Week 1

- Honey bees - Raspberry, Oion, Avocado, Almonds (help grow)
- Mites feed on fat body and carry deformed wing viruses (can't fly)
- Deformed wing virus - Iflavirus (ifla viridae)
- Africanized bees (Killer bees) - European and African bees combined (Better cleaning)

Are viruses alive?

1. Order (Pattern in viruses)
2. Reproduction (viruses reproduce but only uses host cells
3. Growth and Development (not really)
4. Energy Processing (No)
5. Regulation (No)
6. Response to the environment (Viruses interact with their environment but not respond)
7. Evolutionary adaptation (yes)

Cell Theory - All living organisms are comprised of cells. All cells arise from pre-existing cells, cells are the basic units of life and are capable of independent existence

SARS-Cov-2:

- Spike Glycoprotein: Sugars and protein combined that allow virus to attach and inject RNA
- Soap gets into phospholipid bilayer of virus and breaks it up
- Virus is made up of nucleotides, lipids, and proteins

- All matter consists of atoms, smallest unit that retain all of the properties of the type of matter
- Atoms bond together to form molecules
- Chemical reactions can rearrange matter, not create or destroy
- Reactants are transferred into products through chemical reactions

Ex: $C_6H_{12}O_6 + 6O_2$ [Reactants] -> $6H_20 + 6\ CO_2$ + Energy [Products]

- Protons are in nucleus and determines chemical element
- Neutron in nucleus, determines isotope
- Electrons orbit nucleus and determines atom's ion state and chemical reactivity

2 main ways to form bonds to make molecules

1. Sharing electron (Covalent Bonds)
2. Transferring electrons and creating 2 oppositely charged bonds (Ionic Bonds)

Nonpolar Covalent Bonds - Equal sharing of electrons

Polar Covalent Bonds - Unequal sharing of electrons
Covalent Bonds are strongest

Electronegativity - Ability of an atomic nucleus to attract electrons

0 to 0.4 -> Non-Polar Covalent
0.4 to 1.7 -> Polar Covalent
>1.7 -> Ionic

Water is a polar molecule
- Polar Covalent Bonds in water mean unequal charge distribution
- O2 more negative
- H2 more positive
- Weak attractions between polar molecules are hydrogen bonds
- Water molecules align themselves so a negatively charged oxygen faces positively charged hydrogen

- Hydrogen bonds are weak by itself
- Many hydrogen bonds for strength
- All life on Earth is carbon based
- Carbon can form so many shapes (long and branching chains)
- Molecules that contain carbon bonded to other elements are called organic compounds

4 Classes of organic molecules (Important)
1. Carbohydrates
    - Cellulose is a large, complex carbohydrate that forms much of the structure of a plant
    - Glucose is a sugar (monosaccharide) that acts as an energy source for all living cells
2. Lipids
    - Coconut oil is a lipid that is rich in fat and serves as an important dietary staple
    - Cholesterol is a lipid that circulates in the bloodstream and acts as molecular ingredient to make steroid hormones
3. Proteins
    - Hexokinase is an enzyme, protein that helps drive chemical reaction, found in most living cells
    - Keratin is a structural protein found in hair, nails and skin
4. Nucleic acid
    - DNA is a nucleic acid that serves as the hereditary material of all life on earth
    - RNA is a nucleic acid that acts as a messenger between DNA and other parts of the cell found in all types of cells

- Polysaccharide is made by joining many monosaccharides together

- Plants put together polysaccharides starch and cellulose from glucose

- Lipids are a diverse group of organic compounds
- All lipids are hydrophobic due to their non-polar covalent bonds which don't mix with covalent bonds

Phospholipid bilayer - thin polar membrane made of 2 layers of lipid molecules
- Proteins are channels in layer that allows molecules to pass

Proteins are polymers made by joining many amino acid monomers together
- Monomers (amino acids) (20 kinds)
- Polymer (protein)

- Peptide bond joins amino acid
- Polypeptide is a chain of amino acids

Primary Structure: Polypeptide contains amino acids
Tertiary Structure: Twists and folds lead to a unique 3D shape
Quaternary Structure: Chains may be joined together into large complex

Protein may not perform if the amino acid sequence is different

Enzymes speed chemical reactions
- Sum total of all chemical reactions in metabolism
- Enzyme is a protein that speeds up chemical reaction
- Almost every metabolic reaction occurs with help of enzyme
- Enzymes lower activation energy

- Each enzyme recognizes one specific target molecule called its substrate
- Inhibitors are molecules that prevent enzymes from working

DNA (Deoxyribose Nucleic Acid)
- DNA molecule is a double helix with 2 strands of nucleotides
- Each nucleotide consists of a sugar, phosphate, and base

