Learning Summary Check 1

Semi Permeable vs. Selectively Permeable

- Selectively Permeable Membrane Definition: Membranes (plasma membrane) lets selective molecules in and out of the cell freely, lets other molecules in and out only under certain circumstances, and completely stops other molecules from passing through the membrane (http://www.macmillanhighered.com).
  - Because the interior of the lipid bilayer is hydrophobic, it prevents polar molecules from moving across the membrane
  - Allows solutes and solvents to pass through (limited)

- Semipermeable Membrane
  - Only allows certain molecules to pass through
  - Can be in the form of osmosis where water molecules are passed through a membrane from high concentration to low concentration
  - Solutes cannot pass through it
  - Only permits one solvent to enter the membrane

Image from:
This image shows a depiction of osmosis with a semipermeable membrane. This membrane allows only water molecules to pass through from an area of high concentration to low concentration.
This image shows a selectively permeable membrane where the specific molecules are allowed through the membrane channel.

**Active Transport**

- Molecules need help crossing the gradient, so energy (ATP) is used to pass these across the membrane (http://www.macmillanhighered.com)
  - Cells move substances through proteins that are in the membrane (http://www.macmillanhighered.com)
  - ADP is changed to ATP during active transport

This image shows the act of active transport and shows the use of ATP to move molecules across the membrane from an area of low concentration to high concentration.
Properties of Water

Water is the medium of all life on Earth. It influences the inside and outside of the cell. Water is a molecule made up of two hydrogen atoms covalently bonded with a single oxygen atom. This means that this molecule has multiple sites where it has positive and negative charges. Not only did life originate in water, it is also considered a universal solvent due to its capability to dissolve various substances.

**Water Molecule**

![Water Molecule](image)

(Found from eSmartKids)

The hydrogen atoms have a partial positive charge and the oxygen atom has a partial negative charge. This distinction not only recognizes water as a polar molecule, but allows the water molecule to orient itself to the positive and negative charges in another molecule. Due to the interaction between hydrogen (partially positive) and oxygen (highly electronegative), water is considered a hydrogen bond. This hydrogen bond allows water to form a crystalline structure when frozen, and therefore becomes less dense than liquid water.

![Crystalline structure of frozen water](image)

(Crystalline structure of frozen water a.k.a, ice)

Because ice is less dense than liquid water, ice floats. The density also explains why lakes don't freeze 100% through, and why fish can still survive under thick sheets of ice. Hydrogen bonding in water also grants the ability of cohesion. This means that the surface of water is difficult to break and that the bond from water molecule to water molecule is strong due to surface tension. Not only do hydrogen bonds contribute to crystalline structures, density, and cohesion, it also allows water to withstand great temperatures.
What is a Macromolecule?

A Macromolecule is considered polymers. Polymers are long chain of multiple subunits called monomers. Polymers are formed by a process called Dehydration Synthesis. This is where monomers join through a covalent bond therefore, make a long chain. Macromolecules are the building blocks to sustain your body and allow it to proceed with its everyday functions. The four common types of macromolecules, are proteins, lipids, carbohydrates, and nucleic acids.

Proteins begin with the formation of a polymer (polypeptide) of amino acids. Proteins are made up of many polypeptides and is critical for structure, regulation and function of our bodies. They can be made to be antigens (which fight against viral and bacterial invasions), enzymes (aid in digestion and speed up chemical reactions), and transport molecules throughout the cell.

Carbohydrates are molecules that are made up of carbon, oxygen, and hydrogen. Carbohydrates are made up of monosaccharides (simple sugars) and disaccharides (complex sugars). The major difference is size. Simple sugars are used as a quick energy source while complex sugars are used to store and build up structures in the cell.

Lipids are fats and are made up of glycerol and fatty acids. They are essential to giving energy, acting as a cushion for our organs, keeping our bodies warm, and secreting vital hormones needed. Fats are hydrophobic due to the nonpolar bond in the fatty acid.
Nucleic Acids specifically store and transmit genetic information. There are two form of nucleic acids, DNA and RNA. They are stored in the nucleus of every cell in our bodies. They are crucial to replication, transcription, and translation.

Three Domains of Life

The three domains of life are considered as the basic tree of life. This includes Archaeans, Bacteria, and Eukarya.

Archaeans do not look much different from bacteria, but they have one defining feature. They are able to withstand harsh temperatures such as the hot springs at the Yellowstone Park. Archaeans are considered prokaryotes and are acid-loving microorganisms. They do lack a nucleus and are single-celled organisms.

Bacteria are also single-celled organisms and lack a nucleus. They can be disease causing or antibiotic bacteria. The good antibiotic bacteria can be found in your bodies and through foods like yogurt. They also help to break down dead organic matter. They are very important to our bodies health and the fact that they are an abundant source makes them ideal for survival.
Eukarya are the most varied branch of the tree of life. They include fungi, protists, plants, and animals. Even though these microorganisms are different, they share many of the same characteristics of biology. All Eukarya are able to go through mitosis.
Learning Summary #2

Mitochondria

Image from: https://magnesiumandhealth.com/the-function-of-mitochondria/

The image shows the different parts inside of a single mitochondria:

- The mitochondria is an organelle present in animal cells. Different parts of the body or organs can have thousands of mitochondria.
- They have multiple parts within the mitochondria, including the outer membrane which is the outside, the inner membrane (matrix) which is the compartment inside of the mitochondria, ribosomes which help with protein production, intermembrane space which holds protons, cristae which are the ridges of the matrix, granules which are small compact particles within the matrix, and DNA (https://magnesiumandhealth.com/the-function-of-mitochondria/).
- The mitochondria can be seen as the powerhouse or energy source of the cell because it produces large amounts of ATP (https://magnesiumandhealth.com/the-function-of-mitochondria/).
- The mitochondria takes glucose and changes it to a form of energy that can be used throughout the cell.
- Without the mitochondria, energy would not be produced for the powering of different parts of the cell and body.
- The mitochondria is also responsible for the electron transport chain which produces a large amount of ATP.
- This is also where the citric acid cycle occurs,
Chloroplast

