Wednesday, January 7, 2015

BIO 201

Lecture 1 - Chemistry

- Definitions
- **Element -** a substance that cannot be broken down into other kinds of substances by ordinary chemical means.
- **Atom -** the smallest unit of an element that retains all of the element's properties
  - Proton Mass = 1.0073 units Charge = +1
  - Neutron Mass = 1.0087 units Charge = 0
  - Electron Mass = 0.0005 units Charge = -1
  - The number of **protons** in an atom determines the element
- **Isotopes -** Atoms with the same number of protons (i.e. the same element), but different number of neutrons
- - Chemically identical, but have different properties.
- **Electron Shells**: specific electron shells that the electrons orbit
- Finite number of space in each shell - tend to fill up the lower level shells first
  - 1st Shell - 2 electronics
  - 2nd Shell - 8 Electrons
  - 3rd Shell - 8 Electrons
- **Valence Shell:** the outermost shell that contains one or more electrons
- Periodic table is arranged by how many electrons are in the valence shell
- Atoms with a full valence shell are stable and tend not to interact with other atoms
- **Covalent Bond:** A chemical bond in which two atoms share one pair of valence electrons
- **Molecule:** Two or more atoms held together by chemical bonding **(covalent bond)**
- **Compound:** a molecule with two or more elements
- **Emergent Properties**: The properties of a compound are not simply the combination of the properties of its elements
- Within molecule there is an uneven distribution of electrical charge
- **Polar Molecule:** a molecule with an uneven distribution of electrical charge

- An electron can be pulled completely off of one atom and on to another atom
- **Ion:** an atom or a molecule with a net electric charge (+ or -)
- **Ionic Bond:** An chemical bond resulting from the attraction between oppositely charged ions
  - Sodium: Tends to react violently with water
  - Chlorine: Gas (corrosive)
  - When combined it forms Table Salt (NaCl)

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- **Chemical Reaction:** The making and breaking of chemical bonds
- Have to put enough energy in to get reaction started to reach higher energy state - the difference in energy between the energy that started the chemical reaction and ended is the energy that is released/absorbed

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- **Enzyme:** Makes a chemical reaction take place more easily (Biological catalyst)
- Molecules get taken in by the enzyme into an environment where the reaction can take place more easily
- Enzymes are not affected by the molecules (they don't react/don't change)
- Does not change energy released by the reaction

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- **Hydrogen Bond:** Weak attraction between polar molecules
- i.e. Water molecules

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- **Acidity:** The concentration of hydrogen ions
- **Acid:** Substance that in water increases the concentration of hydrogen ions
- **Base:** Substance that in water increase the concentration of hydroxide ions
- Acids and Bases tend to neutralize each other
  - Hydroxide ions and Hydrogen ions tend to stick together and form water molecules

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- **pH Scale:** Measure of acidity (concentration of hydrogen ions)

- The lower the pH the higher the concentration of hydrogen ions

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- **Acidity of Water**
- pH 7 - neutral - hydroxide and hydrogen ions are balanced out
- pH >7 - greater concentration of hydrogen ions
- pH <7 - lower concentration of hydrogen ions (**base)**

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- Lecture 2

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- **Kinetic Energy:** Molecules always have kinetic energy, they are moving
- Temperature is just a measure of the average kinetic energy of molecules
- Solid: Molecules tend to vibrate around in the same place
- Tendency for molecules to move from high concentration to low concentration
- **Diffusion:** the net movement of a substance from an area of high concentration to an area of low concentration; individual molecules are moving at random
- Semi-Permeable Membrane: diffusion does not necessarily give the same concentrations on both sides.
  - **Osmosis:** the diffusion of water across a semi-permeable membrane

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- Mean Speed of oxygen molecules: 460 m/s ~ faster than the speed of sound
- Mean free path: distance a molecule can travel before it hits another molecule - 60 nm
- Collision Frequency: the frequency of collisions - 10 billion per second

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- **MACROMOLECULES**
- **Lipids:** oil, fat, wax
- Made up of glycerol and fatty acids
- Non-polar molecules: **hydrophobic -** don't mix with water
- Water molecules tend to stick together and ignore the lipid molecules
- Relatively high in chemical energy

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- **Carbohydrates:** sugar, starch, cellulose
- High in chemical energy
- Polar molecules: **hydrophilic** - dissolves in water
- Simple Carbohydrates - **Monosaccharide**
  - Each molecule has a single sugar unit
- Monosaccharides can be bonded together to form a **disaccharide -** each molecule has two sugar units
- **Polysaccharide -** long chain of saccharide units joined together
  - Example of a **polymer** - made up of a simple repeating part i.e. repeating chains of glucose

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- **Nucleic Acids:** DNA, RNA
- Genes, expression of Genes
- Example of a polymer: **nucleotides**

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- **Proteins:** enzymes, hormones, structure
- Polymer: made up of units called **amino acids**
- Some parts may be polar; other parts may be non-polar
- There are 20 different kinds of amino acids that are used to make proteins
- Characterize the protein by the specific chain of amino acids
- **Primary Structure:** sequence of amino acids
- **Secondary structure:** repeated coils/folds
- **Tertiary Structure:** irregular folding
- All proteins have primary, secondary, and tertiary structure
- **Quaternary Structure:** two or more chains aggregated to form a functional unit - only few proteins have this type of structure
- All for levels exist simultaneously - they don't replace each other

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- **LIFE**
- Response to the environment
- Exchange of material with the environment
- Metabolism
- Growth
- Reproduction
- Life is an emergent property of a particular arrangement of certain molecules
- Everything that is alive is made up of one or more cells
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- **Prokaryotic Cells:** no true nucleus
- Bacteria
- **Eukaryotic Cells:** have a true nucleus
- Humans, animals, plants, etc…
- **Unicellular:** each cell carries out all life processes
- all prokaryotes are unicellular
- **Multicellular:** made up of many cells, with different cells specialized to perform different functions
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- Most eukaryotic cells are 10-100 um
- Typical prokaryotic cells are between 1-10 um
- The smaller an object gets the higher the surface area to volume ratio gets - allows for faster exchange of material with the environment
- Cells are small because they require a high surface to volume ration to exchange materials with their environment
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- **Cytosol:** complex mixture of enzymes and many other molecules in water
- many of the chemical reactions take place here
- **Plasma Membrane:** Boundary between cell and environment
- controls exchange material with the environment
- **Phospholipid:** makes up most of the plasma membrane

- Made up of a polar head and two non-polar tails
- Polar heads like to form hydrogen bonds with water molecules - non-polar tails tend to get isolated away from the water
- **Phospholipid Bilayer** - structure of a plasma membrane
  - The Non-Polar layer makes it relatively impermeable to polar molecules
  - Non-polar molecules (Oxygen, CO2, Lipids) diffuse through freely
  - Small polar molecules (H20, ethanol) diffuse through much more slowly.
  - Larger polar molecules (glucose) and ions diffuse through hardly at all
  - Thus it is a **semi-permeable membrane**
  - There are proteins embedded in the bilayer
- Plasma membrane is a fluid - it is not a solid
  - Phospholipid bilayer is constantly shifting around

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Lecture 3:

- **Channel Protein:**

- Shuttle things through the phosolipid bilayer
- have no control over the actual movement of things
- Very specific to regards to what can pass through them - due to the chemical composition of the amino acids that make up the protein
- Classified as to what they allow to pass through
- Aquaporins: channel protein that is specific for water molecules
- **Gated Channel Protein:** have a lid/stopper
  - No control over direction of movement
  - Can potentially **open/close** under some circumstances
  - Important in the function of neurones

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- **Carrier Protein:**

- When it folds, it has a specific opening that allows the pick up of a molecule - can flip around and deposit the molecule on the other side of the membrane

- No control of the direction of movement

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- **All these proteins** are **facilitated diffusion:** allow the diffusion of molecules across the cell membrane (**passive transport)** - something is passing passively from the cell to the environment - vice versa

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- **Active Transport Protein:**

- Functions in a similar way to the carrier protein
- Gets chemical energy from the cell in the form of **ATP**
- Converts **ATP to ADP -** releases energy that is used to transport a molecule from one side of the membrane to the other side
- Has control over the direction of movement - regardless of the concentration gradient
- Allows the cell to control the concentration of various molecules within the cell

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- **Ribosome:** site of protein synthesis - where proteins are made

- where amino acids are formed to from proteins

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- **Nucleoid:** where much of the genetic information of a cell is found

- single loop of double stranded DNA

- **For Prokaryotic cell:** most have a cell wall

- Does not replace function of plasma membrane
- rigid, gives the cell shape and protects it from bursting

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- **Optional Components of a Prokaryotic Cell**