DNA and RNA are polymers of nucleotides
- Nucleotides are composed of a nitrogenous base, 5 carbon sugar, and phosphate roup

In a DNA molecule there are 4 bases with specific pairing rules
- Adenine can only bond with thymine A-T
- Guanine can only bond Cytosine G-C

Each strand of DNA is a double helix is complimentary
Instead of thymine, RNA has Uracil

RNA Virus

1. Viral RNA release
2. Viral polymerase protein translation
3. RNA replication
    - Genomic RNA (- series)
    - RNA (+ series)
4. Assembly and building

Polar nature of water means frozen water floods
- As water freezes, stable hydrogen bonds hold molecules apart
- Chunk of ice has fewer water molecules than an equal volume of liquid water

- Many liquids can act as a solvent, dissolving agent, to form a solution
- Water is the most biologically important solvent
- Water is more likely to break ionic bonds
- Water absorbs heat and release heat
- Water moderates temperature

Living things can use water to regulate temperature
- Evaporative cooling is one way that living things can use water to regulate temperature (sweating)
- Cohesion is tendency of molecules to stick together
- Due to hydrogen bonding, water molecules hve a strong cohesion and create surface tension

pH is the measure of the acidity of solution
- Aqueous solution is one that contains a substance dissolved in water
- Break apart to H+ and OH-
- Concentration of H+ determines pH
- pH scale log scale (10 fold) (0-14)
- Acidic (0) Basic (14)
- When acid is dissolved in water, releases H+
- Base removes H+

Soap
- Non-polar tail with polar head
- Similar to phospholipid
- Has hydrophilic head and hydrophobic tail
- Able to break into lipid bilayer of virus
- Hydrophilic part interacts with water and forms balls around dirt
- Tails et away from water while head goes toward water

<u>Week 2</u>

Epidemiology - branch of medicine which deals with the incidence, distribution, and possible control of diseases and other factors relating to health

Scientists study disease dynamics through how it's transmitted, the spread of virus through models and graphs

COVID 19 is studied by scientists by forecasting number of cases by current actions (through mathematical models using transmission parameters esteemed from available data)

- Models based on equations, assumptions, parameters
- Mathematical modeling is a branch of science where the scientist uses math to understand how the world works

Population into classes
In relation to a disease, people are

- Susceptible : Can get the disease
- Infected: Sick
- Recovered: immune

Variations:

- Exposed - Not sick but a carrier of the disease
- No immunity - Recovered individuals are therefore susceptible

SIR Model
S - susceptible individuals
I - infected individuals
R - recovered individuals

- Models can be less or more complex: SI, SIS, SEIR

Model an epidemic

- Constant (closed) population size, N
- Constant rates (e.g. transmission, removal rates)
- No demography (i.e. births and deaths)
- Well - mixed population

If you add vital dynamics (births and deaths) to the model, ou can also model endemic diseases over long periods

Parameters
B- Transmissibility

- C contact rate
- t(gamma) - probability of infection if contact occurs

V - recovery (or removal) rate

Demos - people
Epi- upon (Epidemic)
Pan - all (Pandemic)
En - in or within (Endemic)

Epidemic occurs when transmission is greater than clearance

Beginning of an epidemic S = 1 (everyone is susceptible)
R0 > 1

Vital dynamics equations
A = birth rate
B = death rate
y = rate at which hoste clears disease
a = mortality caused by infection
Useful for modelling endemic infections

Virulence - negative effect of pathogen on its host (mortality caused by infection)

Parasite/pathogen fitness is determined by

- bs : the rate at which new infection occur
- b + y + a: length of infection

Parasite can't evolve to affect either background mortality (b) nor host clearance (y)
To prolong the infection, the parasite can decrease virulence (a)

Parasite fitness is increased by either

- Increasing transmission
- Prolonging the infection by decreasing virulence

But for many parasites, greater transmission requires greater virulence

R0 vs RE

- R0 applies to the beginning of an epidemic, when everyone is susceptible
- RE applies when some portion of the population has been recovered and is immune
- RE = R0X (X = proportion of the population that is susceptible)

Evolution via natural selection

- Variation in traits
- Hereditary
- Over production of offspring (competition)
- Unequal reproductive success
- Result is that a more advantageous trait increases in the population over time

Evolution via natural selection

1. Population with varied inherited traits
2. Elimination of individuals with certain traits and reproduction of survivors
3. Increasing frequency of trails that enhance survival and reproductive success

Evolution is science
Posits testable hypothesis that have been supported

- Bacteria evolve resistance to antibiotics
- Shape for Galapagos finch bills adapt to food that is available

Parasite fitness is increased by either
- Increasing transmission
- Prolonging the infection by decreasing virulence

But for many parasites, greater transmission requires greater virulence

Week 3

Gene - Stretch of chromosome or genome that encodes either an RNA molecule or a protein