![Chloroplast Diagram](https://micro.magnet.fsu.edu/cells/chloroplasts/chloroplasts.html)

This image shows the basic inner structure of a chloroplast

- Chloroplasts are present within plant cells that are eukaryotic
  - Eukaryotic cells need chloroplasts, the outer membrane is for eukaryotic cells while inner membrane is for bacteria cells
- Chloroplasts are a part of photosynthesis which takes sunlight and turns it into a form of energy for the cell
- The chloroplast is similar to the mitochondria in ways, it has an inner membrane space, it also has a stroma which is similar to the cytoplasm which contains ribosomes, DNA, and also RNA, it also has an inner and outer membrane, the inner membrane contains the more important components inside, there is also an important part called the thylakoid which is similar to a mitochondria because it helps create ATP but has three membranes, there is also a granum which is a stack of these thylakoids, there are also stroma lamellae which is a membrane fold within the chloroplast ([https://micro.magnet.fsu.edu/cells/chloroplasts/chloroplasts.html](https://micro.magnet.fsu.edu/cells/chloroplasts/chloroplasts.html))
- The chloroplasts receives sunlight and uses it to create ATP or energy for the cell, it has multiple reactions within (light dependent and the calvin cycle)
- The sunlight excites electrons within the chloroplasts which helps start th cycles and production of ATP ([https://micro.magnet.fsu.edu/cells/chloroplasts/chloroplasts.html](https://micro.magnet.fsu.edu/cells/chloroplasts/chloroplasts.html))
- The space within the chloroplast is not folded so that it can capture the light from the sun, when it is folded it does not capture light
Cytoskeleton

Image from: https://staceywantschipotle2.weebly.com/cytoskeleton.html
This image shows the compartments and some functions of the cytoskeleton and the placement of the cytoskeleton throughout the cell

- All cells have a cytoskeleton
  - The eukaryotic cell cytoskeleton is more prominent than prokaryotes
    (https://biologydictionary.net/cytoskeleton/)
- The eukaryotic cytoskeleton is made up of three filaments: microfilaments, intermediate filaments, and microtubules
- Microfilaments or actin are the thinnest filaments and help with movement of cells, they are mostly prominent in muscle cells (https://biologydictionary.net/cytoskeleton/)
- Intermediate filaments are mostly found in the nucleus where is surrounds the nucleus, it helps with cell shape and also help provide structural support to the cell (https://biologydictionary.net/cytoskeleton/)
- Microtubules are the largest of the cytoskeleton and help move the cell forward. They also help transport molecules throughout the cell and helps with the formation of the cell wall that helps protect the cell and let things in and out of the cell through a permeable membrane (https://biologydictionary.net/cytoskeleton/)
- The main function of the cytoskeleton is to give and maintain the cells shape, gives the cell movement and helps keep the organelles in their place, and helps move organelles and molecules throughout the cell, it also provides extra support for the cell (https://biologydictionary.net/cytoskeleton/)
ATP

An ATP Molecule

This image shows the structure of an ATP molecule

- ATP is a molecule that provides energy throughout the cell.
  - ATP is the universal form of energy that is readable throughout the cell (https://biologydictionary.net/atp/).
- This is the end product of processes throughout the cell such as glycolysis, the citric acid cycle, fermentation, the electron transport chain, and more
- ATP is made of adenine molecule, ribose sugar, and three phosphate groups (https://biologydictionary.net/atp/)
- ATP can also be used as a form of cell signaling
  - Kinases (an enzyme) uses ATP as a source of phosphate groups
  - This is how physical and chemical signals are sent from inside and outside of the cell
- ATP is made from cellular respiration which is a series of steps and cycles that lead up to ATP synthase
  - For an animal cell, ATP is made from glycolysis which taking glucose and making ATP and pyruvate, the citric acid cycle also makes ATP along with NADH and FADH which are then used in the electron transport chain where ATP synthase occurs. ATP synthase at the end of the electron transport chain is where the bulk of ATP is created to power the cell.
- ATP is also used for DNA synthesis
  - The adenine molecule is directly put into RNA (https://biologydictionary.net/atp/)
  - ATP is also converted into dATP before becoming apart of DNA (https://biologydictionary.net/atp/)
Electron Carriers

This image shows two common electron carriers that are used throughout the cell for ATP synthase.

- Electron Carrier molecules are important in cellular respiration.
  - The specific electron carrier molecules that are used are NAD+ and FAD.
  - These are reduced which means electrons are added so they become NADH and FADH.

- Electron carriers are responsible for electrons that are lost throughout each step of cellular respiration from the oxidation process.

- The electron carriers are created from the citric acid cycle where they are reduced.

- The electron carriers are used and prominent throughout the electron transport chain where they are used for ATP synthase.

- NADH is an electron carrier that is higher energy.
  - This means that it will be responsible for creating high amounts of ATP in the electron transport chain.

- FADH is an electron carrier that is lower energy.
  - This means that it will be responsible for creating significantly lower amounts of ATP in the electron transport chain.

- Electron carriers are constantly oxidized and reduced throughout cellular respiration in order to obtain high energy protons.
Electron Transport Chain

The electron transport chain is the main source of ATP synthase where large amounts of ATP are made for the cell.

