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100 SHEETS

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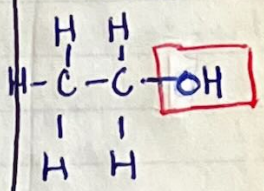
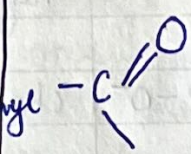
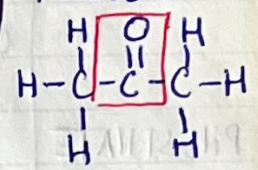
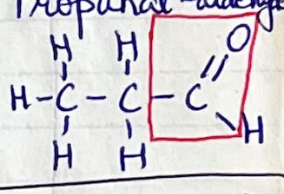
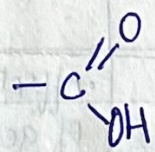
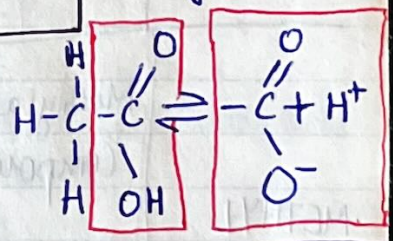
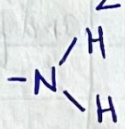
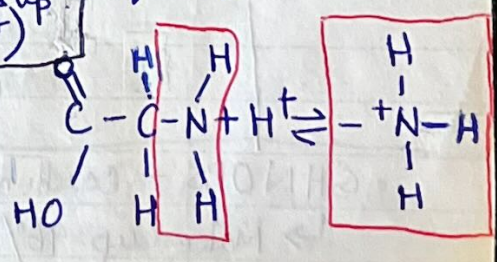
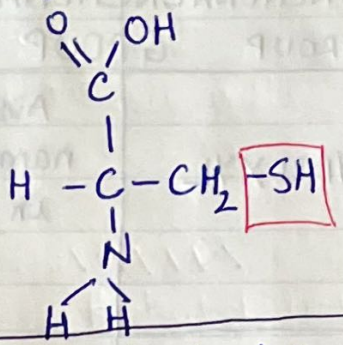
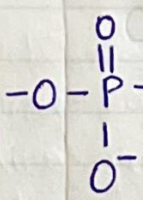
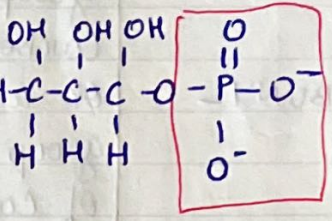
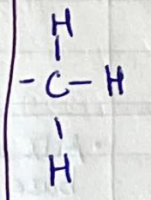
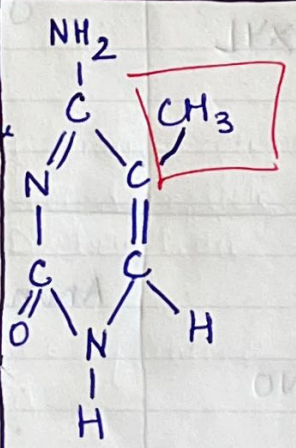
CHEMISTRY OF LIFE.

- FUNCTIONAL GROUPS

FUNCTIONAL GROUP	COMPOUND NAME	STRUCTURE	PROPERTIES	EXAMPLE
HYDROXYL	Alcohol (specific name usually ends in -ol)	-OH or HO-	• Polar • Forms H bonds with H_2O ↳ Helps dissolve compound	Ethanol 
CARBONYL	Ketone (carbonyl group is within carbon skeleton) or aldehyde (carbonyl group is at end of carbon skeleton)	>C=O 	• Polar	Acetone-ketone  Propanal-aldehyde 
CARBOXYL	Carboxylic acid or organic acid	-COOH 	• Acidic (donates H^+)	• Acetic acid ⇌ Ionized form of carboxylate ion 
AMINO	Amine	$-NH_2$ 	• Acts as base (picks up H^+)	Glycine ⇌ Ionized form of $-NH_2$ 

FUNCTIONAL GROUP	COMPOUND NAME	STRUCTURE	PROPERTIES	EXAMPLE
SULFHYDRYL	Thiol	$-SH$ or SH^-	• Two thiol groups can react forming a disulfide bridge – helps stabilize protein structure	Cysteine 
PHOSPHATE	Organic phosphate	$-OPO_3^{-2-}$ 	• contributes negative charge ↳ one inside chain of phosphate ↳ two when at the end • When attached allows a molecule to react with H_2O releasing energy	Glycerol phosphate 
METHYL	Methylated Compound	$-CH_3$ 	• Affects expression of genes when on DNA or protein bound to DNA • Affects shape and function of sex hormones	