- Flagellum: Capable of rotation to provide mobility in water - acts as a propeller
- Thylakoid: membrane sacs
  - provide a membrane for photosynthesis
- Capsule: sticky slimy layer that protects the cell from attack or dehydration
  - Helps to retain water
  - Difficult for other cells to detect the bacterial cell if it has a capsule

- Plasmid: extra loop of DNA
  - Carry accessory genetic information
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- **EUKARYOTIC CELL - Animal Cell**
- Look quite different as to which function they perform
- Cytosol
- Plasma Membrane
- Ribsomes
- In some cases can have flagellum
  - Whip to provide mobility
- **Cillium:** hair on the cell membrane
  - coordinated motility to move through water
- **Chromatin**: where most of the genetic information of a cell is found
  - made of several diffuse chromosomes
  - Each chromosome is a one double-stranded DNA molecule with associated proteins
- **Nucleolus:** region where ribosomes are assembled
- **Nuclear Envelope:** separates the chromatin from the surrounding cytosol
- **Nucleus:**
  - Includes the Nucelolus, Chromatin, and nuclear envelope - membrane bound nucleus
  - Defining feature of Eukaryotic Cell
- **Smooth Endoplasmic Reticulum:**
  - Extension of the Nuclear Envelope - apart of the same membrane system
  - Two Functions
    - 1.) Synthesis of Lipids
    - 2.) Destruction of drugs and toxins
- **Rough Endoplasmic Reticulum:**
  - Has ribosomes stuck to the surface

- Synthesis of proteins to be packaged - to be moved elsewhere where they are needed
    - I.e. insulin
- **Golgi Apparatus:** Made up of same phospholipid bilayer
    - Packaging, modifying, and sorting of proteins from the **Rough E.R.**
- **Vesicle:** Small membrane sack of material - often proteins from the Golgi Apparatus
- **Vacuole:** A larger vesicle
    - **Lysosome:** a vacuole of digestive enzymes - help reactions that break material down
- **Mitochondrion:** Generates ATP for the cell
    - Outer membrane: simliar to Eukaryotic plasma membrane
    - Inner Membrane: Similar to Prokaryotic plasma membrane
    - **Matrix:** similar to cytosol
    - Ribosomes: similar to prokaryotic ribosomes
    - **Loop of DNA:**
- **Organelle**: refers to all parts found in a Eukaryotic Cells (Golgi Apparatus, Vacuole, etc..)
- **Cytoplasm:** refers to everything in the cell membrane - contains the organelles & cytosol
- All through the cell there is a network of tubules called the **cytoskeleton**
    - Give the cell shape, allow the cell to move and allow for intracellular transport
- **Centrosome:** with a pair of centrioles, organizes the **cytoskeleton**
    - Particularly noticeable during cell division because it has to be reorganized
    - “Microtubule organizing centre” - more broad term
    - Allows to manipulate the cytosol
    - Outside of the phospholipid bilayer - **Extracellular Matrix**
        - Web that attaches to an animal cell
        - Helps to strengthen tissues, helps cell to react to environment (with glycoproteins, e.g. collagen)
        - Embedded in the phospholipid bilayer is **cholesterol** - non-polar molecule; helps to maintain membrane fluidity

  - **Receptor Proteins:** respond to specific chemicals
    - Does not transport material across the membrane - changes shape and can perform different function
- **Enzymes** - embedded in the phospholipid bilayer
- **Identification Markers -** allows for other cells to be recognized by other cells
- **Tight junction proteins:** Hold cells together

CYTOSIS - transport via folding of a membrane

- PLasma membrane folds in around the bacterial cell
  - Gets folded into a vacuole or a vesicle
- **Endocytosis**: enter the cell via cytosis
- **Exocytosis:** exiting the cell via cytosis

Lecture 4:

- Lysosome contains active hydrolytic enzymes
  - Food vacuole
- Proteins that are built in the Rough E.R. - can be moved by cytosis forming vesicles to the Golgi apparatus to be sorted, moved, exited the cell through endocytosis

Plant Cell

- Has membrane bound nucleus
- Do not have a centrosome with centrioles - it has a microtubule organizing center on nuclear envelope
- Have a **cell wall** - rigid, gives cell shape and protects it from bursting cellulose)
- Have one large central Vacuole
  - Fucntions: Storage & turgor (stiffness caused by water pressure)
- May also contain **chloroplasts**
  - Site of photosynthesis in plant cells
  - In the inner membrane fliud called **stroma**

    - In the storma there are sacs called thylakoids - provide a membrane for photosynthesis
        - There are ribosomes present
        - Also contains a loop of DNA
- **Plasmodesma**
    - Openings from one cell to the next
    - Connect cells to their neighbours
    - The phospholipid bilayer continues from one cell to the next
    - Allows the passage of cytosol from cell to cell
    - Allows for material to move easily from cell to cell in the tissue

BACTERIAL CELLS

- No true nucleus - no membrane bound nucleus
- No Endoplasmic reticulum
- No Golgi Apparatus
- No mitochondria
- No Chloroplasts
- No vesicles or vacuoles
- No centrosome

ANIMAL CELLS

- No Cell Wall
- No Plasmodesmata
- No Chloroplasts
- No Central Vacuole

PLANT CELLS

- No centrosome
- No Lysosomes

- Cell wall composed of cellulose

FUNGAL CELLS

- Eukaryotic cells - true Nucleus
- Cell Wall - composed of **chitin**
- Pores between cells but no plasmodesmata
  - Pores are big enough that organelles can pass easily from cell to cell
  - Sometimes there are no division among cells - one big supercell
- No centrosome
- No Chloroplasts

Metabolism

- Refers to all chemical reactions taking place in an organism

Metabolic Pathway

- A particular sequence of connected reactions
- Largely controlled by enzymes - protein that facilitates a specific chemical reaction
- Doesn't exist in isolation - part of a wider web of interacted chemical reactions

ATP (Adenosine TriPhosphate)

- A high energy molecule to provide energy in cells
- Provides energy by being connected into **ADP (Adenosine DiPhosphate)**
  - The lower energy form of **ATP**
- ATP loses a phosphate - turns into ADP = releases energy that can be used for active transport
- To convert ADP into ATP - you need an extra phosphate molecule and energy to fuse it on to the ADP Cell

NADH, FADH2, NADPH

- High-energy molecules (carrying high-energy electrons)

NAD+, FAD+, NADP+

- Lower energy forms of the above molecules (without high energy electrons)

Cellular Respiration

- Taking sugar + Oxygen = Carbon Dioxide + Water + energy (in ATP and heat)
- Whole point of cellular reparations is to generate ATP

1.) Starts with a glucose molecule - undergoes chemical reaction to become **Glycolysis (Releases energy; generates NADH & ATP)**

2.) Glucose undergoes glycolysis to become **pyruvate** - has less chemical energy than glucose

3.) Pyruvate goes through the **Citric Acid Cycle**

4.) In the Citric Acid Cycle turns Pyruvate into **Carbon Dioxide -** less energy than Pyruvate

- releases energy which is used to create NADH & FADH & **ATP**

5.) **Oxidative Phosphorylation** - Will take energy from NADH & FADH to generate more **ATP**

In a Prokaryotic Cell

- Glycolysis and the Citric Acid Cycle take place in the **Cytosol**
- Oxidative Phosphorylation occurs along the **plasma membrane**

In a Eukaryotic Cell

- Glycolysis occurs in the **Cytosol**
- The rest of cellular respiration occurs in the **Mitochondria**
  - The Citric Acid Cycle occurs in the **MATRIX** of the mitochondria
- Oxidative Phosphorylation occurs in the **INNER MEMBRANE** of the mitochondria

GLYCOLYSIS

- A metabolic pathway that breaks down glucose into **TWO** molecules of **PYRUVATE**
- Energy is released which is used to change **ADP** into **ATP** and **NAD** into **NADH**
- Occurs in the CYTOSOL for both Eukaryotes and Prokaryotes

THE CITRIC ACID CYCLE

- a cyclical metabolic pathway that breaks down **PYRUVATE** into 3 CO2 molecules
- Energy is released is used to change ADP to ATP, NAD+, to NADH, and FAD+ to FADH2
- Occurs in the CYTOSOL in Prokaryotes; in MATRIX of the Mitochondria in Eukaryotic Cells
- Total Benefit to cell = +4 NADH, +1 FADH, +1 ATP
- From 1 Glucose = +8 NADH, +2 FADH, +2 ATP