- This is the final part of cellular respiration where electron carriers are used for the production of ATP.
  - The electron transport chain takes place within the mitochondria and has four different complexes where oxidation occurs and releases energy.
    - The first complex is the oxidation of NADH, the high energy protons are pumped in the intermembrane space.
    - The second complex is the oxidation of FADH, where the high energy protons are also pumped into the intermembrane space.
    - The third complex pumps protons across the membrane and passes electrons to cytochrome c for the fourth complex.
    - The fourth complex is where oxygen atoms picks up hydrogen atoms to make water.
- The protons within the intermembrane space create an electrochemical gradient that is extremely high energy.
- The high energy protons contained in the intermembrane space is used to power the ATP synthase to turn ADP into ATP energy.
Fermentation

![Image showing two types of fermentation: alcohol and lactic acid fermentation](https://www.quora.com/Why-do-cells-need-fermentation-to-continue-glycolysis)

This image shows the two different types of fermentation, lactic acid fermentation for animal cells and alcohol fermentation for non-animal cells.

- Fermentation is when glucose is converted to energy in the absence of oxygen (https://www.britannica.com/science/fermentation)
  - The absence of oxygen makes the process of fermentation anaerobic
- There are two types of fermentation, lactic acid and alcohol fermentation (https://www.ck12.org/biology/lactic-acid-fermentation/lesson/Lactic-Acid-Fermentation-Advanced-BIO-ADV/)
  - Lactic acid fermentation is apparent in animal cells, and also muscle cells.
    - This occurs when there is no oxygen to complete the full cycle of cellular respiration, so NAD+ is reduced to NADH where ATP is formed from the 2 pyruvate from glycolysis (https://www.ck12.org/biology/lactic-acid-fermentation/lesson/Lactic-Acid-Fermentation-Advanced-BIO-ADV/)
  - Alcohol or ethanol fermentation is similar to lactic acid fermentation because it also produces ATP in low oxygen conditions
    - This processes the two pyruvate from glycolysis where is it broken down and reduced to ethanol and carbon dioxide (https://www.ck12.org/biology/alcoholic-fermentation/lesson/Alcoholic-Fermentation-Advanced-BIO-ADV/)
- Fermentation can also be done with yeast
  - All forms of fermentation still produce levels of ATP under low oxygen levels and also use pyruvate molecules and reduce NAD+
Calvin Cycle

Image from: https://biologywise.com/chloroplast-structure-function
This image shows a chloroplast within plant cells, within the chloroplast it shows the calvin cycle along with light dependent reactions and the components and molecules involved in the reactions

- The calvin cycle is involved in the process of photosynthesis where ATP is used to give off oxygen and glucose molecules
- Carbon dioxide enters the chloroplast into the stroma where the calvin cycle takes place (https://courses.lumenlearning.com/biology1/chapter/the-calvin-cycle/)
- The enzyme RuBisCO and ribulose biphosphate initiate the calvin cycle
- RuBisCO causes a reaction between carbon dioxide and ribulose biphosphate
  - This forms a six carbon compound that is broken up into three carbon compounds (carbon fixation)
- ATP and NADPH which are high energy molecules use their energy to convert the three carbon compound into another three carbon compound called GP3
  - NADP+ and ADP are both reduced (electrons gained) in order for this reaction to occur
- The GP3 molecule leaves the calvin cycle to create a glucose molecule
Redox Reactions

Redox reactions in biology can also be referred to as oxidation-reduction reactions where electrons are either gained or lost in a particular reaction.

Redox reactions play a central role in metabolism. A lot of redox reactions in biology occur in cellular respiration.

- These occur during glycolysis, citric acid cycle, the electron transport chain, the Calvin cycle and light-dependent reactions.
- When redox reactions occur, molecules such as ADP, NAD+, FAD, NADP, pyruvate, and ATP are either reduced or oxidized within cellular respiration.

When a reaction or molecule is reduced, this means that electrons are gained.
- For example, when NAD+ is reduced, a proton is gained which makes the molecule NADH.

When a reaction or molecule is oxidized, it means electrons are lost.
- For example, when FADH is oxidized, electrons are lost and the proton is taken away and turns the FADH into FAD at a lower energy state.

Redox reactions are required in biology for certain reactions and cycles to take place.
- For example, in order for the electron transport chain to occur and ATP to be synthesized, NAD+ and FAD have to be reduced and a proton must be added so that it can be in a form and have energy needed for the chain.

In redox reactions, energy is released through the gain or loss of electrons.
Enzyme Inhibitors

Image from: https://iweb.langara.bc.ca/biology/mario/Biol2415notes/biol2415chap6.html
This image shows the different types of enzyme inhibitors in relation to the enzyme and the active sites

- Enzyme inhibitors lower the rate of reactions that are catalyzed by enzymes by interfering with the enzyme (https://alevelnotes.com/Enzyme-Inhibitors/148)
- There are three types of enzyme inhibitors
  - Competitive enzyme inhibitors
    - Prevent the formation of enzyme-substrate complexes, they have similar shape to the substrate molecule
    - They fit into the active site but remain unreacted which means less substrate molecules can bind to it so the reaction rate is decreased
    - These are typically temporary inhibitors and eventually leave the enzyme, substrate and inhibitor are competing for the active site (https://alevelnotes.com/Enzyme-Inhibitors/148)
  - Non-Competitive Inhibitors
    - Prevent the formation of enzyme-product complexes (prevent substrate from reacting to form product)
    - They bind to a site other than the active site (allosteric site) which distorts the enzyme shape so nothing can bind to it
    - These are permanent and irreversible (https://alevelnotes.com/Enzyme-Inhibitors/148)
  - Enzyme inhibitors can be needed if there are too many reactions taking place by enzymes, they are used to slow down or completely stop reactions when needed, however this can also cause medical problems if used at a high rate
Transcription

This image shows the process of mRNA making a copy of one of the DNA strands.