• CHNOPS – carbon, hydrogen, nitrogen, oxygen, phosphorus, sulphur
↳ Make up 96% of the mass of all living things

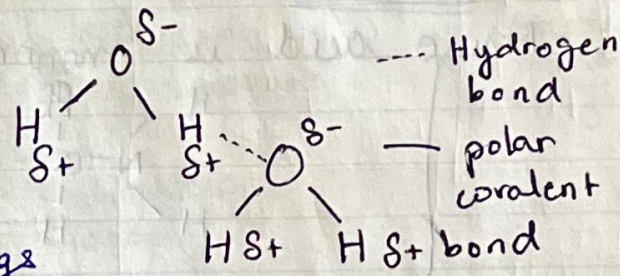
CHEMICAL BONDS.

IONIC "steal" electrons
- charged ions

Polar Covalent "shared" unequally
- partially charged regions

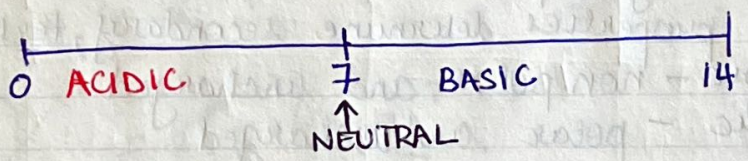
Non-polar covalent "shared" equally
- no charges

Hydrogen bond attraction between partial +ive and partial -ive of molecules
- not a real bond



WATER
- Polar molecule
- Cohesion → sticks to itself
- adhesion → sticks to other things
- surface tension → tension on surface
- high specific heat → resists change in temp.
- expands when frozen → H bonds keep molecules apart
  ↳ insulates water below it

pH.



- ACIDS release H^+
- Bases release OH^-
- $pH = -\log(H^+ \text{ concentration})$
- change in one pH number is ten fold change in H^+ concentration

ORGANIC MOLECULES
- organic compounds contain C and H atoms
- Macro molecules are chains of building rocks called polymers, which are made up of monomers

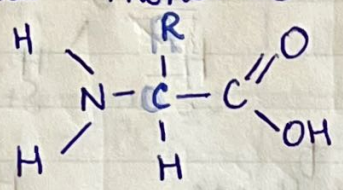
CARBODYDRATES
- $(CH_2O)_n$
- Saccharide – sugar
- Monosaccharide – glucose, fructose, glactose, (deoxy)ribose
- Dehydration synthesis – hydrogen from one sugar combines with hydroxyl group of another sugar molecule
  ↳ creates one H_2O molecule and bonds sugars together

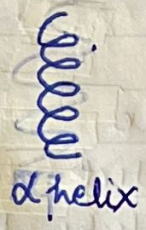
↳ Bond called glycosidic linkage

- Hydrolysis – Adds H_2O molecule and breaks sugars
- Polysacchrides – Polymers of monosacchrides
  - ↳ Starch – sugar storage molecule
  - ↳ Glycogen – sugar storage molecule
  - ↳ Cellulose – structural element of plant cell walls

PROTEINS.

- Amino acid is monomer





β pleated sheet

  - ↳ Four parts
    - ↳ central carbon bonded to hydrogen
    - ↳ amino group ($-NH_2$)
    - ↳ carboxyl group ($-COOH$)
    - ↳ R-group or side chain
- Side chain properties determine secondary, tertiary structure
  - ↳ Hydrophobic – non polar and uncharged
  - ↳ Hydrophylic – polar and uncharged
  - ↳ Ionic – polar and charged
- Polypeptide – Polymer of amino acids
  - ↳ Formed with dehydration synthesis
    - ↳ OH of carboxyl group and H of amino group
  - ↳ Bond between two amino acids called peptide bond
  - ↳ Polypetide is string, protein is 3D structure
- Structure
  - ↳ Primary structure – linear sequence of amino acids
  - ↳ Secondary structure – Twist or fold
    - ↳ α helix or β pleated sheet
  - ↳ Tertiary structure – Amino acids far away in sequence can interact
    - ↳ Locks into stable 3D shape, minimizes free energy
  - ↳ Quaternary structure – different polypetides interact