Ribosomes - Factory floor in cells

SARS-CoV-2 genome - 30k letter (GUAC)
- Cellular Saboteur (NSP1) = slows down infected cell's production of its own proteins, sabotage forces ell to make more virus proteins and prevents assembling antiviral proteins
- Genetic Camouflage (NSP10) - protein works with NSP16 to camouflage genes
- Copy Machine (NSP12) - assembles genetic letters into new virus genomes, remdesivir interferes with NSP12
- Vikral Proofreader (NSP14) - cuts out errors from NSP12 wrong letter duplication

Our genomes vs DWV and SARS-COV-2
- DNA is double stranded, the viruses are RNA based so single stranded

Deoxyribose (in DNA) does not have oxygen molecule

5' and 3' come from Carbon atoms,

Species - Group of organisms that can't mate outside of that group (Viruses do not meet)

Viral Species - Monophyletic group of viruses whose properties can be distinguished from those of other species by multiple criteria
- Monophyletic - group that shares a most recent ancestor

Genetics - Study of heredity
Heredity - transmission of traits from one generation to the next
- DNA is the unit of heredity in humans, RNA in SARS-CoV-2

Humans are diploid - 2 copies of each chromosome (23 unique chromosomes) (22 somatic, 1 sex chromosome)

Only haploid cells in sperm and egg (Haploid (n) is 23))

Human Genomes
- DNA based
- 6 billion base pairs long (diploid)
- 30k genes

SARS-Cov-2 genomes
- RNA based
- Single stranded
- 30k bases
- 10 genes encoding 25 proteins

Character and traits are inherited
- Eye color

Alleles - individual units of inheritance
- Trait derive from genes
- Alternate form of a particular gene are called alleles

Phenotype - Physical traits
Genotype - Underlying genetic makeup, alleles it is carrying

Heterozygous - 2 different alleles
- Only 1 allele will usually determine organism's appearance

Capital letter is dominant trait, lower case is recessive trait
Punnett square - follows one character in a monohybrid cross

Law of segregation - 2 alleles for a character separate during gamete formation
Test cross - determines individual's genotype

Midterm Study Guide

Characteristics of Life - Order, Reproduction, Growth and Development, Energy Processing, Regulation, Response to the environment, Evolutionary adaptation

Viruses exhibit order, Reproduce but only using host cells, Don't grow and develop, Don't process energy, Don't regulate internal energy, Interact with environment but don't respond to it, And evolve

Herd Immunity - Spread of a disease ends because there are not enough susceptibles for the epidemic to keep a foothold in the population

R Naught - Reproductive number, beginning of epidemic r naught > 1
R Naught = Beta / V where

Electronegativities - Ability of an atomic nucleus to attract electrons

:Predict genotypes and phenotypes
- Monohybrid cross (Punnett Square)
- Test Cross

Soap
- Polar and Non-polar Molecule
- Micelles
- Polar Head with non polar tail

SIR
- Susceptible Individuals
- Infected individuals
- Recovered Individuals
    - SI, SIS, SEIR
- Parameters: beta - transmissibility
    - c - contact rate
    - t - probability of infection if contact occurs
    -v - recovery or removal rate

Dihybrid cross - 2 separate characters are studied
Gamete - Organism's reproductive cells (sex cells)

Sars-CoV-2 is evolving 2 mutations a month, half of influenza and a quarter of HIV

Human vs Sars genomes
Human - DNA based, 6 billion base pairs long in dipoid form, 30k genes
Sars - RNA based, signal strand 30k bases long, 10 genes that encode 25 proteins

Week 4

Immune system - tissues, cells, molecules that mediate resistance to infections
Immunology - study of structure and function of the immune system
Immunity - Resistance of a host to pathogens and their toxic effects
Immune response - Collective and coordinated response to the introduction of foreign substances in an individual mediated by the cells and molecules of the immune system

Immune System Role
- Defense against microbes
- Defense against growth of tumor cells
- Homeostasis
    - Destruction of abnormal or dead cells

Immune System Parts
1. Organ and Tissues
    - Skin as a barrier

    - Tonsils and adenoids
    - Thymus
    - Lymph nodes
    - Spleen
    - Appendix
    - Lymphatic vessels
    - Bone marrow
2. Cells
    - Lymphocytes
        - T-lymphocytes
        - B-lymphocytes, plasma cells
        - Natural killer Lymphocytes
    - Monocytes, Macrophage (Large white blood cells that eat other cells(dead or bad))
    - Granulocytes
        - Neutrophils
        - Eosinophils
        - Basophils
3. Molecules
    - Antibodies
    - Complement system
    - Cytokines (Telling rest of immune system that there is war in body)
        - Interleukines
        - Interferons