- Transcription is the act of copying data from one form into a different form. It is the first step in gene expression.
- A section of DNA unwinds for transcription to take place. As you can see in the image above, the base pairs in DNA are C-G and A-T, but in the messenger RNA (mRNA) the base pairs are C-G and A-U.
- During transcription, existing proteins copy one strand of DNA to form a similar molecule called RNA.
- DNA acts as a model to create RNA.
- Transcription means that both DNA and RNA communicate in the same way (through nucleic acids).
- Transcription is regulated so it does not take place consistently throughout the cell.
- In prokaryotes, transcription takes place in the cytoplasm.
- In eukaryotes, transcription takes place in the nucleus.
- Transcription in eukaryotes is separate from translation due to the addition of a 5’ cap and Poly A tail.

Information found through “How Life Works” by James Morris
Translation

This is an image of the translation process.

- Translation is the process of reading and interpreting the RNA molecule.
- It is the second step in gene expression.
- After the RNA molecule is created, specified molecular structures analyze it and determine what type of protein needs to be created.
- Translates the language of nucleotides to make nucleic acids to the language of amino acids to make proteins.
- The specific RNA being read is messenger RNA (mRNA)
- Translation is regulated so it does not happen continuously in a cell.
- In Prokaryotes and Eukaryotes, translation takes place in the cytoplasm.
- Ribosomes with proteins bind to the mRNA molecule to translate.
- The site of translation is composed of three steps
  - Aminoacyl Site: incoming tRNA with amino acid joins the ribosome
  - Peptidyl Site: tRNA is matched with codon and elongation begins
  - Exit Site: tRNA is excreted

Information found through “How Life Works” by James Morris
Types of RNA

- RNA stands for ribonucleic acid
- There are 3 types of RNA

Found on Khan Academy

- Messenger RNA (mRNA): mRNA is a template of DNA that will be used for protein synthesis. It carries coded information from DNA to the cytoplasm. Usually has a 5’ cap and Poly A tail and joins with ribosomes.

[Diagram of mRNA and amino acids]

Found on Khan Academy

- Transfer RNA (tRNA): tRNA is also known as sRNA (supernatant RNA). It serves as a link between mRNA and the amino acid. It also aids in decoding mRNA.

[Diagram of tRNA and amino acids]

found on [www.biologydictionary.net](http://www.biologydictionary.net)

- Ribosomal RNA (rRNA): rRNA works with proteins to create ribosomes. It also has no relation/similarities with tRNA and mRNA and is relatively small compared to them.
Function of Membrane Proteins

- Membrane proteins have various functions, are very integral to a cell survival, and is found in phospholipid bilayers
- Membrane proteins are polar and nonpolar sides that allow it to move through the phospholipid bilayer with ease.
- Functions:
  - Intercellular Joinings: has the ability to join/be a bridge between two cells to share information and resources.
  - Enzyme Activity: The enzymes go through metabolic activities when bonding to a substrate and aiding a particular process needed in the cell such as transforming maltose into lactose.
  - Transport: Aids in facilitated diffusion and active transport of polar and nonpolar molecules.
  - Recognition: Can distinguish molecules need and allowed to cross the membrane and foreign molecules not allowed to cross the membrane.
  - Attachment: Has attachment points to help support the structure of the cytoskeleton and extracellular matrix.
  - Signalling: It also functions as site the recognize hormone signals. This helps the cell know what needs to be turned “off” or “on”.

Phospholipid Bilayers

Found on https://www.bioexplorer.net/phospholipid-bilayer.html/

This image shows the components of the phospholipid bilayer.

- Phospholipid Bilayer is found in cell membranes and are made of lipids.
- It has a polar head and 2 nonpolar tails which makes the bilayer amphipathic.
- When placed in water a bilayer forms.
- The components of the phospholipid bilayer include proteins, cholesterol, glycoproteins (form strong hydrogen bonds), and antigens.
- It is also considered fluid mosaic because of the ability for proteins and carbohydrates to pass easily through it.
- The phospholipid bilayer maintains the shape of the cell, acts as a semipermeable membrane, controls communications from the outside environment to the inside environment, and maintain homeostasis inside the cell.
- The pH of water is critical to the formation of the bilayer because it guarantees that the phospholipid forms spherical bilayer structures.
- The polar ends face the water while the tails face each other on the inside.
- In bilayers the head is less bulky so the tails are able to bunch together.
- Small tears in the membrane are repaired rapidly by spontaneous rearrangement of lipids.

Information found through “How Life Works” by James Morris and https://www.bioexplorer.net/phospholipid-bilayer.html/.
Endomembrane System

It is a series of structures that work together to package and transport needed proteins and various molecules.

- **Rough ER**: It has bumpy ribosomes attached to it. Proteins are sent to the ER to undergo folding and other modifications. They are then packaged in vesicles and sent to the Golgi Body. It also makes phospholipids that are transported in vesicles to need structures.

- **Smooth ER**: It makes carbohydrates, lipids, and hormones. It also aids in detoxifying the body from medications and poisons taken. Smooth ER is used as a storage container for calcium ions.

- **Golgi Body**: The modified proteins are received from the vesicles and go through sorting, tagging, and packaging before being sent to other organelles.

- **Lysosomes**: They contain digestive enzymes that get rid of waste and unwanted products in the cell.