- Folding of proteins sometimes involves chaperone proteins (chaperonins)

LIPIDS

- Triglycerides, phospholipids, steroids

Triglycerides
- Glycerol bonded to three fatty acids
- Carboxyl group of fatty acid bonds to hydroxyl group of glycerol molecule
  - ↳ Dehydration synthesis
  - ↳ called ester linkage

Phospolipids
- Glycerol bonded to two fatty acid 'tails' and one -ively charged phosphate 'head'
- Tails are hydrophobic, Head is hydrophylic
- Amphipathic molecule

Steroids
- Cholestrol
  - ↳ Increases membrane fluidity

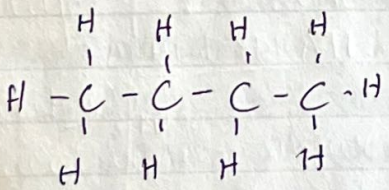
NUCLEIC ACIDS

- Made up of nucleotides
- Phosphate group, five carbon sugar, nucleotide
- DNA and RNA

$$\chi^2 = \sum \frac{(O-e)^2}{e}$$

Fatty Acids

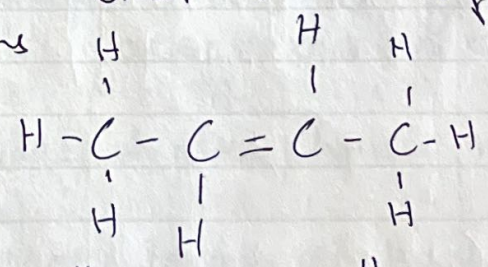
Saturated



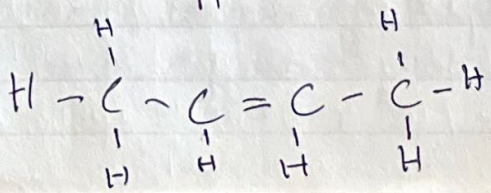
solid @ room temp.

Unsaturated — liquid @ room temp.

trans



cis



CELL STRUCTURE AND FUNCTION

- All living things are composed of cells
- surface area to volume ratio greater allows for more cell-enviornment exchanges
- 2 types of cell - Prokaryotic and Eukaryotic
  - → Prokaryotic has no nucleus - DNA is one continuous circular molecule found in the nucleoid
    - → Most have a cell wall
    - → Smaller ribosomes than Eukaryotic cells
    - → Some bacteria may have flagella - long projections used for movement
    - → Bacteria and archaea
  - → Eukaryotic - organized into smaller structures called organelles
    - → Fungi, protists, plants and animals
- Organelles and cells bound by plasma membrane - Phospholipid bilayer
- Endosymbiotic theory - Mitochondria and chloroplast used to be independent prokaryotic cells then were engulfed by eukaryotic cells

ORGANELLES

- Plasma Membrane - Hydrophobic tails face each other, hydrophilic heads face enviornment and cytoplasm
  - → semipermeable - small hydrophobic molecules pass through
  - → Fluid-mosaic model - each layer of phospholipids is flexible and peppered with different proteins and carbohydrate chains

↳ Proteins fall into categories
- → Adhesion proteins - form junctions between adjacent cells
- → Receptor proteins - accept ligands
- → Channel proteins - allow passive transport
- → transport proteins - help with active transport
- ↳ cell surface markers - help with cell recognition

• Nucleus
- → largest organelle in the cell
- → holds DNA
  - ↳ organized in chromosomes
- ↳ nucleolus - where rRNA is made and ribosomes are assembled

• Ribosomes
- → sites of protein synthesis
- → composed of large and small sub-unit
- → composed of rRNA and proteins
- ↳ found either free floating or attached to ER

• Endoplasmic Reticulum (ER)
- → region attached to nucleus and studded with ribosomes called rough ER (RER)
- ↳ smooth ER (SER) - lacks ribosomes, makes lipids, hormones and steroids and breaks down toxic chemicals

• Golgi Bodies
- → looks like stacks of flattened sacs
- → golgi bodies modify process, and sort proteins synthesized by RER
- → package final products in vesicles
- ↳ also involved in production of lysosomes