Lecture 5

Oxidative Phosphorylation

- A chain of molecules uses energy from NADH and FADH2 to generate a H+ gradient.
- The H+ gradient is used to change **ADP** to **ATP**
- Involves 10 electron carriers
- 2 Parts of focus
  - 1)Eletron Transport Chain - Focus is to pump Hyrogen ions out of the cell to create a gradient
    - FOund in the plasma membrane in the Prokaryotic cell
    - Found in the inner mitochondrial membrane in a Eukaryotic cell
    - NADH will drop its hydrogen electrons off = NAD+
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    - Energy used to fuel active transport of hydrogen ions across the membrane

- Electrons transported used to fuel active transport along the membrane (Electron Transport Chain)
  - Used to pump Hydrogen ions out of the cell
  - Water molecule is created from Oxygen and hydrogen ions created from the Electron transport chain
    - Oxygen's job is to pick up loose hydrogen ions

2.) Chemiosmotic ATP Synthesis

- Phospholipid bilayer is impermeable to Ions
- Uses the molecule **ATP Synthase -** a channel protein and an enzyme
  - Allows Hydrogen ions to pass through the membrane
  - Energy transported through ATP Synthase is used to create an ATP Molecule - fuses a ADP and Phosphate molecule together
  - Will only work if there is a Hydrogen ion across the membrane
- Electrons carried by FADH2 have less energy - can contribute less to active transport of hydrogen ions across the membrane

Oxidative Phosphorylation

NADH —> 3 ATP

FADH2 —> 2 ATP

Glycolysis: 2 ATP +

2 NADH —-> 6 ATP

Citric Acid Cycle: 2 ATP+

8 NADH —> 24 ATP

2 FADH —> 4 ATP

- Without oXygen Oxidative phosphorylation doesn't work -
  - The whole process backs up and shuts down

FERMENTATION

- Alternative when there is no oxygen present
- A metabolic pathway that changes pyruvate
- Energy required is supplied by the conversion of NADH to NAD+
- By generating NAD+, it allows glycolysis to continue in the absence of oxygen
- Much less efficient than cellular respiration, only used in the absence of oxygen

Fermentation

- Takes place in the CYTOSOL for both Prokaryotes and Eukaryotes
- In animals, Pyruvate is converted into **LACTIC ACID**
- It allows glycolysis to continue which produces ATP - only in little quantities

PHYSICS

- Frequency: how many waves pass a particular point in a given amount of time
- Velocity/frequency = wavelength
- **Electromagnetic Waves:** waves in the electromagnetic field (electromagnetic radiation)
  - occurs in packets called photons - move at a predictable speed - speed of light
- The wavelength or frequency is correlated with the energy of the photon
- HIgh wavelength = low frequency: low energy photon
- Low wavelength = high frequency high energy photon
- Middle of the picture a photon has just enough energy to drive chemical reactions

Pigments

- A molecule that absorbs visible light
- each pigment absorbs only light of certain wavelengths
- When a pigment absorbs light, it absorbs the energy from the photons

PHOTOSYNTHESIS

- The use light energy to synthesize carbohydrates out of CO2 and H2O
- Two Stages
  - 1) Light Reactions (light-dependent reactions)
    - Requires pigments and absorbs photons - **CHLOROPHYLL A** is the most important
    - Take place among the membrane of the thylaoir
    - Also **Accessory Pigments** play a minor role

      Photosystem I

      - Cluster of pigments
      - One particular chlorophyll a which is apart of the **Reaction Centre**
      - Energy absorbed by photons ends up as a pair of high energy electrons in the Reaction Centre - wherever the photon is absorbed it always ends up at the Reaction Centre
      - High energy electrons are passed along the membrane where they are picked up by a NADP+ molecule = NADPH; releasing chemical energy

      Photosystem II

      - Cluster of pigments with a reaction centre
      - High energy of electrons can be passed along the membrane which can be used to fuel active transport across the cell membrane
      - After which the electrons can be used to in Photosystem I
      - Water molecules are stripped of their electrons by Photosystem II to be used in that system
      - Oxygen and 2 Hydrogen ions are produced
  - 2.) Calvin Cycle (dark/light-independent reactions)

Lecture 7:

Eukaryote: Plant

- Cell wall do not get stretched out during the anaphase
- New nucleus form in each end of the cell
- **Cytokinesis:** Accumulation of vesicles in the middle of the cell instead of the cleavage furrow - generated before mitotic phase began
  - Contain the particular material for building a cell wall - adjacent vesicles begin to fuse together; more start to accumulate = start to form a cell wall - **cell plate**
  - Grows and grows until it forms two cells and cytogenesis is complete

MEOISIS AND SEXUAL LIFE CYCLES

Zygote: a single cell; fertilized egg - goes through the cell cycle - forms a multicellular organism

Gametes: Sperm and egg cells involved in the process of *fertilization* which forms a **zygote**

- Haploid

Haploid: One complete set of genes or one complete set of chromosomes

- Number of chromosomes = n
- do not have homologous pairs

Diploid: two complete set of genes or two complete sets of chromosomes

- Number of chromosomes = 2n
- Homologous pairs: one complete set of chromosomes

Fertilization: the zygote ends up being diploid

- the 23 chromosomes from the egg & 23 chromosomes from the sperm fuse together
- Each homologous pair is made up of one chromosome from the sperm and one chromosome from the egg

Meiosis: change the diploid cells into haploid cells - only in the production of gametes

1.) Interphase:

Meiosis I

- 1.) **Prophase I**: chromosomes condense & nucleolus disperses; nuclear envelope breaks up; spindles being to from around the centrosomes
  - Homologous pairs of chromosomes are found together - 2 chromosomes; 4 chromatids
  - **Crossing Over:** the homologous pairs condense together and begin to cross over each other - genetic material is exchanged between the pair - can be made up of a mix of genetic material
- 2.) **Metaphase I:** The homologous pairs are lining up together at the metaphase plate
- 3.) **Anaphase I**: homologous pairs are being split; chromosomes pulled to opposite ends of the cell; the cell elongates
- 4.) **Telophase I**: Chromosomes disperse; nucleoli form; nuclear envelope assembles; spindle breaks up - cytokinesis
  - Each of the nuclei is going to haploid - one chromosome from each homologous pair

Cytokinesis I

- No Interphase in between
- Centrosomes double

Meiosis II - essentially identical to Mitosis

- 1.) Prophase II
- 2.) Metaphase II
- 3.) Anaphase II

- 4.)Anaphase II
- 5.)Telophase II

Cytokinesis II

- each cell divide - end up with four cells with chromosomes and no pairs

Variations - Life Cycles

Fungi - some Algae

- Zygote does not go through the cell cycle - it undergoes meiosis
  - Produces a bunch of haploid cells - not gametes - they are **spores**
  - No Fertilization occurring
- Cell Cycle occurs where they settle and where there is food
- End up with a multicellular organism that is **haploid**
- Continues through the cell cycle to generate gametes
- Gametes fuse together through fertilization to produce another **gamete**

Plants - some algae

- **Zygote**: goes through the cell cycle to produce a diploid multicellular organism
- a few cells may go through meiosis - produces haploid spores and not gametes
- Spores if they find a place to live go through the cell cycle - the cells are haploid
  - Multicellular organism being generated which is haploid
- Multicellular organism can continue through the cell cycle to produce gametes
- The gametes can be fertilized to produced a zygote

GENETICS

Character or Trait: A potentially variable quality or quantity in an organism

- E.g. flower colour - purple, white

- When pea plants reproduce, if the new generation of pea plants always has the same characters, it is a *true breeding* variety

Hybrid: the offspring of two different varieties

Monohybrid Cross: Studying the inheritance of single character in a hybridization experiment

P Generation: parental generation - starting point for experiment

- **F1**: First filial generation - offspring of P generation
  - **F2:** Second filial generation - offspring of F1 generation
  - Gave Mendel insight into how inheritance occurred

Particles of Inheritance:

- There would be a P: purple particle of inheritance and a P: white particles of inheritance
- Each pea plant inherits two such particles
- For some reason one particles id dominant: it determines the colour of the flower even when the other type of particle is present

GENETICS CONT'D

Punnet Square: see diagrams

Definitions

Gene: a sequence of genetic material (DNA)

Locus: the place on a chromosome where a gene is located

Allele: one form of a gene found at a particular locus

Diploid: having two alleles at each locus

Haploid: having one allele at each locus

Homozygous: The two alleles at a particular locus are the same

- Only makes sense when taking about a diploid organisms

Heterozygous: the two alleles at a particular locus are different

Dominant: an allele that is fully expressed in a heterozygote

Recessive: an allele that is not expressed at all in a heterozygote

Genotype: the specific alleles that an organism has

Phenotype: the character that the organism has (due to the genotype and the environment)

Pea Plant: are diploid (2 alleles at each locus)

- Flower color locus
- Purple allele (dominant) & White allele (recessive)

Examples.