Information found from [https://www.khanacademy.org/science/biology/structure-of-a-cell/tour-of-organelles/a/the-endomembrane-system](https://www.khanacademy.org/science/biology/structure-of-a-cell/tour-of-organelles/a/the-endomembrane-system)
Enzymes

Found on [www.science.howstuffworks.com](http://www.science.howstuffworks.com)

This image shows how an enzyme takes sugars and aids in transforming it into something else.

- Enzymes have many functions such as aiding proteins as catalysts.
- They do not go through permanent changes, they just bend or twist when coming into contact with proteins.
- Enzymes consist of a protein and a nonprotein.
- Enzymes collide with another molecule to create energy called activation energy.
- They contain active sites for a specified substrate to collide with it.
- Temperature and pH affect the strength of enzymes.

Information was found from [http://www.rsc.org/Education/Teachers/Resources/cfb/enzymes.htm](http://www.rsc.org/Education/Teachers/Resources/cfb/enzymes.htm)

Evolution

Found on [www.science.howstuffworks.com](http://www.science.howstuffworks.com)

- Evolution is a proven theory discovered Darwin.
- It is believed that all life on Earth is connected.
- Evolution is where a species unfavored trait either dies off or the unfavored species somehow goes through a mutation and revives the more favored trait to survive.
Natural Selection

- Is a proven theory from Darwin
- It is a part of evolution.
- The steps include:
  - Variation: A variation could include color for camouflage, height to be able to reach things, a sharpened beak to hunt for food. It is a different trait in the same species.
  - Reproduction: The more favored trait will survive and reproduce more quickly than the less favored trait.
  - Heredity: As the less favored trait dies off, the more favored trait will pass its genes along as it reproduces. Its offspring will inherit the favored genes.
  - Result: The more favored trait becomes the sole survivor and is now seen as the common trait. The less favored trait is forgotten.

Information found on [https://evolution.berkeley.edu/evolibrary/article/evo_25](https://evolution.berkeley.edu/evolibrary/article/evo_25)
Phospholipids

Found on www.wiki.com

This is an image of the structure of a phospholipid.

- A lipid is a component of fat.
- It is composed of a phosphate group, a glycerol group, and one or two fatty acids
- It is also hydrophobic and hydrophilic
- The outermost layer of animal cells are composed of hundreds or thousand phospholipids
- It helps maintain inner structure of the cell and allows simple diffusion of small molecules

Information found on https://sciencing.com/primary-functions-phospholipids-7349125.html
Learning Summary Check #3

DNA Mutation

Image from: https://dnasu.com/what-is-a-dna-mutation/

- Mutations occur randomly but very often
  - They can be caused by external or native factors (exogenous or endogenous factors) [https://dnasu.com/what-is-a-dna-mutation/](https://dnasu.com/what-is-a-dna-mutation/)
- Mutation is a permanent change in the sequence of DNA
- Mutations can disrupt normal gene activity [https://www.yourgenome.org/facts/what-is-a-mutation](https://www.yourgenome.org/facts/what-is-a-mutation)
- There are different types of mutations that affect specific nucleotides
  - Nonsense Mutation: occur when the DNA change creates a premature STOP codon which truncates the polypeptide
  - Frameshift Mutation: occur when the addition or removal of a base alters the reading frame of the gene
Variation in DNA

Variations in DNA makes everyone different from each other.
There can be changes added (insertions) or deleted (deletion) from our DNA.
The most common variation occurs when one genetic “letter” (A, T, C, or G) is replaced by any of the other three letters, this is known as a SNP.

These SNPs cause different proteins to be synthesized.
SNPs make cause different variations with traits.
SNPs can also cause some diseases depending on the how the change affects the new strand of DNA.

PCR (Polymerase Chain Reaction)

Polymerase Chain Reaction (PCR)

STAGES

Denaturation → Annealing → Elongation

This is used to focus on a specific part of DNA and copy it many times
(http://learn.genetics.utah.edu/content/labs/pcr/)

Primers (short pieces of DNA) are used to match the segment of DNA you want to take a copy of

- One primer matches to the top of the strand while the other primer attaches to the bottom (of the desired DNA fragment)
- Primers are also important for DNA polymerase (http://learn.genetics.utah.edu/content/labs/pcr/)
  - DNA polymerase is the process of DNA copying itself before the cell divides

PCR is known as DNA photocopying

Many scientists and labs use this method because it is a great way of diagnosing different diseases

Image from:
Phylogeny has to do with
Control of the Cell Cycle

- The cell cycle control system is the control center behind DNA replication, mitosis, meiosis, cytokinesis, and other processes.
- The control system is based on a clock.
- The control system is also responsive to the processes that it is controlling.

Image from: https://courses.lumenlearning.com/biology1/chapter/control-of-the-cell-cycle/
Gel Electrophoresis

- Gel Electrophoresis is used to determine the size of DNA fragments after using the Polymerase Chain Reaction (PCR).

- Samples of the DNA fragments are incorporated into the wells near the edge of a porous agar gel with a micropipette.

- The gel contains polymers whose purpose is to block/make it difficult for large DNA molecules to pass and continue downward.

- Large DNA molecules = longer bands

- Small DNA molecules = shorter bands

- The gel is placed into a machine and submerged in a solution that allows electrical currents to pass through it.

- The samples of DNA are negatively charged and at the side where the wells house the sample is negatively charged. This charge repels the sample and current away from each other. The repelling effect pushes the particles downwards toward the positive side of the current.

Information was found using Chapter 12: DNA Replication and Manipulation from “How Life Works” by James Morris second edition.
The cell cycle consists of Interphase, G1, S, G2, and M phases.

Interphase
- is known as the inactive term of the cell and the duration of which the cell prepares to divide.

G1 phase
- is where the cells’ bio mass increases. New proteins and organelles are made which in turn cause the cell to grow in size.
- It consists of normal cell activity.