• Mitochondria
- ↳ powerhouse of the cell

↳ produce ATP
↳ double membrane
  ↳ inner membrane forms folds known as cristae
    ↳ separates matrix (inner most area) from inter-membrane space

- Lysosomes
  ↳ carry digestive enzymes
  ↳ breakdown worn out organelles, debris, or large ingested particles
  ↳ very acidic
  ↳ important for apoptosis
- Centrioles
  ↳ small, paired, cylindrical structures
  ↳ found within microtubule organizing centers (MTOCs)
  ↳ important for mitosis
  ↳ common in animal cells, not found in most plant cells
- Vacuoles — fluid filled sacs that store water, food, wastes, salts, or pigments
- Peroxisomes
  ↳ detoxify various substances
    ↳ produce hydrogen peroxide (H_2O_2) as by product
  ↳ common in animals liver and kidney cells
- Cytoskeleton
  ↳ determines shape of cells
  ↳ microtubules participate in cellular division and movement
    ↳ made up of protein tubulin
  ↳ microfilaments
    ↳ assist during cytokinesis
    ↳ made up of the protein actin
- Cilia and Flagella
  ↳ thread like structures
  ↳ used for movement in single celled organisms

PLANT VS. ANIMAL CELLS

- Plant cells have a cell wall made of cellulose outside the plasma membrane
- In fungi cell wall is made of chitin
- Plant cells have chloroplasts
- Most of cytoplasm in plant cell is taken up by central vacuole

TRANSPORT

- Facilitated transport – molecules need assistance to pass through bilayer
- Passive transport – no outside energy required
  - ↳ simple diffusion – diffusion of small non polar molecules down concentration gradient
  - ↳ Facilitated diffusion – simple diffusion, but through channel protein
- Active transport – outside energy required
  - ↳ transport protein moves molecule against concentration gradient

DIFFUSION, OSMOSIS, AND WATER POTENTIAL

- Diffusion – solute moves toward equilibrium
  - ↳ occurs if membrane is permeable to both solvent and solute
- Osmosis – solvent moves toward equilibrium
  - ↳ occurs if membrane is permeable to solvent but impermeable to solute
- Tonicity – describes osmotic gradients
  - ↳ if enviornment is isotonic to cell solute concentration is same inside and outside cell
  - ↳ hypertonic solution has more dissolved solutes than cell, hypotonic has less
- "Osmotic" used instead of tonic when comparing two solutions

- Water Potential (Ψ) – Potential energy of water
  - → $\Psi = \Psi_s + \Psi_p$
    - → Ψ_s is solute potential
    - → $\Psi_s = -iCRT$
    - → Ψ_p is pressure potential
  - → water flows from areas of high water potential to areas of low water potential

ENDOCYTOSIS, EXOCYTOSIS, BULK FLOW, AND DIALYSIS

- Endocytosis – portion of cell membrane engulfs substance and forms vacuole or vesicle
  - → pinocytosis – cell ingests liquid
  - → phagocytosis – takes in solids
  - → receptor-mediated endocytosis – ligand is brought into the cell
- Bulk flow – one way movement of fluids caused by pressure
- Dialysis – diffusion of solutes across a selectively permeable membrane
- Exocytosis – ejects waste products by the fusion of a vesicle with the plasma membrane

CELLULAR ENERGETICS

FIRST LAW OF THERMODYNAMICS – sum of energy in the universe is constant

Second Law of thermodynamics – as the number of energy transfers in the universe increases, so does its entropy

TYPES OF REACTIONS

- Exergonic – products have less energy than the reactants
- Endergonic – products have more energy than the reactants
- Activation energy – molecules must reach transition state for reaction to happen; activation energy gets reactants to transition state

ENZYMES

- Enzymes are biological catalysts that speed up reactions (lower activation energy)
- Enzymes specificity – each enzyme catalyzes only one kind of reaction
- Targeted molecules known as substrates
- Substrates bind to enzyme's active site, forming an enzyme-substrate complex
- Enzymes are unaffected by the reaction
- Enzymes neither change the reaction nor cause a reaction that would not have occurred otherwise
- Enzyme changes its shape slightly to accomodate substrate (induced-fit)
- Enzymes work with cofactors
  - ↳ If organic, called co enzymes
  - ↳ Inorganic cofactors are usually metal ions
- Factors affecting reaction rates
  - ↳ temperature – rate of reaction ↑ with temp upto a certain point after which enzyme becomes denatured