Two types of immunity

1. Innate (non-adaptive)
    - First line of immune response
    - Relies on mechanisms that exist before infection
    - Born with fully formed innate immune system
2. Acquired (adaptive)
    - Second line of response
    - Relies on mechanisms that adapt after infection
    - Handled T and B lymphocytes

Innate Immunity

- Based on genetic makeup
- Relies on already formed components
- Rapid Response
- Not specific: Same molecules/ cells respond to range of pathogens
- No memory

Key cells in innate immunity include several types of circulating white blood cells (leukocytes) and cells that reside in tissues

Natural killer cells - detect and kill stressed or infected host cells by releasing pro-apoptotic molecules

Cytokines, chemokines, histamine, and other proinflammatory mediators send signals to other immune innate immune cells and the cells of surround tissue which then allow proteins from the blood to enter the tissue and interact directly with pathogens

The innate immune receptors on these cells are able to bind to a wide variety of threats by recognizing common structures called pathogen-associated molecular patterns (PAMPS)

Infection from the beginning

- Sentinel cells (innate immune cells that are always present in tissues) are the first to recognize and respond to an invading pathogen
- When sentinel cells recognize PAMPS, they release pro-inflammatory mediators
- Pro-inflammatory molecules stimulate blood cells to become leaky
- Circulating complement proteins move from blood into affected tissue and bind to and kill pathogens
- Cytokines also stimulate blood vessels to attract circulating immune cells
- Neutrophils migrate into tissue - Detect, ingest, and kill pathogens
- Monocytes also migrate into the tissue - differentiate into macrophages which ingest and kill pathogens
- As pathogens and dead cells are cleared by macrophages, homeostasis is restored

Bees

- Have social and individual immunity
- Compared to fruit lies, honey bees have ⅓ of immune genes

Adaptive immune system is our body's defense against specific, repeated threats
Has

- Specificity : Adaptive immune system responds in a targeted way to specific antigens rather than general categories of pathogens
- Recognition of self : Can identify and respond to dangerous foreign molecules while ignoring harmless foreign molecules and molecules produced by our own body
- Memory : Adaptive immune system has responded to a threat, it will be able to do so more quickly and robustly in the future

Unique cells of adaptive immune system are called lymphocytes

1. T cells - recognize protein fragments presented on specific surface proteins and either kill pathogens or help other immune cells
2. B cells - lead production of antibodies, antibodies recognize many types of molecules and assist in the removal of pathogens in a variety of ways

All antibodies have same basic structural components

- Antigen recognition site is highly variable from one B cell clone to another and binds to antigens
- Constant region of an antibody is different for each of the different isotypes

Neutralization (IgM, IgG, IgA) - Process of binding to an antigen to prevent it from interacting with other molecules or cells

Complement fixation (igG and IgM) - ability of antibodies to active complement system

Opsonization - coating of the surface of a pathogen with molecules so that it is more easily recognized and ingested by immune cells

Antibody dependent cellular cytotoxicity (ADDC) - process by which IgG antibodies target natural killer cells to initiate cell death

Antibodies also mediate neonatal immunity, Maternal IgG transported through the placenta to the fetus for about 6 months

T-cell response to invading virus

- Pathogen such as a virus invades, initiating an innate immune response, Dendritic cells then travel to lymph nodes through circulation, dendritic cells ingest viralproteinss from dying cells, process these proteins into peptides that bind to MHC molecules, and display peptide- MHC complexes on cell surface
- In lymph nodes, naive T cells encounter these dendritic cells preventing viral peptides on an MHC molecule
- To become activated, naive T cell must receive 2 signals
- Once activated, naive T cell will undergo clonal expansion and differentiate into effector T cells, many effector T cells specific for the same presented antigen will be generated
- Effector CD8 cells are also called cytotoxic T lymphocytes (CTLs). These cells travel through the body and kill cells presenting the peptide-MHC 1 complex they recognize
- CTLs may also kill cells, such as tumor cells, presenting peptides from mutant proteins
- CD4 effector cells are also called helper T cells, these cells help other immune cells execute their functions
- Different subtypes of CD4 T cells have different functions
- After a T cell response has eliminated an infection, some long lived memory T cells specific for the microbe will remain on the body
- Thus, the T cell response, along with B cells and antibodies, protect us from repeated attacks by the same pathogens in our environment

mRNA vaccines

- Vaccine enters cell
- mRNA is releasd
- APCS present immunogens

RNAi to protect honey bees from DWV

DNA and RNA are polymers of nucleotides
- Nucleotides are composed of a nitrogenous, a 5 carbon sugar, and a phosphate group

Hydrogen bond between A-T and C-G in DNA (G-C has 3 hydrogen bond, A-T has 2)

Week 5

Information flows from DNA
- Information stored in 46 chromosomes

DNA directs production of RNA and RNA directs production of Proteins
- Proteins control Physical appearance