S phase
- synthesis and DNA replication takes place in the nucleus.
- Helicase, Topoisomerase, a binding protein, DNA polymerase 3 and 1, and a ligase are made.

M phase
- Mitotic phase and is where the formation of two daughter cells takes place. (will be further talked about when you scroll to Mitosis)

Information was found on Chapter 11: Cell Division from “How Life Works” by James Morris second edition.
Mitosis

Eukaryotic cells divide every 24 hours. Mitosis contains six phases.

1. **Prophase**
   - This is the preparatory stage where the cell is basically “clearing” the space in the cell.
   - The endomembrane system and nuclear envelope dissolves, centrioles begin to move to opposite sides, and mitochondria is flattened towards the edges of the cell.

2. **Pro-Metaphase**
   - This is where the cell builds a movement mechanism.
   - The centrioles are finally at polar ends, chromosomes have came to the middle, microtubules stretch along centriole to the kinetochore, and the aster acts as an anchor to the centrioles

3. **Metaphase**
   - The alignment of chromosomes take place. Each chromatid of each chromosome are facing their separate poles so the came be separated by the movement mechanism built in Pro-Metaphase.

4. **Anaphase**
   - Separation of chromatids take place. The molecular motor that moves up and down along the kinetochore takes apart the chromosomes.

5. **Telophase**
   - This is when the cells reverts back to normal. The cell will reform the nucleus and each distinct organelle that is apart of the cell.

6. **Cytokinesis**
   - Actin wraps and pulls the opposite sides of the cell membrane together so that the phospholipid bilayer “pops” and rearrange themselves to make two new daughter cells.
Cytokinesis

- Cytokinesis is the process of separating the mother cell into two daughter cells. A ring of actin filaments wraps around continuously and forms a contractile ring.
- The contractile ring is propelled by motor proteins. This ring tightens perpendicular to the spindles and acts like a drawstring that pull together the cell membrane and slices through the cytoplasm until the membrane “pops”.
- The phospholipid bilayer then rearranges itself to form two daughter cells.

Information was found on Chapter 11: Cell Division from James Morris second edition.
Meiosis

Image for on: https://biologydictionary.net/meiosis/

1. **Prophase 1**
   - Chromosomes move to middle of cell and pair with their homologous partner, nuclear envelope dissolves, and microtubules attach to kinetochores.

2. **Metaphase 1**
   - Homologous pairs of chromosomes line up and are pulled apart to contain two different alleles. They may crossover as well.

3. **Anaphase 1**
   - The separated chromosomes are pulled towards the centrioles.

4. **Telophase 1**
   - Chromosomes are pulled completely apart and cytokinesis occurs to separate the cell into two different daughter cells.

During Prophase 2, Metaphase 2, Anaphase 2, and Telophase 2, mitosis occurs and therefore creates two more different daughter cells. All together four unique daughter cells are created.

Information was found on https://biologydictionary.net/meiosis/
What is biology - the study of life’s organisms.

Taxonomy - classification of subjects practiced in science. How animals are classified.

What is science - a branch created to better learn about the structure, behavior, and nature of the organisms through testing and research.

Survey of chemical bonds - sharing or exchanging of electrons
- Covalent bond - attraction of electron pairs between atoms.

- Ionic bond - attraction of ion with opposite charges
Proteins—made up of long chains of amino acids
- Structural proteins—shape and support for cell
- Enzymes—causes things to react in cell
- Receptors—binds and transmits signals
- Non-categorized Functional—specific functions depending on location.

Taxonomy https://www.britannica.com/science/taxonomy
What is science- https://undsci.berkeley.edu/article/whatisscience_01
Survey of chemical bonds https://en.wikipedia.org/wiki/Covalent_bond; http://hyperphysics.phy-astr.gsu.edu/hbase/molecule/hmol.html#c1;
Proteins https://www.pinterest.co.uk/pin/413416440786325755/; https://c689cb19-a-62cb3a1a-s-sites.googlesites.com/site/passnceanalogy/biology-level-2/gene-expression/proteinType.gif?attachauth=ANoY7colH-GLPPNpT0AX-jnyRGWdgDyJ1USGSVE2HRPAgWrVq9nSj2zwfPOZsDSoxgN-LpN58Xh6QnFWXCJBAWIOz9h3khrZ1ZFvi78_R2uwz9f_tRINHeb2kP2YS2v2omMTitq9BgkhkvkmbdOW03q7G0IZNfUKA7KYw97Di3nam1fl9kT0Q9ZOxpscIVM1x9UjwKVDKf0hTczphBFJaX5vHU3wjaB0chLLEZFrxeQnaF7cBkyXT_z_F7bq6z9zhSVSQUYUPQ_J44Se_noPYZSfu0Cv5lqKw%3D%3D&attredirects=0

Housthon Parks
Final Summary

Carbohydrates—main use is energy storage.
- Also used as modifiers of protein
- Used in forming cellular receptors and anchors
- Carbons are important
- Carbon 1, 5 and 6 for positions on various parts of carbohydrates
- Carbon 1 is especially unique because it influences how sugar is metabolized

\[6 \text{ CO}_2 + 6 \text{ H}_2\text{O} + \text{energy (from sunlight)} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6 \text{ O}_2\]
Nucleic Acids- like DNA and RNA

- Makeup genetic information
- Made up of carbon, hydrogen, phosphorous, nitrogen and hydrogen, nucleotides
- Nucleotides are monomers
Central Dogma—Passing of information.
- 3 core genetic processes.
- DNA carries information. How to build RNA and proteins.
- RNA carrying information from DNA.
- Proteins—reading the genetic information stored in DNA.
- Transcription and Translation—Transcriptions is the first step in gene expression. DNA to RNA. Translation makes proteins. Decodes genetic message and start polypeptide chain.