- Aniamls are diploid (with a few exceptions
- Humans have a locus which determines where or not they will have attached earlobes
  - E: allele for free earlobes
  - e: allele for attached earlobes
- Humans have a locus which determines whether or not they are able to roll their tongue - ability to roll is dominant

Codominance: Both are fully expressed in the heterozygote

- Adds a complexion into the expression of the alleles

Incomplete Dominance

- Both alleles contribute partially to the phenotype in a heterozygote
- E.g. Snapdragon flower: one locus, two alleles
- If heterozygous the expression is influenced by the alleles - it is different than they other heterozygotes

Pleiotropy

- The genotype at a single locus influences more than one trait
- A whole bunch of different expressed traits being influenced by the allele at a specific locus

Dihybrid Cross

- A hybridization experiment in which the inheritance of two traits is studied
- E.g. Pea color & pea shape
- Dependent vs independent assortment
  - **Dependent Assortment:** the allele inherited at one locus is dependent on the allele inherited at the other locus - Mendel did not find this
  - **Independent assortment:** The allele inherited at one locus is independent on the allele inherited at the other locus
    - each combination is independently equal

Polygenic Traits

- The phenotype is influenced by many loci - e.g. skin color in humans
- Many loci - two are more alleles at each locus
- Things dont fall into nice discrete polygenic categories - it falls into a gradient; similar to a bell curve

- In sexually-reproducing organisms, alleles are carried by gametes
- These gametes are haploid - carrying one allele for each locus
- Through fertilization, each zygote gets one allele (for each locus) from each gamete, and is therefore diploid
- The loci (and alleles) are found in chromosomes

Lecture 9: Mitotic Cell Division Cont'd

HUMAN SEX DETERMINATION

- Determined by a homologous pairs called **Sex Chromosomes -** All other ones are called **Autosomes**
  - **XX -** Female
    - Goes through cell cycle - Oogenesis
    - Copies genetic information in the Interphase
    - Produces Gametes - will always carrier an X chromosome - 50% chance of either X chromosome
      - Primary Oocyte - still a diploid cell - goes through Meiosis I - gets rid of extra material **Primary Body**
      - Becomes Secondary Oocyte - haploid cell - goes through Meiosis II —> produces an Ootid and another **Polar Body**
  - **XY -** Male - Y chromosome doesn't have as much information - stunted
    - Goes through Spermatogenesis
    - DNA gets copied - Primary spermatocyte goes through Meiosis I to produce 2 Secondary Spermatocytes (haploid)
    - Secondary Spermatocytes go through Meiosis II to produce 4 spermatids - each spermatid will become a Spermatozoa
    - Half the spermatozoa will carry X chromosome and half will carry Y chromosome.
- On Average 50% will be boys; 50% will be girls

- **Meiosis is not perfect** - it sometimes makes “mistakes”
- Sometimes when the chromosomes line up in Meiosis I - Anaphase I a chromosome might be pulled the wrong way - **NONDISJUNCTION -** too many chromosomes being pulled to one end of the cell; not enough being pulled to the other
  - Neither of the cells is either Diploid or Haploid
  - It is possible for Nondisjunction to occur in Meiosis II
  - If it happens in Oogenesis - Can have an egg with two XX Chromosomes or no chromosomes
  - If it happens in Spermatogenesis - can prodcue XY, XX, YY or no chromosomes
- If the egg is fertilized:
  - XO: No Second X chromosome - Turner Syndrome - 1 in 2,500 Girls
  - XXY: Kleinfelter Syndrome - 1 in 500 boys
  - XXX: Tiplo X Syndrome - 1 in 1,000 Girls
  - YO: No X chromosome - Lethal
  - XYY: Jacob Syndrome - 1 in 1,000 boys

- Humans have 23 homologous pairs of chromosomes -
- This include 22 pairs of autosomes and 1 pair of sex chromosomes - numbered from largest to smallest 1-22
- Having three of chromosome 21 (trisomy 21) results in Down Syndrome
-

Heterozygote at two Loci

- 4 possible combinations from the gametes - Depends on how they line up - could be pulled into different directions
- LInkage - can have independent assortment or linkage - indicated when the numbers dont match dependent assortment or independent assortment
  - Due to **Crossing Over** - genetic material to be exchanged - creates new combinations
- Allows for the Combination of all 4 alleles

Non-Mendelian Inheritance

- Prokaryote with asexual reproduction (Bacteria)- goes through binary fission - produces Clones
  - **Plasmids - Conjugation**: two cells connecting to each other through their plasma membrane
    - Bacterial Cell can pick up a plasmid - exchange of genetic information
- Eukaryotic with asexual production
  - *Euglena* - goes through mitosis & cytokinesis - produces clones
- Haploid Eukaryote with sexual reproduction
  - *Chlamydomon* - haploid cell can fuse together to produce a diploid zygote - goes through meiosis and produces haploid cells
- Mitochondria -
  - Sperm do not transfer mitochondria DNA from the males - only from Females

POPULATION GENETICS

- Regular genetics is not circled with how common any genotype is in a population
- Concerned with how common certain genotypes are in a population rather than the genotypes of specific parents their offspring

- The probability that two particular things will happen at two particular times may be calculated as the probability of the first multiplied by the probability of the second

Cystic Fibrosis:
- 1 in 25 Europeans are carriers of cystic fibrosis, they are heterozygous at this locus (Cc)
- 1 in 25 = 1/25 = 0.04
- The probability that both parents are heterozygous - 0.04 x 0.04 =
- If both parents are heterozygous, the probability of they having a child with Cystic Fibrosis in 1/4
- Thus, the probability of a child with cystic fibrosis being born to European parents is 0.00016

A different Approach
- If 1 in 25 people are heterozygous at this locus, then 1 in 50 alleles are cystic fibrosis alleles
- What is the probability of getting 2 cystic fibrosis alleles = 1/50 x 1/50

DNA - Guest Lecturer

DNA Structure

- Made up of subunits called nucleotides
- nucleotides made of
  - 1.) Phosphate group
  - 2.) 5-Carbon sugar
  - 3.) Nitrogen Base
- Adenine, Guanine
- Two strands coiled called a double helix
- Sides made of a pentose sugar **Deoxyribose** bonded
- Base Pairings
  - **Purines** only pair with Pyrimidines (A with T and G With C)
  - Three Hydrogen bonds required to
  - Two Hydrogen bonds

DNA Replication

- Replication is the process of producing two identical replicas from the original
- DNA has to be copied **before a cell divides**
- New cells will need **identical** DNA Strands
- Leading strand:

Lecture: February 11th

DNA

- Sugar-phosphate backbone with nucleic acid bases
- Polymer of nucleotides each with a sugar, phosphate, and a nucleic acid
- The nucleic acid bases form hydrogen bonds with each other - the bases are very specific about which base they will form hydrogen bonds with
  - Adenine - Thyamine
  - Guanine - Cytosine

- Two nucleic acids that are held together by hydrogen bonds are called a base-pair
- DNA is typically found double-stranded with complementary strands held together by base pairs
- DNA muse be replicated for cell division
  - 1.) break the hydrogen bonds apart
  - 2.) Use each individual strands as a template - complementary nucleic acids are brought in to attach to the templates
  - 3.) Form complementary strand for each template strand - end up with 2 double stranded DNA each with its new complimentary strand
- **DNA Polymerase**: main enzyme in DNA replication
  - Works its way along the template strand and bring in complementary bases
  - Adds to new complementary strand
- 5' and 3' prime end - opposite ends
  - Called **Antiparallel** for complimentary strands
- Legging Strand & leading Strand
  - Leading Strand: when DNA gets pulled apart DNA polymerase can work in one direction when replicating
  - Lagging Strang: because it can only go one way it has to copy in fragments and go back to position

GENE EXPRESSION

- DNA —-> Protein —-> Trait (Central Dogma)
  - Ex.) ATAC…. —> Insulin
  - Ex.) GCCT… —> enzyme —> chlorophyll
- Occurs more or less constantly in living cells
- Some genes are only expressed by certain cells
- Some genes are only expressed in certain times

RNA

- RiboNucleic Acid
- Similar to DNA - both have sugar phosphate backbones with nucleotide

- Sugar in backbone is different - its ribose sugar
- RNA is typically single stranded
- Once of the acid bases is different - Thyamine is never found
  - **Uracil** replaces Thyamine

3 Groups

1.) Messenger RNA (mRNA)

- Carries protein blueprint from DNA to ribosomes

2.) Transfer RNA (tRNA)

- Carries Amino Acids to ribosomes
- **Anticodon:** three bases are exposed on the end of the TRNA
- **Amino Acid Attachment Site:** at the other end
- 61 different tRNA molecules
- Each has a specific Anticodon and carries a specific amino acid