Transcription rewrites the DNA code into RNA, which then leaves the nucleus

Transcription follows the DNA base-pairing rules with 1 exception:
- Uracil is used instead of thymine

Molecule that results from transcription is called messenger RNA (mRNA)

In translation, RNA molecule servers as instructions for making a protein
- At the ribosomes in the cytoplasm, each mNRA codon is translated into an amino acid to build a protein

Transcription creats a molecule of RNA from a molecule of DNA
- During transcription, DNA double helix separates
- One strand of DNa is used to generate a molecule of RNA
- The RNA is processed to become messeneger RNA which exits nucleus via nuclear pore

Some key similarities and differences between RNA polymerase and RNA dependent RNA polymerase
- Template
  - DNA versus RNA
- Input
  - Nucleoside Tripohsphates
- Product
  - RNA

Translation involves three kinds of RNA: rRNA, mRNA, and tRNA
- Translation of mRNa takes place in cytoplasm within robosomes

- Ribosomes are made from proteins and ribosomal RNA
- Transfer RNA molecules carry amino acids to the ribosome

Ribosome start AUG

Translation creates a molecule of protein via genetic code
- Translation is divided into 3 phases
    - Initiation
    - Elongation
    - Termination

- Translation begins when 2 subunits of a ribisome assemble on an mRNA
- A tRNA brings in amino acids that match codon in mRNA

Translation results in a polypeptide
- Elongation continues until the ribosome reaches a stop codon on mRNA
- Ribosome machinery dissabembles
- Completed polypeptide is now available to be used or modified by cell into functioning protein

Capsid - Outer protein shell of a virus
Envelope - Enclosing structure or cover, such as a membrane
Filamentous - Having the form of threads or filaments
Isometric - Of or being a geometric system of 3 equal axes lying at right angles to each other (crystallography)

Fillamentous
- Ling and cylindrical, many plant viruses

Isometric (icosahedral)
- Spherical, such as poliovirus or herpesviruses

Enveloped
- Membrane surrounding capsids (HIV, SARS-Cov-2)

Head and Tail
- Infect bacteria - bacteriophages
- Head similar to icosahedral viruses
- Tail shape like filamentous viruses

Endoplasmic Reticulum (ER) is filled with membranes
- Smooth ER contains enzymes that produce lipids (steroid hormones)
- Rough ER contains ribosomes that produce many kinds of proteins
- ER is assembly line

Proteins are finalized and packaged in Golgi apparatus
- Golgi apparatus finishes, sorts, and ships cell products

- Golgi apparatus finishes cell products in vesicles, small bubbles made of membrane
- Shipping and receiving

Week 6

Gene expression, production of proteins, is regulated by

1. Gene regulation is the process of turning genes on and off
2. Difference cell types express different genes

DNA Methylation

- Methylated DNa is a promoter sequence blocks transcription

Translation offers more opportunities for gene regulation
Cell can control

- Whether translation proceeds
- How proteins are modified after translation
- When proteins are broken down

Cell to cell communication is particularly important in a developing embryo

- Development involves frequent cell division (to increase body size) that must be carefully coordinated

Positive-strand RNA Viruses

- Genome serves as an mRNA
- The first synthetic event in the replication cycle is protein synthesis
- Genome replication is cytoplasmic
- Genomes of positive strand RNa viruses fold into complex structures. These RNa structural elements have key roles in genome replications, transcription, and translation
- Purified genomes (or chemically synthesized genomes) are infectious if introduced into a permissive cell

Positive Strand Viruses

1. Ribosome assembly and translation of some or all viral proteins from the genomic RNa. Key among these is the RdRp
2. RdRp synthesizes a complementary copy of the genome
3. The copy genome or cRNA serves as a template for the synthesis of additional mRNAs and genomes
4. Viral mRNAs are translated. Viral genomes are packaged

A mutation is any change in the nucleotide sequence of DNA

- Replacing, deleting, or adding a nucleotide base can have a wide range of effects
- Mutations are the raw material of evolution by natural selection
- However, most mutations are harmful

Mutations in DNA can change the protein produced
Mutations can be

- Spontaneous
- Induced by mutagens
    - High energy radiation
    - Chemicals

Point mutations can have varying effects
Point mutations occur at a single nucleotide

Frameshift mutations are due to the addition or deletion of a nucleotide

Furin is a host enzyme that cuts the spike protein and allows cell entry

Cells can be grouped into two categories
Prokaryotic cells

- Bacteria and Archaea

Eukaryotic cells

- Plants, Animals, Fungi, and Protists

Plant and animal cells have many organelles in common

- All eukaryotic cells are fundamentally alike
- All eukaryotic cells share
    - Plasma membrane
    - Nucleus
    - Mitochondria