https://courses.lumenlearning.com/boundless-biology/chapter/the-genetic-code/

Membrane as a dynamic structure
- Constantly changing depending on environment
- Its semi-permeable state allows for regulation of things entering and leaving the cell.
  Through active and passive transport.
- Depending on what need to pass through the membrane there are many ways for that to happen: 1. Osmosis 2. Diffusion 3. Protein channels 4. Endocytosis 5. Exocytosis
- The structure is almost a perfect process for any and every process possible to happening.
- There are both hydrophobic and hydrophilic phospholipids
- Extracellular and intracellular surfaces

https://www.britannica.com/science/membrane-biology#ref201795
Passive transport through the membrane—movement across the cell without energy input
- Diffusion is a type of passive transport.
- Diffusion - is the movement of molecules from high concentration to an area of low concentration
- Facilitated diffusion - Tunnels in the membrane are formed to help molecules move down the concentration gradient without dealing with hydrophobic heads and hydrophilic tails.
- Channel proteins make facilitated diffusion possible

Biology 2107L Lab book
http://pediaa.com/difference-between-channel-and-carrier-proteins/
Bulk transport-how large molecules or large groups of molecules get across the concentration gradient.

- Each molecule gets enclosed in capsule allowing it to attach to other molecules to move down the gradient together
- There are three diverse types of bulk transport
  - Phagocytosis-large particle passes through the cell and form a food capsule to consume nutrients
  - Pinocytosis-captures extracellular fluid for nutrients and protection passes through the membrane
  - Receptor mediated endocytosis- protein receptors capture a certain type target molecule


Electrochemical gradients- electrical charge causes a channel where ions can move across the membrane. The gradient effects the ion channel based on where the gradient has a membrane potential or not. A concentration gradient with no membrane potential has a mix of both positive and negative ions. A gradient with membrane potential has either all negative or positive ions. Meaning that ion will not have to compete with one another.
Difference between prokaryotes/eukaryote cell

Prokaryotes-
· No membrane
· Cell wall made by peptidoglycan
· No membrane bound organelles
· Binary fission
Protein trafficking-How cells transport proteins

- Transport to Rough ER
- Proteins are then transported through the membrane to the Golgi apparatus
- Golgi apparatus then modify proteins for adding anything needed for transport to a specific area
- Proteins leave Golgi apparatus and are repackaged and sent to cell membrane

https://www.slideshare.net/sheryl912/protein-trafficking-in-lysosomes

Cell signaling-communication using chemical signals. Ligand-signaling molecule.

Receptor-receives molecules.

- Paracrine signaling-cell to cell communication
(b) In **paracrine signaling**, secreted molecules diffuse locally and trigger a response in neighboring cells.

- Autocrine signaling—cells produce signals that they themselves respond to

(c) In **autocrine signaling**, secreted molecules diffuse locally and trigger a response in the cells that secrete them.

- Endocrine signaling—cells release hormones that react to target cells

(a) In **endocrine signaling**, secreted molecules diffuse into the bloodstream and trigger responses in target cells anywhere in the body.

- Direct contact—a cell targets a cell with a gap junction
Endosymbiotic theory- Discovery of cells. Evolution from prokaryotic cells.
- Prokaryotes -> bacteria
- Bacteria -> Mitochondria
- Mitochondria->Cyanobacteria
- Mitochondria -> Animal cell
- Cyanobacteria -> Plant cell

Cellular energetics-Role of ATP in energy production.
- Glycolysis- breaks down glucose, forms pyruvate through ATP however it is not actually this simple. Looking at the chart below that are important steps necessary to complete this breakdown.
- Aerobic oxidation-oxidation of CO2 and atp.
- Photosynthesis-light energy into chemical energy.

https://www.khanacademy.org/science/biology/cell-signaling
https://communismalex.wordpress.com/2014/03/06/a-detailed-look-at-endocrine-and-hormone-signaling/

https://www.myinterestingfacts.com/photosynthesis-facts/
Central metabolism- Helps maintain life through chemical reactions like catabolism and anabolism. The cells as we know have a constant flow of molecules. In order for this to take place molecules need energy to be available. Sometimes that energy is stored (anabolism) and other times it needs to broken down (catabolism) for use.

Organelles in an animal cell-

- Cell membrane-
- Plastids
  1. Leucoplasts
  2. Chromoplast
- Central vacuole

http://www.edu.pe.ca/gray/class_pages/rcfleming/cells/notes.htm
Oxidative Phosphorylation

- Oxygen is needed so cells can use this during oxidative phosphorylation which is the last component of cellular respiration.
- Oxidative phosphorylation is used within the electron transport chain and chemiosmosis.
  - In the electron transport chain, electrons are passed from one molecule to the next and energy is released in this exchange of electrons which is used to create an electrochemical gradient (https://www.khanacademy.org/science/biology/cellular-respiration-and-fermentation/oxidative-phosphorylation/a/oxidative-phosphorylation-etc).
- In chemiosmosis, energy is stored in the gradient that is used to make ATP

Variations from Mendel

Variations on Mendel

- **Multiple alleles**: when there are more than two alleles that code for a trait

- Example: ABO blood type
  - A type = AA or Ao
  - B type = BB or Bo
  - O type = oo
  - AB type = AB

![Image](http://slideplayer.com/slide/7490278/)

- Basis of inheritance, can be observed in humans and animals
- Can mean changes such as codominance, incomplete dominance, polygenic inheritance
- When both genes are expressed, this is known as codominance
- Incomplete dominance is when one allele does not dominate another allele so a new phenotype is made
- Polygenic inheritance is when the offspring is coded for both alleles