3.) Ribosomal RNA (rRNA)

- With certain proteins, makes up ribosomes

Ribosomes

- Made up of Subunits - Small & Large Subunits
- Subunits get built in the nucleolus

In Prokaryotes

Transcription: the process of copying DNA to RNA

Translation: Use the sequence of mRNA to direct the production of a protein

In Eukaryotes

- Also has transciption
- RNA Processing: Pre-mRNA goes through

Transcription

- Along DNA strand there is a region called the **Promoter region**
  - Next to the Promoter is the **Transcription Unit**
  - After the Transcription Unit is the **Terminator**

1.) Initiation

- **Promoter region** is recognized by RNA polymerase - pulls the DNA strands apart
- It brings in RNA nucleotides - complementary

2.) Elongation

- RNA polymerase works its away long the template strand adding in complementary bases
- **Transcription Unit**

3.) Termination

- RNA polymerase releases the RNA
- **Terminator**

DNA Replication	VS	Transcription
• S Period		Constantly
• All DNA		Only Certain Genes
• Both DNA Strands		One DNA Strand
• DNA Polymerase		RNA Polymerase
• DNA To DNA		DNA to RNA
• Original DNA Strands Stay Apart		Original DNA strands recoil

Translation (occurs in Ribosome)

1.) Initiation

- Small Subunit ribosome and mRNA
- There is a particular sequence called the **Start Codon**
- There is a tRNA with a complementary sequence to the **Start Codon**

- Large subunit comes together and forms a whole

2.) Elongation

- Next three bases to the Start Codon are exposed - a transfer RNA can come in if it has the complementary bases
- The whole ribosome will shift along the mRNA
- The first tRNA will be ejected off and a new tRNA will come in
- One after another amino acids are being chained together

3.) Termination

- Gets to a stop codon - no tRNA has a complementary base to the mRNA
- Releases the free polypeptide of amino acids and ejects the ribosomes

Eukaryotic Cells

- The extra Step: RNA Processing
  - A Cap and Tail are attached to the ends of the pre-mRNA
  - Introns are removed from the pre-mRNA
  - Cap and tail help to protect the mRNA from degradation
- In eukaryotes, some proteins will be translated into the rough endoplasmic reticulum
  - Ribosome with mRNA in it that jams -
  - Can't get rid of the mRNA unless it goes to the Rough E.R.
  - Can only be translated if it gets to the Rough E.R. where they can release the amino acid chain and the mRNA

Mutation

- Any change in DNA
- Once the mutation has occurred, the new (mutant) DNA is treated just like any other DNA
- All current DNA was "mutant" DNA at some time in the past

<u>Substitution</u>

- One base is substituted for Another
- Can not have any effect in the organism - amino acid chain could be the same

- Could result in a different amino acid in the chain
- If it creates a Stop Codon where there wasn't one before could have drastic effects

Insertion

- One or more nucleotides are inserted into DNA
- Can create a Stop Codon

Deletion

- One or more nucleotides are deleted from DNA
- Frame Shift: Changes from of reference for all the rest of Codons from where the base was removed

Mutagen

- Something that causes mutation
- i.e. High Energy Radiation, Certain Chemicals

DNA Replication

- About 1 error per 1-10 Billion bases

Mutation Rates Vary

- Environmental effects on DNA replication
- The average human has about 128 mutations

Lecture: February 13th

Gene Regulation:

- The expression of genes is regulated; some genes are expressed at certain times, in certain cells, some more than others
- the control of transcription is the most important mechanism in the control of gene expression
- **Negative Control:**

- Something must be removed to allow transcription
- **Positive Control:**
  - Something must be added to allow transcription

Population Genetics

- Example: Sickle-Cell Disease
  - Differences in DNA leads to to transcription of RNA being different between homologous pairs
  - Leads to different chains of amino acids produced which fold differently - produce different proteins
- Neurofibromatosis
  - Gene involved in control of cell division
- Huntington Disease
  - Gene function unknown

Pattern

- Inherited diseases that prevent reproduction are generally caused by dominant alleles
- Recessive alleles can hide amongst the population; Dominant alleles can't be inherited on before reproduction because the likely hood of fatality is high.

- Red-Green Color Blindness
  - Sex Linked: genes with their loci on the sex chromosomes
  - X-Linked: Genes with their loci on the "x" chromosome
  - Male with color blindness cannot pass on the color blindness to sons because it is not found on the Y chromosome.

END OF MATERIAL FOR MIDTERM EXAM

LECTURE: EVOLUTION

Linnaean Classification System:

- Kingdoms: groups of things that were fundamentally different; Animalia, Plantae, Fungi
- Phylum: smaller subgroup of kingdom based on similarities
- Class: each phylum subdivided into different classes
- Order: each class subdivided into orders
- Family: each order subdivided into families
- Genus: each family into different genera
- Species: within genus can have different species

- Another group added above Kingdom = **Domain**
  - 3 different domains: Eukarya, Archaea, Bacteria
  - Within Eukarya - at least 3 Kingdoms - Animalia, Plantae, Fungi
  - Dumb
  - King
  - Philip
  - Comes
  - Of
  - Fairly
  - Good
  - Stock
- Mnemonic device

Lecture: Evolution

Evolution: an inheritable change from one generation to the next in characteristics of individuals in a population

The History of Life on Earth: Living things have evolved by descent with modification from common ancestors

Natural Selection: A functional association between individual traits and average reproductive success

Darwin's Observations:

- Organisms differ from each other, they are variable
- Some of the differences among organisms are inherited
- More organisms are produced than survive to reproduce in their turn
- Some of the carnations among organisms will affect their ability to survive and reproduce
- **Natural Selection** is when organisms with certain characteristics tend to produce more offspring than other organisms in the **same population**
  - If natural selection acts on a characteristic that is inherited then evolution may result

Scientific Terminology

Hypothesis: a statement of what might be true

Fact: A hypothesis "confirmed to such a degree that it would be perverse to withhold provisional consent"

The Evidence for Evolution

- The Fossil Record: mineralized remains of organisms
  - Evolution does not predict that there will be fossilization
  - Evolution predicts a pattern: any fossils found will be consistent with descent with modification from common of ancestors
  - Each of the billions of fossils found is a test of evolution

Timeline

- Earth about 4.5 billion years old

- 4 Billion years: oceans formed
- 3.5 BYA: fossil prokaryotes
- 2.5 BYA: Oxygen being built up in the air
- 2 BYA: Fossil Eukaryotes
- 1.5 BYA: Fossil Multicellular
- 7-800 Million Years Ago: Fossil Animals
- 500 MYA: Fossil Fungi
- 250 MYA: Fossil Plants
- First see different domains and then different kingdoms

Last 500 Million Years

- 4.25 MYA: Jawed Fish
- 3.5 MYA: Amphibians
- 3 MYA: Reptiles
- 250 MYA: Fossil Mammals
- 50 MYA: Fossil Animals

Last 50 MYA

Homo Sapiens - around 150,000 years old

Fossil Transitions

Between intermediate forms and earlier forms

BioChemistry

- Pseudogenes: a gene that has a couple of breaks; particularly in the promoter, so it doesn't get transcribed
- Universality of DNA as genetic material:
- Universality of Codons: all living things use exactly the same set
- Pattern of genetic similarity

Comparative Anatomy

- **Homologous Structures:** demonstrate common descent
  - i.e. Same underlying set of bones - same structure
  - Structures in different species that are similar because of common ancestry
- **Vestigial structures:** demonstrate descent with modification
  - A feature of an organisms that is historic remnant of a structure that served a function in the organism's ancestors
- **Superfluous embryonic structures:** demonstrate descent with modification
- Agrees with fossil record and biochemical evidence

HUMAN EVOLUTION

**** See Human Evolution Comparison Chart *****

Lecture: March 4th

Natural Selection

- Evolution may defined as a change in allele frequency over time
- Natural selection does not result in evolution if the characteristic is not inherited
  - If there is no genetic difference between individuals
- Natural selection does not necessarily result in evolution if the characteristic is inherited

Modes of Selection

- Directional Selection**:** natural selection in which individuals at one end of the photooptic range survive or reproduce more successfully than do other individuals
- Stabilizing (Balancing) Selection: Natural selection in which intermediate phenotypes survive or reproduce more successfully than do extreme phenotypes
- Disruptive Selection: Natural selection in which individuals on both extremes of a phenotypic range survive or reproduce more successfully than do individuals with intermediate phenotypes.