The nucleus houses the chromosomes

- DNA molecules are warped around proteins to form fibers called chromatin
- Each very long chromatin fiber twists and folds to form a chromosome

Only eukaryotic cells contain organelles surrounded by membranes

- The most prominent membrane-enclosed organelle is the nucleus
- If you think of a cell as a factory, nucleus is central office

Nucleus - Contains instructions
Endoplasmic Reticulum - Makes proteins
Golgi Apparatus - Modifies and packages proteins
Plasma membrane - Controls traffic in and out of cell
Mitochondria - Produces energy

Protein production

1. Transcription in the nucleus results in the production of RNA from DNA
2. Translation at the ribosomes results in production of proteins

Endoplasmic Reticulum is filled with membranes

1. Smooth ER contains enzymes that produce lipids

2. Rough ER contains ribosomes that produce many kinds of proteins
3. ER is assembly line

Proteins are finalized and packaged in Golgi apparatus
Golgi apparatus finishes, sorts, and ships cell products
Golgi apparatus finishes cell products in vesicles, small bubbles made of membrane
Shipping and receiving

Two organelles help provide energy for the cell
- Chloroplasts are found in all plant cells and the cells of some algae
- Mitochondria are found in both plant and animal cells
- Mitochondria are the cells power plant

All prokaryotes are relatively simple single-celled organisms
- There are two domains of prokaryotes: Bacteria and Archaea
- Prokaryotic fossils date back at least 3.5 billion years

Bacteria have some unique features and some features common to all cells

What are you really made of?
- Scientists estimate that only half of the cells in your body are actually human, rest are largely prokaryotic cells, these good bacteria help us digest food, synthesize vitamins and protect against disease

Week 7

Passive transport requires no energy
- Substances move along concentration gradient from high to low

Active transport requires energy
- Substances move against a concentration gradient from low to high

Diffusion - movement of molecules from area of higher concentration to an area of lower concentration (Passive)

Diffusion of water is called osmosis
Water will always flow from area of higher water concentration to an area of lower water concentration

Hypertonic - Greater solute on outside than inside (Water leaks out)
Isotonic - Water molecules are going in and out at the same rate (Good for red blood cells)
Hypotonic - Higher concentration inside compared to outside (Water moving in)

Glycoprotein - Protein with carbohydrate attached
Glycolipid - Lipid with carbohydrate attached

Facilitated diffusion - Large molecules can move through embedded transport proteins
Substances still move from an area of higher concentration to area of lower concentration

Active transport requires energy to move substances
- Usually driven by a protein that sits within membrane

Endocytosis - Cell absorbs mRNA

Midterm 2 Study Guide

Cells in innate immune system
- Lymphocytes: White blood cell in immune system
    - T-lymphocytes: Develop from stem cells and bone marrow that fight infections and cancer
    - B - lymphocytes plasma cells: Develop from stem cells and provide defense against pathogens through antibody production
    - Natural killer lymphocytes:
- Monocytes: Type of white blood cell that becomes macrophage or dendritic cell, Macrophage: Surround and kill microorganisms, ingest foreign material, remove dead cells
- Granulocytes: Help body fight bacterial infections
    - Neutrophils: patrol organisms for signs of infections and trap and kill pathogens
    - Eosinophils: help fight off infections, build up and cause inflammation
    - Basophils: immune surveillance, help detect and destroy early cancer cells

Immune System:
- Skin as barrier
- Tonsils and adenoids
- Thymus
- Lymph nodes
- Spleen
- Appendix
- Lymphatic vessels
- Bone marrow
- Antibodies
- Complement System
- Cytokines
    - Interleukines
    - Interferons

Adaptive:
- T cells
- B cells
- Antibodies

DNA:

- Adenine binds with Thymine (2 hydrogen bonds)
- Guanine binds with Cytosine (3 hydrogen bonds)

RNA goes from 5 prime to 3 prime end
DNA goes from 3 prime to 5 prime end

3 prime connects to OH
5 prime connects to Phosphate group

Can only be built off of 3 prime end of DNA

NSP1 suppresses host innate immune functions, and blocks mRNA from attaching to ribosome which blocks translation

Viruses can infect: Plants, Animals, Fungi, Bacteria

Viruses are single or double stranded RNA or DNA

Mutations:

- High energy radiation
- Chemicals

Point Mutations occur at single nucleotide
Silent Mutation: Same Amino Acid
Missense: Changes Amino Acid
Nonsense: Stop Amino Acid
Frameshift: Adds or removes DNA

A in DNA turns to U in RNA
C in DNA turns to G in RNA

Table is for mRNA

mRNA vaccines pros:

- Adaptable
- Quick updates
- Quicker and more reliably manufactured

mRNA vaccines cons:

- Not as stable at high temperatures
- Unknown long term effects
- Has to be kept cold to preserve structural integrity

mRNA vaccines

- Codes for a portion of spike protein

- Does not modify genome
- Degrades over time
- Translated via ribosomes
- Does not stay in cells permanently
- Creates a protein that is recognized by our cells as something that shouldn't be there

Osmosis - Diffusion of water where water will always flow from area of higher water concentration to lower water concentration
(Water will go where there are more molecules) - Water molecules will hit the big molecules and have a less chance of moving over to the other side

CRISPR/Cas9 is the adaptive immune system of bacteria. It remembers phage pathogens by capturing part of their genome in the CRISPR locus, powerful tool to edit genomes
CRISPR steps

1. DNA Invasion
2. Invading DNA is incorporated into CRISPR Array
3. Pre cRNA Transcription
4. Guide RNA Formation
5. Cas9 Activation
6. Target Binding
7. Target Cleavage

PCR Test for DWV

1. Denature DNA (94-96 Degrees)
2. Anneal Primers (50-65 Degrees)
3. Extend Primers (72 Degrees)
4. Second cycle
5. Third
6. Fourth

PCR detects DWV RNA after it has been reverse transcribed into DNA

RNA vs RNA dependent RNA polymerase

- Template
    - DNA vs RNA
- Input
    - Nucleoside Triphosphates
- Product
    - RNA

mRNA vaccine enters cell through endocytosis
Endocytosis - Substances are brought into cell by engulfing in with cell membrane

Viral Replication:

1. Influenza virus becomes attached to target epithelial cell

2. Cell engulfs virus by endocytosis
3. Viral contents are released and Viral RNA enters nucleus where is replicated by viral RNA polymerase
4. Viral mRNA is used to make viral proteins
5. New viral particles are made and released into extracellular fluid, cell continues making new virus

Elements present during viral replication
- Nucleus
- Virus
- Epithelial cell
- mRNA
- RNA polymerase

Golgi apparatus and Endoplasmic Reticulum are directly utilized by SARS-CoV-2

Week 8

Hypothesis includes how or why and is a testable explanation

Scientific method is a series of steps that can provide insight about the natural world

We can reject hypotheses, but never prove them

Science can be
- Experimental
    - Design experiments to isolate one factor and determine causality
- Descriptive
    - Observation based
    - Correlations or associations between factors
    - Does not prove causation
    - Allows scientists to identify patterns that can then be tested with experiments

In a controlled experiment, test is run multiple times by changing one variables

Independent variable- what is being manipulated as a potential cause
Dependent variable - response, output, or effect under investigation

Control group establishes baseline
- Negative control is group which no change is expected
- Positive control is a group where change is expected

Science is self correcting

Scientific thinking can be distinguished from other ways of viewing the world

- Science is one way of knowing the world
- Science has hallmarks and limitations
- Pseudoscience is any field of study is falsely presented as having a scientific basis

Cognitive Bias

- Brains use shortcuts
- Can lead to illusions

Primary source - Original material presented for the first time by person who performed research
Secondary resource- Description or review of primary sources, often containing commentary

Peer review - evaluation of work, qualified often anonymous experts who are not involved in that work

Week 9

Media

- Splashy, clear results
- Simple, unambiguous interpretation
- Keeps consumer's attention

Science

- Mostly incremental advances
- Not ambiguous
- Usually only interesting to others in same field

Science is often ambiguous

- Hypothesis driven
- Can only reject null hypothesis
- Supports but does not prove alternative hypothesis
- New data can change our views
- Any single study may have flaws in interpretation or execution
- Hypothesis needs multiple lines of evidence to be supported

Study shows vaccines protect you from getting COVID-19
Length of infection in vaccinated versus unvaccinated people is shorter

Plant mass come from the air

Calvin Cycle

- 3 Carbon sugar is from output from Calvin Cycle
- Plant uses G3P to generate glucose
- Glucose can be used for energy right away, or stored

Plants store glucose in 2 ways
Both ways represent many glucose molecules stitched together

CO_2 absorbs and re-emits infrared radiation

Parts per million
- Concentration of a substance

Final Study Guide

1. properties of life and viruses
    Properties of Life
    - Order
    - Reproduction
    - Growth and Development
    - Energy Processing
    - Regulation
    - Response to environment
    - Evolutionary adaptation

    Viruses
    - Exhibit Order
    - Reproduce but only using host cells
    - Do not grow and develop
    - Do not process energy
    - Do not regulate internal environment
    - Interacts with environment but don't respond to it
    - Viruses evolve
2. Dihybrid crosses and gametes
    - Dihybrid Cross is one which two separate characters are studied
    - Gametes : BbDd
3. Interpret a graph on herd immunity and R nought.
    - Herd Immunity: when spread of a disease ends because not enough susceptibles for the epidemic to keep a foothold in population
4. Use logic to order specific molecules/cells by size.
    1. Water
    2. Soap
    3. Virus
    4. Human Cell
5. Use electronegativites to predict bonds.
    Electronegativity table
6. Characteristics of RNA dependent RNA polymerase.
    - RNA template
    - Nucleoside triphosphates input