Variations on Mendel’s Laws

- **Incomplete dominance**: F1 has an appearance in between the two parental phenotypes
- **Codominance**: both alleles are fully expressed in heterozygous individuals
- **Pleiotropy**: single gene influences more than one character
- **Polygenic Inheritance**: additive effects of two or more genes on a single phenotype
- **Environmental Factors**: non-genetic, non-hereditary factors that contribute to phenotype
Mendelian Genetics

- Inheritance of a trait depends on the passing on of the units (http://knowgenetics.org/mendelian-genetics/)
- These units to be passed on are known as alleles
  - If the alleles are the same it is the homozygous, if they are different, then it is considered heterozygous (http://knowgenetics.org/mendelian-genetics/)
- Mendel conducted a pea plant experiment to come to these conclusions
  - He did this by breeding different pea plants with each other and realized the next generations showed only one of the traits which means that the pea plant would have had to inherited the traits from both parents and possess alleles from both parent plants (http://knowgenetics.org/mendelian-genetics/)
- The interactions of the alleles and genetics are importance and have different laws that are used for these such as the law of segregation and codominance and other topics (http://knowgenetics.org/mendelian-genetics/)
Speciation

- Speciation is a lineage-splitting event that produces two or more separate species
  - This involves the splitting of evolutionary lineages
    (https://evolution.berkeley.edu/evolibrary/article/evo_42)

Image from: https://evolution.berkeley.edu/evolibrary/article/evo_42
DNA Sequencing

- This means determining the order of the chemical building blocks that make up the DNA molecule (https://www.genome.gov/10001177/dna-sequencing-fact-sheet/)
- This shows the specific genetic information given within the DNA
- DNA sequencing is important because it codes for specific DNA
Hardy-Weinberg Principle

\[(p + q)^2 = p^2 + 2pq + q^2 = 1\]

Where:
- \(p\) = the frequency of allele A
- \(q\) = the frequency of allele a
- \(p^2\) = the frequency of individual AA
- \(q^2\) = the frequency of individual aa
- \(2pq\) = the frequency of individual Aa


- Developed in 1908 by Wilhelm Weinberg
- States that a population will remain the same (genetically) as long as other disruptive forces do not occur
- Shows what an “ideal” population should look like
- Can be altered by mutation, natural selection, random mating, genetic drift, and gene flow.
- The equation represents what type of allelic variations should take place in a population.
- Almost always not reliable because the equation will be ruined if one of the disrupting forces

Information found using [https://www.nature.com/scitable/definition/hardy-weinberg-equilibrium-122](https://www.nature.com/scitable/definition/hardy-weinberg-equilibrium-122)
Mechanisms of Evolution

- Evolution is the process of a population going through small or large allelic variations.
- There are four mechanisms of evolution
- **Natural Selection:** is an environmental change where a portion of a species has acquired a new trait/traits that are essential to survival.
  - Follows the motto “only the fittest survive”
- **Genetic Drift:** is a random fluctuation of a certain allele. For example, the bottleneck effect occurs when a particular species of beetle gets killed by being stepped on. Only a few of the beetles survive and the other species of beetles are left unharmed. Therefore, the unharmed species becomes the more dominant allele.
- **Mutations:** are very random and can either harm or help an organism. For example influenza constantly acquires a mutation each year and that benefits the virus in making it more resistant to the flu shot. This in turn, creates a new species of flu.
- **Gene Flow:** is the transfer of genes from one population to another.
  - Gene flow can help minimize genetic differences
  - Gene flow can involve a horizontal gene transfer (HGT) which helps an organism trade genes asexually

Information found on

http://nectunt.bifi.es/to-learn-more-overview/mechanisms-of-evolutionary-change/
Darwin and Mendel: Cornerstones of Evolution

● MENDEL
  ○ Experimented on plant hybridization
  ○ Developed the law of segregation which describes how pairs of gene variants are separated into reproductive cells
  ○ Developed the standard genotype: RR (homozygous dominant), Rr (heterozygous), and rr (homozygous recessive)
  ○ Developed the law of independent assortment which describes how different genes independently separate from one another when reproductive cells develop.
    ■ The two traits do not influence each other

● DARWIN
  ○ Developed the principle of natural selection
  ○ Stated and believed that as long as organisms keep reproducing, the population will survive
  ○ Individuals with favored traits will survive and ones without favorable traits will die off
  ○ He hypothesized that evolution takes place through phenotypic variations and when reproductive isolation occurs.
  ○ Some of his beliefs were proved wrong by Mendel

Information found using: http://www.scientus.org/Mendel-Darwin.html
https://www.ndsu.edu/pubweb/~mcclean/plsc431/popgen/popgen5.htm
Light Reactions of Photosynthesis

- Light energy is absorbed through the pigments of leaves (chlorophyll) and converted into chemical energy (food) for the plant.
- Steps in light reactions of photosynthesis
  - The Bonds in water are broken in order to make O2, free electrons, and H+ ions which takes place in the Thylakoid membrane.
  - The free electrons move to photosystem II. In here, the light energy absorbed by photosystem II gives the electrons the maximum energy which will still take place in the Thylakoid membrane.
  - The Electrons then move through the electron transport chain which in turn provides energy to move H+ ions from the stroma into the thylakoid space.

Picture found on
○ Photosystem 1 then absorbs the light energy to give to traveling electrons
○ The electrons are then used by NADP+ and combined with hydrogen to make NADPH
○ Finally the hydrogen ions move from the thylakoid space to stroma through ATP synthase which in turn powers the production of ATP and hence makes food for the plant.

DNA replication