- Natural Selection is the result of different rates of reproduction
- Natural selection often acts through survival, because the individuals generally must survive to reproduce.
- Natural selection can act directly through reproductive rates.
- In sexually-reproducing organisms, natural selection can also act through access to mates
- **Sexual selection:** Natural selection that acts through access to mates
- Natural selection (including sexual selection) is the only known mechanism that drives the evolution of adaptations
- **Adaptation:** Inherited characteristic of an organism that enhances its survival and reproduction in a specific environment
- Evolution may also be drive by **Genetic Drift**
  - **Genetic Drift**: Changes in allele frequency due to chance
- Where does new genetic Variation come from
  - **Mutations** generates new variation
  - In real population of organisms there is a lot of new genetic variation being generated due to the greater probability of mutation

Common Descent

- **Speciation**: The evolution of reproductive isolation within an ancestral species, resulting in two or more descendant species
  - First define **Species:**
    - **Biological Species Concept:** A group of organisms that can potentially interbreed successfully

Starts with **geographic isolation**

- Afterwards each group can **evolve independently (**independent evolution)
- After a long period of time **gradual reproductive isolation**
- Speciation is often gradual - after many generations, perhaps interbreeding is still possible but sometimes fails
  - After yet more generations, perhaps interbreeding is impossible

Formation of Life

- Though that one of the 1st components of living things was RNA that began to copy itself

Organisms may be categorized by Nutrition

- Autotrophs: obtain carbon from carbon dioxide
- Heterotrophs: obtain carbon from organic molecules
- Phototrophs: obtain energy from light
- Chemotrophs: Obtain chemical energy from chemicals
- Photoautotrophs: Obtain carbon from carbon dioxide and energy from light
- Chemoautotrophs: Obtain carbon from carbon dioxide and energy from chemicals
- Photoheterotrophs: obtain carbon from organic molecules and energy from light
- Chemoheterotrophs: Obtain carbon from organic molecules and their energy from chemicals

By type of Reproduction

Sexual: haploid cells (gametes) fuse to from a zygote

Asexual: there is no fusion of haploid cells (gametes)

Lecture March 11th 2015

PLANT ORGANS

- Endodermis on the outside of vascular cylinder
  - Has embedded a waxy material **Casparian Strip** in the cell wall - essentially waterproofs the cells
  - Allows cell to control movement of water and minerals into the vascular cylinder
- **Pericycle**
  - Meristem tissue but not constantly growing - has the potential to grow at any time
  - Can grow and become another apical meristem

  - Provides meristem tissue for a new branch to grow from the root
- Xylem and Phloem
- In between xylem and phloem a layer of **Cambium**

Stem

- Contains Apical meristem - doesn't have to push its way through soil so it doesn't need protection
  - Cells are laid down and grow into various tissue types
  - **Leaf primordia -** structures that can later grow into leaves
  - Left over meristem tissue - **Axillary Bud Meristems:** branches from the stem grow from these tissues
- Outside - **Epidermis**
  - Cortex
  - Under cortex is a ring of **Vascular Bundles** around the stem - each vascular bundle is protected by **fibres** (ground tissue) and contains:
    - Underneath the fibres is **phloem** and under theses is the xylem
- Between xylem and phloem is the **Cambium**
  - **Primary tissues:** mature from apical meristem
  - **Primary Xylem & Primary Phloem** outside of vascular cambium
  - The Cambium can grow and divide - can produce **secondary tissues:** tissues mature from the cambium - **secondary xylem or phloem**
- Further down the branch you will find secondary tissue because more time has allowed them to mature
- In the center of the steam is the **pith**

Leaf

- Outside surface covered by **epidermis**
- **Cuticle**: Helps to reduce the loss of water - a waxy layer -
- **Stomata**: openings in the epidermis that allows the exchange of gases between the plant and the environment
  - On either side of the openings there are **guard cells**: can change shape - if the leaf drys out they close to prevent the loss of water

- Inside the leaf there is **mesophyll tissue**(ground tissue) - main site of photosynthesis in the plant
  - Spongy Mesophyll: has air spaces in between
  - Palisades Mesophyll: aligned parallel to one another
  - Constantly losing water through photosynthesis - become **hypertonic** to the **xylem** - water will diffuse from the xylem into the mesophyll
  - Movement of water throughout the plant is the loss of water at the top of the plant
- **Veins**: continuation of the vascular bundles from the stem - surrounded by fibres
- **Phloem:** Source cell - has extra sugar (in summer mesophyll)
  - Sugar can be pumped by active transport into the phloem - insider of the phloem becomes hypertonic to the outside - water will diffuse into the phloem
  - Increases pressure in the phloem
  - Elsewhere, there is a cell that is removing sugars from the phloem (sink) makes it hypotonic to the surrounding cells - water will diffuse out and cause the pressure to go down -

Flower

Carpel: single ovule - 1 pistil; 4 carpels fused to form 1 pistil = 4 ovules

Life Cycle Of Flowered Plant

- Each **Antler** has 2 **Pollen Sacs -** cells in pollen sacs go through meiosis
  - Produces haploid cells = **Spores**
  - Grows into a multicellular (haploid)organism (**Pollen grain)** which can produce sperm
- In the Ovule
  - Some cells go through meiosis to produce haploid cells - **A Spore**
  - Grows into a gametophyte in the ovule called the **Female Gametophyte**

Fertilization

- Germinated pollen grain fores down the pollen tube into the ovule and into the egg
- egg is fertilized and becomes a zygote - goes through cell cycle to become an **embryo** (sporophyte)
  - The cells around the embryo begin to change it - changes it into a seed (a mature ovule)

- Ovary around the ovule become the fruit
  - Function of the fruit is just to transport the seeds somewhere else
- Function of seed is to store food from the embryo

Monocot vs Dicot

Monocots

- No vascular cambium - no secondary growth - no monocot trees
- Parallel veins

FUNGI

- Made up of **Hyphae** - long chains of cells underground
- **Mycelium** - catch all term for all the hyphae growing underground

Zygomycota

- Can reproduce sexually

Homeostasis

- Steady state physiological conditions of the body
- The body maintains the internal environment within the narrow limits required for life
  - Temperature
  - acidity
  - Osmosis
- Typically maintained by organ systems - made up of organs
  - Organs are made up of tissues
- 4 Basic animal tissue types
  - 1.) Epithelial Tissue - Surface tissue
    - Cuboidal Cells - rounder cells
    - Columnar Cells - column cells
    - Squamous Cells - flat cells

  - **Simple:** Single layer of cells
  - **Stratified:** Multiple layer of cells
- 2.) Connective Tissue - cells scattered in a matrix
  - Loose Connective Tissue - scattered in a liquid matrix - lots of fibres - under the skin
  - Fibrous Connective Tissue - Tendons and ligaments
  - Bone - Hard matrix
  - Cartilage -
  - Adipose Tissue - liquid matrix, filled with a droplet of fat
  - Blood -
- 3.) Muscle Tissue - Contracting
  - Skeletal - Voluntary control
  - Smooth - Found in internal organs; fibres are shorter and tapered
  - Cardiac - Has ribbed appearance of skeletal, not under voluntary control
- 4.) Nerve tissue - Conducting

Integumentary System (Skin)

- Protection from mechanical injury
- Immunity
- Osmoregulation - regulating the concentration of solute
- Thermoregulation
- Sensing the environment

Muscular System

- Movement
- Protection from mechanical injury
- Thermoregulation
- Attached to bones by **tendons** - can only pull on bones

Skeletal System

- Protection from mechanical injury
- Support - for other organs
- Leverage for movement
- Storage of minerals (e.g., Calcium)
- Production of blood cells

Animal Phyla

- Porifera - sponge
- Cnideria (Colenenterate) - sea anemone, sea jelly, coral, hydra
- Platyhelminthes - flatworm
- Mollusca - snail, slug, limpet, chiton, clam, mussel, scallop, squid, octopus, cuttlefish, nautilus
- Annelida - segmented worm
- Nematoda - roundworm
- Arthropoda - centipede, millipede, insect, spider, scorpion, crustacean
- Echinodermata - sea star, sea urchin
- Chordata - Tunicate, fish, amphibian, reptile, bird, mammals - vertebrates

Nutrition

- Unicellular chemoheterotrophs obtain molecules from their environment
- **Intracellular digestion** - chemically breaking down food inside the cell
- **Extracellular Digestion** - digestions that takes place outside the cell - digest materials that can't fit in the cell
  - Bacteria and Fungi are good at this type of digestion

Digestive System

- Ingestion of food
- Digestion of food
- absorption of nutrients

- elimination of waste

Nutrients

- Chemical energy - from carbs, lipids, proteins
  - Need these materials for organic carbon
- Vitamins - organic molecules that we need but can't make ourselves
- Minerals - inorganic materials that our body needs

Colonial Flagellate

Porifera:

- Rely on intracellular digestion - no digestive system

Cnideria:

- Gastrovascular Cavity - food gets transported here
  - Gland Cells - produce digestive enzymes and release them into the gastrovascular cavity
  - Flagella: move water around in the cavity so digestion can occur
  - Cells than engulf food by endocytosis and have digestion o the food inside the cells
- Mouth is simultaneously an anus - there is only one opening
- Have **Incomplete Digestive System**: food enters and waste exits through the same opening
  - Both intracellular & extracellular digestion

Platyhelminthes:

- Have a gastrovascular cavity
- Has a mouth/anus
- **Incomplete Digestive System**
- Rely on both intracellular & extracellular digestion

Nematoda:

- Have mouth, gut (alimentary canal), and anus at the other end
- **Complete digestive system**

- Digestion is exclusively extracellular

Mollusca:

- Complete digestion system
- Extracellular digestion

Echinodermata:

- Complete digestive system
- Mouth underneath, anus on top
- extracellular digestion

Lecture - March 18th

Human Digestive System

- Mouth & Oral Cavity - interchangable
  - Teeth - Mechanical Digestion - grinding up food
    - Makes digesting food more efficient
  - Salivary Glands - produce saliva
    - Helps to hold lump of food together
    - Lubricate lump of food
    - Enzymes for digestion

- Tongue - initiates swallowing - pushes food towards the **Pharynx**
  - Opens into both the Nasal and Oral Cavity
  - Below the Pharynx there is the **Glottis**
    - To prevent food from going through the Glottis and into the lungs there is a flap called the **Epiglottis**
    - Food goes down through the **Esophagus**

- Muscles around the Esophagus - alternatively contracting and relaxing = **Peristalsis** -moves food down through the esophagus and into the stomach

Stomach

- At the end of the stomach there is the **Sphincter**: a ring of muscles that when contracts it closes off the tube
- There are a lot of wrinkles and folds of the lining of the stomach that allows it to expand to accommodate the incoming food
- **Gastric Glands** - openings within the epithelial tissue
  - Produce an enzyme that aid in digestion
  - Produce HydroChloric Acid
  - Produces **Mucus**: protects the epithelium from being digested
- Basic Functions:
  - Stores food
  - Digests food
  - Kills Bacteria
- Food is released into the **Small Intestine**

Pancreas and Liver

- **Pancreas:** Produces a fluid called **Pancreatic Juice** that is released through a duct into the **Small Intestine**
  - **Pancreatic Juice:** Contains bicarbonate which neutralizes the acids coming from the stomach
    - Has a wide variety of digestive enzymes
- **Liver:** Produces **Bile**
  - **Bile:** Emulsifies fats - allows fats to mix with water
  - Can store Bile in the **Gall Bladder**

Small Intestine

- Surrounded by **Smooth Muscle** that move food through **Peristalsis**
- Lining of the wall is folded and there are finger like projections called **Villi**

- Within the **Villi** there is MicroVilli - aim is to increase the amount of Surface Area to increase the amount of contact with food
- Basic Functions:
  - Digestion
  - Absorbs nutrients

Large Intestine

- Absorption of water & minerals
- Accumulates in the **Rectum:** stores wastes - mostly undigested material & bacteria

Respiratory Gases (O2 & CO2)

- Unicellular organisms exchange gases with their environment
  - Typically obtain gases through diffusion

Respiratory System

- Absorption of O2
- Elimination of Carbon Dioxide

Porifera

- No respiratory system
- rely on diffusion

Cnideria

- No respiratory System
- Rely on Diffusion

Platyhelminthes

- NO respiratory system
- Rely on diffusion

Nematoda

- No respiratory System
- rely on diffusion

Gill: Extension of the body that allows gas exchange

- Echinodermata
  - Also Tubefeet
- Annelida
  -
- Mollusca
  - Land Snail - keep respiratory system inside - contains **Mantle Cavity** that allows gas exchange
- Arthropoda
  - **Spiracle:** Series of openings that open into a system of tubes called **Trachea -** connect spiracles to all over the body

Human respiratory System

- **Nostril:** typically breathe air through the nose
  - Connects to the Oral cavity, Pharynx
  - Glottis opens between the **Pharynx and the Larynx**
  - **Larynx:** surrounded by cartilage and relatively thick

Trachea, Bronchus, Bronchial Tree

Bronchiole: smallest openings - does not have cartilage rings - connect to sacs called **Alveoli**

Heart: in the middle of the lungs

Diaphragm: Below the lungs

- Inhaling: Diaphragm

Typical Volume of air in lungs (ml):

Typical inspiration - 2,700

Typical Expiration - 2,200

Forced Expiration -

Lecture March 20th

Distribution of materials in an organism

- Unicellular organisms move materials through cyclosis (cytoplasm streaming) and along the cytoskeleton

Circulatory System

- Distribution of materials in the body

Porifera

- No Dedicated system

Cnideria

- No Circulatory System

Platyhelminthes

- No circulatory System

Nematoda

- No Circulatory System

Annelida

- Have circulatory system
- Can distribute material
- **Closed Circulatory System:** circulatory fluid never leaves the vessels in an organism

Open Circulatory System: no distinct circulatory fluid - body fluid leaves the vessels and gets sucked back into the circulatory system

Arthropoda

- Open System

Mollusca

- Generally open
- Exceptions - Octopods, squids, cuttlefish, nautilus

Echinodermata

- Open circulatory system
- Have another system that plays a bigger role in distributing materials - **Water Vascular System** - unique to this phylum

Chordata

- Closed circulator system

Fish

- Normally have a 2 chamber heart - 1 Atrium (generally does not have as much muscle) & 1 Ventricle
- Blood moves fairly slowly through this system

Amphibians

- Have 3 chamber heart - 2 Atrium & 1 ventricle
- Don't have a single loop of circulation - has 2 loops
- Heart pumps blood through each circuit separately - blood can more more quickly

Reptile

- Similar to Amphibian System
- 2 Atrium & 1 Ventricle that is partially separated - (3 1/2 Chamber Heart)
- Potential for blood to move back and forth - redirect blood away from the lungs so that oxygen being stored in the blood can be used for the body and not into the lungs

Mammals

- True 4 chamber heart

Human circulatory System

- Heart - 4 chambers
- Arteries - carry blood away from the heart; delivers blood to —>
- Capillaries - exchange of materials with other tissues —> goes into
- Veins - carry blood to the heart

- **Right Ventricle** pumps blood into the **Pulmonary Artery** which supplies blood to the **lungs**
- Gets pumped into **capillaries** where gases are exchanged and then gets pumped into the **pulmonary Vein (high in oxygen),** which drain into the **Left Atrium**
- Left Atrium pumps blood into the **Left Ventricle**(most muscular part of the heart) - has to pump blood with enough pressure to rest of body - Pumps blood into the **Aorta**
- Goes into **capillaries** into various parts of the body —> returned to the heart via the **vena Cava**, which empty into the **Right Atrium** - which pumps blood into the **right ventricle**

<u>Artery & Capillaries & Veins</u>

Artery

- Lining is **Endothelium -** direct contact with blood
- Around the endothelium there is a layer of **smooth muscle**
- Around the **smooth muscle** is the **connective tissue** (allows artery to expand)

Capillary

- There is only **endothelium**

Vein

- Lining is **endothelium,** surrounded by **smooth muscle**, surrounded by **connective tissue**
- blood going through veins is much lower pressure - has a relatively thinner wall
- Veins have **1 way valves:** blood can only go in one direction
  - Muscle contractions forces pressure on the veins and helps pump blood back to the heart - 1 way valve closes due to pressure change of the blood

Blood

- Clear part is **blood plasma** (55%)
  - Made up of mostly water - solvent for carrying other substances; Ions dissolved in the water
  - Ions play a role in **Osmotic Balance** - keeps the environment **Isotonic** to the red blood cells
  - Variety Of proteins dissolved in plasma - keeps the plasma **isotonic**
- **Cellular Elements** (45%)
  - **Erythrocytes** - (red blood cells): most common; transport oxygen and help transport CO2
    - Packed with **Haemoglobin**: picks up oxygen and incorporates it into the molecule
- **Leukocytes** (white blood cells): defines and immunity
- **Platelets**: Blood clotting
- Cellular components are built in the **Bone Marrow**
- Blood proteins are produced in the **Liver**

Respiration & Circulation

- Concentration of oxygen in Alveoli is lower than the oxygen being breathed in
- Lots of opportunities for oxygen to diffuse into the capillaries - concentration gradient
- Rely on diffusion to move oxygen in and out of the right place

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Lecture March 27th

Platyhelminthes

- Protonephridia: Pump body fluid out of the organism
  - cells that make up the tubes reclaim useful molecules by active transport
  - Primarily for osmoregulation