- RNA product
  COVID 19
- Enzyme
- Copies SARS-Cov-2 genome
- Copies viral RNa that host machinery turns into proteins

7. Structure of DNA/RNA, similarities and differences between DNA & RNA.
   - RNA has OH instead of H
   - DNA (deoxyribose) has no O
   - Thymine in DNA
   - Uracil in RNA
   - Both have sugar phosphates
   - Single stranded vs double stranded
8. Predict phenotypes and genotypes
   Punnett squares
9. Interpret the reproductive number (R naught).
10. SIR models - how does human behavior affect the parameters?
    S - susceptible
    I - infected
    R - recovered
11. DNA replication - identify 5' versus 3'.
    Can only be built off of 3 prime end of DNA
12. RNA transcription - identify 5' versus 3'.
13. given a strand of DNA in the 5'-3' direction tell me the complementary strand in the 3'-5' direction
    - Guanine with Cytosine
    - Thymine with Adenine
14. Match DNA bases based on H bonds.
    - Adenine binds with Thymine (2 hydrogen bonds)
    - Guanine binds with Cytosine (3 hydrogen bonds)
15. translate RNA to amino acids

16. identify a mutation based on anticodon sequence.
    Nonsense - Stop codon
    Missense - Different Amino Acid
    Silent - Same amino Acid
    Frameshift - Add or minus one nucleotide
17. Osmosis and solute concentrations.
    - Water flows from higher concentration to lower concentration (Passive)
18. understand how mRNA vaccines work with the immune system.
    1. Vaccine enters cells
    2. mRNA is released
    3. Immunogens are built
    4. APCS present immunogens
    5. Activates T and B cells

6. Attacks virus infected cells and helps increase length of protection

19. Describe the cell as a factory analogy.
    - Mitochondria: Power plant
        - Plasma membrane - Security
        - Golgi apparatus - Shipping and receiving
        - Endoplasmic reticulum - Assembly line
        - Nucleus - Central office
20. Know the parts of the cell that SARS-CoV-2 interacts with.
    1. Plasma membrane
    2. Ribosomes
    3. Endoplasmic reticulum
    4. Golgi apparatus
21. Know the characteristics of preprints and peer-reviewed publications.
    Preprints
        - Have not gone under peer review
        - Communicates research in real time

    Peer review
        - Not just junk

22. Know the characteristics of science and pseudoscience.
    Science
        - Mostly incremental advances
        - Not unambiguous
        - Usually only interesting to others in same field
        - Hypothesis
        - Scientific Method
        - Reject hypotheses but never prove
        - Hallmarks and limitations
        - One way of knowing the world

            - Adheres to a well recognized scientific method
            - Repeatable results
            - Testable claims that can be disproven
            - Open to outside review
            - Multiple lines of evidence

    Pseudoscience
        - Not adhere to generally accepted processes
        - Cannot be duplicated, rely on single person
        - Unprovable or untestable
        - Rejection of externa review
        - Over Reliance on small amount of data

-

23. identify trustworthy sources of information (and not trustworthy sources).
    Trust:

Society journals
Listed in JCR
Experts
No financial interests

24. Understand how to design a study well (e.g. random sampling).
    Negative control - group where no change is expected
    Positive control - change is expected
25. Describe a double-blind study.
    Information is withheld from both participants
26. Dependent and independent variables.
    - Independent variables - What is being manipulated as potential cause Ex: flour type
    - Dependent variables - Response, output, or effect under investigation Ex: Cookie height
27. Immune memory and disease dynamics.
    - Mathematical models based on equations, assumptions, and parameters
        - Immune memory is in phase 2 of vaccine development,
28. SIR models and vaccines.
    - Recovery rate
    - Probability of infection if contact occurs are affected by vaccination
29. The carbon cycle.
30. Interpret graphs with correlation and causation in mind.
31. Data visualization: when should Y axes include zero or not? How does changing the scale or orientation of an axis lead to misinterpretation? What is a violation of the principle of proportional ink?
    - Bar chart axis should include 0
    - Line graphs don't need 0
    - Principle of proportional ink: shaded region is used to represent a numerical value, area should be proportional
32. Photosynthesis: where do trees get carbon, where does it go, and how does climate change affect photosynthesis.
    - Mass of plant comes from air
    - Trees get carbon from carbon dioxide
    - Carbon dioxide goes into soil and air

33. Calling BS - interpret the validity of a blog or social media post.
34. Interpret an abstract from a published paper.