sperms) each day through meiosis from primordial germ cells.

Divided into two parts:

Spermatocytogenesis - There are over 1 billion spermatogonia in male which form the basal layer of the germinal epithelium and categorized into two: Type A and Type B spermatogonia.

Type A spermatogonium - undergo mitosis and produces two daughter cells *(Type B spermatogonium and primary spermatocyte).*

Type B spermatogonium - from Type A and will repeat mitosis.

Primary Spermatocyte - undergoes interphase and meiosis I; produces 2 haploid daughter cells *(secondary spermatocytes)*.

Secondary Spermatocyte - undergoes meiosis II; produces 4 haploid daughter cells *(spermatids).*

Spermiogenesis - spermatids move to the lumen (part of the semini-ferous tubule) and undergo differentiation to become sperm cells.

FSH (Follicle Stimulating Hormone) releases Sertoli cells that trigger spermatogenesis; LH (Lutenizing Hormone) releases testosterone when it reaches the testes.

+ Oogenesis - production of female gametes (ova) within ovaries (sometimes in oviduct).

Oogania - or ovarian stem cells; formed during fetal development.

- starts when primordial germ cells move to primordial gonad and undergo continuous mitosis.

Primary Oocytes - about 2 million cells that will undergo meiosis I; which are then arrested in prophase I until puberty.

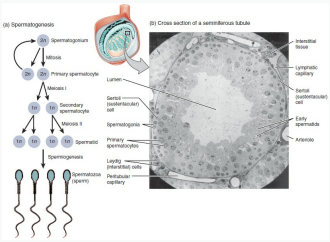
FSH will trigger the continuation of division of the primary oocytes. They will then finish meiosis I with 2 unequal size daughter cells: ***secondary oocyte and first polar body*** *respectively.* ***Progesterone and Estrogen*** *stimulate oogenesis*

Secondary Oocyte - meiosis II but get arrested at metaphase II UNLESS fertilized by sperm and will form another polar body.

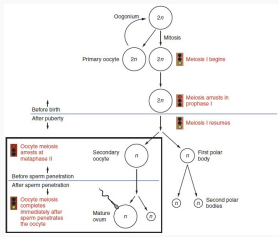
Module 17 - Gametogenesis (cont)

- Once meiosis II finishes, the mature egg forms an ovum, before joining its nucleus with the sperm's nucleus to form a zygote.
- The first polar body may also undergo meiosis II to form a third polar body when produced together with the secondary oocyte.

Spermatogenesis



Oogenesis



Spermatogenesis vs Oogenesis

	SPERMATOGENESIS	OOGENESIS
PROCESS		
Location	Occurs entirely in testes	Occurs mostly in ovaries
Meiotic Divisions	Equal division of cells	Unequal division of cytoplasm
GAMETES		
Number produced	Four (4) spermatids	One (2-3 polar bodies) and 1 ovum
TIMING		
Duration	Uninterrupted process	In arrested stages
Onset	Begins at puberty	Begins in fetus
Release	Continuous	Monthly from puberty
End	Lifelong (reduces with age)	Terminates at menopause

Significance of Meiosis

Meiosis	main reproduction of gametes (haploids).
Ova	produced by follicle cells in the ovaries of the female organism and in plants.

Significance of Meiosis (cont)

Sperms	carries biological information in producing new organism when joined with egg cell.
Recombination	combining the parents' DNA that produces unique features of offspring.
DISEASES RELATED TO MALFUNCTIONS DURING MEIOSIS	
Aneuploidy	abnormality in the number of chromosomes.
Autosomes	there is an excessive copy of chromosome (normally it is a pair (2) but in these cases, there are 3 chromosomes)
Trisomy 21	or Down Syndrome; excess chromosome in chromosome 21.
Nondisjunction	pairs of homologous chromosomes or the sister chromatids fail to separate during anaphase I or anaphase II.
Klinefelter Syndrome (XXY)	having an extra x chromosome on males, one of the signs of having this syndrome is enlarged breast, little to no sperms, no body hair, and broader hips.
XYY Syndrome	also only happens to males; no distinct physical features and mostly show behavioral difference.

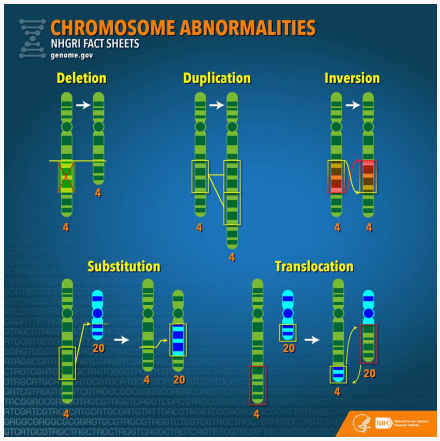
Significance of Meiosis (cont)

Trisomy X (XXX)	happens to females; widely spaced eyes, abnormally curved pinky fingers, flat feet and abnormally shaped breastbone. They also have kidney abnormalities, and ovarian abnormalities.
Monosomy X	or Turner's Syndrome; females do not mature sexually during puberty.
	- web like neck, fingernails and toenails that are narrow and turned upward, slightly smaller than average height at birth and short fingers and toes.
Chromosomal Alterations	
Duplication	fragment joins the homologous chromosome, then that region is repeated.
Deletion	part of the chromosome is lost during the cell division and the result is mostly lethal.
	Cri du chat - small part of chromosome 5 is missing.
Translocation	small part of the chromosome is moved to another chromosome.
	Reciprocal Translocation - there is an exchange with the parts of chromosome.

Significance of Meiosis (cont)

Inversion	section of DNA breaks away from a chromosome and then reattaches to the chromosome in reversed order.
Substi-tution	one nucleotide is replaced by a different nucleotide.

Chromosomal Abnormalities



Module 9 - Membrane Transport: Passive Transport

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help