Annelida

- Metahephridia: function similar to protonephridia
  - Live in an environment that is
  - Excretion(removal of ammonia) and osmoregulation

Mollusca

- Metanephridia

Arthropoda

- Metanephridia
- Insects do not have metanephridia
  - **Malpighian tubules:** Nitrogen wastes are removed by these tubules and pumped into the digestive system
  - Rectum: cells reabsorb ions and useful molecules
  - Wastes pimped out lost with fees
  - Excretion and osmoregulation

Nematoda:

- Diffusion, glands

Echinodermata:

- Water vascular system

Chordata:

- Two major pathways -
- Renal artery and vein - provide blood to the **kidneys**
  - Wastes are drained away from the kidneys through **Ureters**
  - Stored in the **Urinary Bladder**
  - Stored until it makes it exit through the **Urethra**

Kidney

- Out layer is called the **Renal Cortex**
  - Tubes that pass from the cortex to the Medulla are called **Collecting Ducts** which drain into the Renal pelvis
  - **Nephron:** branching tubules that drain into the Collecting Ducts
  - **Glomerulus:** a specialized cluster of capillaries - constantly losing fluid that is captured by **Bowman's Capsule** that surrounds it
  - Fluid starts flowing down through the **Proximal Tubule**
    - Main job is to reclaim useful molecules through active transport
  - **Loop of Henle:** Dips into the Medulla and comes back up into the cortex
  - **Distule Tuble:** fluid from distule tubule drains into the **Collecting Duct**
    - Maintains homeostasis by pumping molecules in or out
- Below the Renal cortex is the **Renal Medulla**
  - Has a high concentration of solute compared to the rest of the body
  - Water diffuses out and reclaimed
  - Sodium is being pumped out as well - in order to reclaim water
- In the middle is a hollow space called the **Renal Pelvis**
- Fluid leaking out is **blood plasma**
- In the Collecting Ducts, urea, salt and water diffuses out into the medulla

CELL SIGNALLING

- Chemical signals influence processes in a unicellular organism
- Unicellular organisms respond to chemicals signals in their environment
  - Yeast cells exchange

Endocrine System

- Coordination of body activities
- **Hormone:** a chemical messenger produced by cells that influence the function of cells elsewhere in the body
  - Carried by blood

- **Target Cells:** influenced by the hormones - respond because it has a specific signal reception , typically a protein
- All animals use chemical signals

Human Endocrine System

Pituitary Gland

- "master" endocrine gland
- release many hormones
- Some influences other endocrine glands
- **Growth Hormone:** released by pituitary; promotes the growth of bones
- **TSH:** Thyroid Stimulating Hormone; stimulates thyroid to release more **thyroxine**

Thyroid Gland

- Releases **Thyroxine**: influences metabolic rate; increases metabolic rate
- Blood levels controlled by negative feedback
  - A form of regulation in which accumulation of an end product of a process slows the process
- Thyroxine **inhibits** the pituitary from releasing **TSH**
- The higher the thyroxine levels the slower the release of TSH

Pancreas

- Releases **Insulin**
- **Insulin** lowers blood sugar levels
- Releases **Glucagon**
  - Increases blood sugar levels
  - Receptors are only in the liver to release more sugar

Reproduction

- Unicellular organisms often reproduce through cell division

- Unicellular organisms may also reproduce sexually, through meiosis followed by cell fusion

Sexual Reproduction

- Sexual organs may be present
- Sexes separate or hermaphroditic
- Internal or external fertilization

Porifera

- Can reproduce asexually
- Can reproduce sexually as well - hermaphroditic
  - No sex organs

Cnideria

- Can reproduce asexually
- Can reproduce Sexually
  - Hermaphroditic
  - Have sex organs
  - Fertilization is external

Lecture April 8th

Nervous System

Synapse: Connection between neutrons

- Electrical Synapses - relatively exceptional
- Chemical Synapses - majority
- Action Potentials will start in the cell body and be carried away by the axion to another neutron - where there is a connection there is the synapse
- Presynaptic Cell - from where the synapse originates
- Postsynaptic Cell - where the synapse is going to

- They don't connect together, there is a space between the two called **the Synaptic Cleft**
- Vesicles within the presynaptic cell contain a certain chemical called a **Neurotransmitter**
  - When an action potential reaches the end of the axion it will trigger the release of **neurotransmitters** into the **Synaptic Cleft**
  - Come into contact with the **postsynaptic membrane** can cause ion channels to open to trigger a **action potential** within the **postsynaptic membrane**

Nervous System

- Coordinating activities of the body
- sensing the environment
- responding to the environment

Porifera

- No Nervous system

Cnideria

- Has a nervous system - simple; called a **nerve net**
- Mostly rely on individual sensory neutrons

Playthelminthes

- Net-like, but with brain and nerve cords
- Simple eyes

- All other groups of Animal phyla have some sort of brain with chords
- Some groups of Ganglia: cluster of nerve cell bodies outside of the
  - Mollusca, Annelida, Arthropoda, and Chordata

Human Nervous System

- Brain sits atop the **spinal chord**
- Running to and from the spinal chord there are **spinal & cranial nerves**
- Also, contain **ganglia**
- The brain and the spinal chord together are referred to as the **Central Nervous System**
  - Takes information in, analyzes it and produces the appropriate response
- The Nerves and Ganglia are referred to as **the Peripheral Nervous System**
  - Function is to carry messages to and from the Central feverous system

- **Spinal Chord** is actually the dorsal hollow nerve cord
  - Two main tissues found:
  - On the outside is White Matter (myelinated axons)
    - Carry messages up and down the back
  - In the Centre is **Grey Matter** (cell bodies, dendrites, unmyelinated axons)
    - Where integration occurs

Brain

- Contains white matter and grey matter
- Grey matter on the outside; white matter towards the outside
- **Brainstem:** hollow area below the brain
  - Basic functions for maintaining body: alertness, appetite, breathing, heart rate
- Behind the brainstem is the **Cerebellum**
  - Muscular Coordination
- In the centre is the **Diencephalon**
  - where the pituitary is located
  - Connections from one part of the brain to another
- Largest part is the **Cerebrum**
  - Where higher actions are location

- perception, language, volition

Integration

- reflexes are a simple form of integration

Peripheral Nervous System

- Nerves are bundles of myelinated axons
- Stimuli will trigger sensory receptors where in the information is carried to **afferent neurons** that carry messages to the **central nervous system** where **efferent neutrons** carry messages away from the **central nervous system**
  - **Efferent** neurons can be split up into the **Somatic Nervous System** (voluntary nervous system) - skeletal muscles
  - **Autonomic Nervous system**: no conscious control - carries messages to smooth muscle, cardiac muscles and glands
    - Into three parts
      - 1.) **Enteric Division:** basic digestive functions
      - 2.) **Parasympathetic Division:** rest and digest
      - 3.) **Sympathetic Division:** fight or flight response

Senses

- Initiating action potentials in response to specific stimuli
- **Mechanoreceptors:** respond to mechanical force
- **Chemoreceptors:** respond to specific chemicals
- **Electromagnetic receptors:** respond to electromagnetic energy
- **Thermoreceptors:** respond to temperature
- **Pain receptors:** respond to damaged tissues

Statocyst:

- Have mechanoreceptors that form a hollow ball
- The statolith tend to settle at the bottom of the cilia due to gravity, tell the animal which way is up

Human Hearing

- Outer Ear, Middle Ear, and Inner Ear
- Outer ears has 2 parts:
  - Pinna: the visible portion, helps to direct sounds waves into the ear
  - direct sound into the **auditory canal**
- **Middle Ear**: auditory canal goes along until it hits the **Tympanic Membrane** which seals off the aer
  - Sounds hit the **Tympanic Membrane** and make it vibrate and vibrations are transferred to the **ossicles of the middle ear** and transfer them to the inner ear
- Inner ear: main part concerned with hearing is the **cochlea**
  - **Basilar Membrane**: has **hair cells** sitting on top of it that are mechanoreceptors
  - Fluid transmits the pressure waves and press on the basilar membrane causing it to move up and down
  - The hair cells bash up and down with the membrane above it causes the mechanoreceptors to initiate an action potential which is carried to the brain
  - The Basilar membrane is not uniform; different parts of it will vibrate depending on the frequency
  - Also contains the **vestibule, and semicircular canals**

Human Balance

- Semicircular canals: that are all perpendicular to each other
  - The fluid in the ears continue to move if you move in a circle which trigger action potentials which tell the brain that you're still moving

Chemoreceptors

Human taste

- Taste Buds: clusters of chemoreceptors on the tongue

Human Smell

- Chemoreceptors embedded within the epithelial cells

Electromagnetic receptors:

- usually taking about light - **eyes**
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