↳ all enzymes operate at an ideal temperature (37°C for most human enzymes)

→ pH – enzymes function best at a particular pH (7 for most enzymes)

↳ at an incorrect pH H bonds are disrupted and enzyme's structure can be altered

→ Relative concentration of substrings – initially increase in substrate concentration will speed up reaction, but once all the enzyme is bound by substrate reaction will no longer speed up (saturation point)

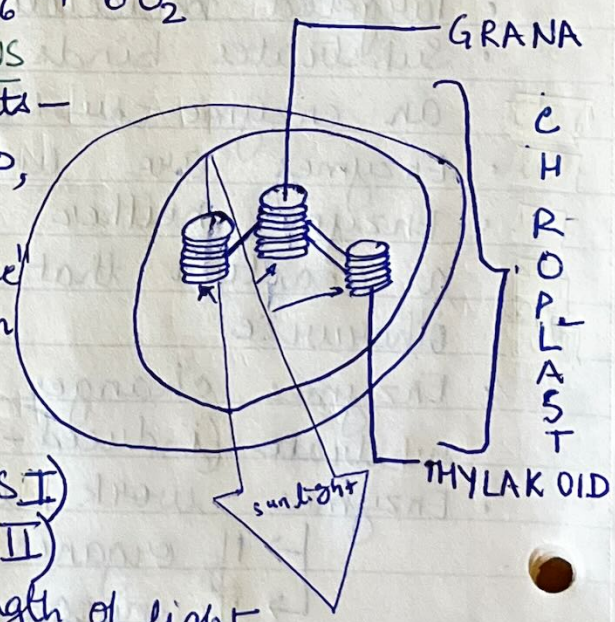
- Enzyme Regulation
  - ↳ competitive inhibition – a substance bonds to the active site of an enzyme
  - ↳ non competitive inhibition – allosteric inhibitor binds to allosteric site and distorts shape of enzyme so that it can't function

PHOTOSYNTHESIS

- $6CO_2 + 6H_2O \xrightarrow{light} C_6H_{12}O_6 + 6O_2$

LIGHT-DEPENDENT REACTIONS

- Light absorbing pigments – chlorophyl a, chlorophyl b, carotenoids
- Antenna pigments "bounce" photons toward reaction center
- Reaction centers
  - → Photosystem I (PSI)
  - → Photosystem II (PSII)
  - → Differ in wavelength of light they absorb



- PSII passes activated electrons to carriers in ETC

PS II and PS I in thylakoid membrane
Calvin cycle happens in chloroplasts

- H_2O is split into O, H^+, and e^- (photolysis)
  ↳ Replenishes electrons in thylakoid
- After passing through PS II ETC and producing ATP, they pass through PS I ETC to produce NADPH
- Some plants perform cyclic electron flow (no PS II)

LIGHT INDEPENDENT REACTIONS:

- Also called Calvin cycle
- Uses ATP and NADPH from light reactions to fix CO_2 to form glucose (carbon fixation)
- Plants in hot climates - take in CO_2 when possible, store in chemicals and perform CF later
  ↳ CAM plants separate carbon fixation and the Calvin cycle - open stomata at night
  ↳ C_4 plants perform carbon fixation in different part of the leaf than the rest of the Calvin cycle

CELLULAR RESPIRATION

- $C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O + ATP$

AEROBIC RESPIRATION

- Oxygen is present

Glycolysis

- Glucose + 2ATP + $2NAD^+$ ⟶ 2 Pyruvic acid + 4ATP + 2NADH
- occurs in cytoplasm

Formation of Acetyl-CoA

- Each pyruvic acid is converted to acetyl-CoA and CO_2 is released
  ↳ Catalyzed by PDC
- 2 pyruvic acid + 2 CoA + $2NAD^+$ → 2 Acetyl-CoA + $2CO_2$ + 2NADH

Krebbs Cycle

- occurs in matrix of mitochondria
- Each Acetyl CoA enters Krebbs cycle and both carbons are converted to CO_2
- Acetyl CoA combines with oxaloacetate to produce citric acid and eventually turns back into oxaloacetate

- With each turn of the cycle one ATP, 3NADH, and 1 $FADH_2$ are produced

<u>Oxidative Phosphorylation and Chemiosmosis</u>

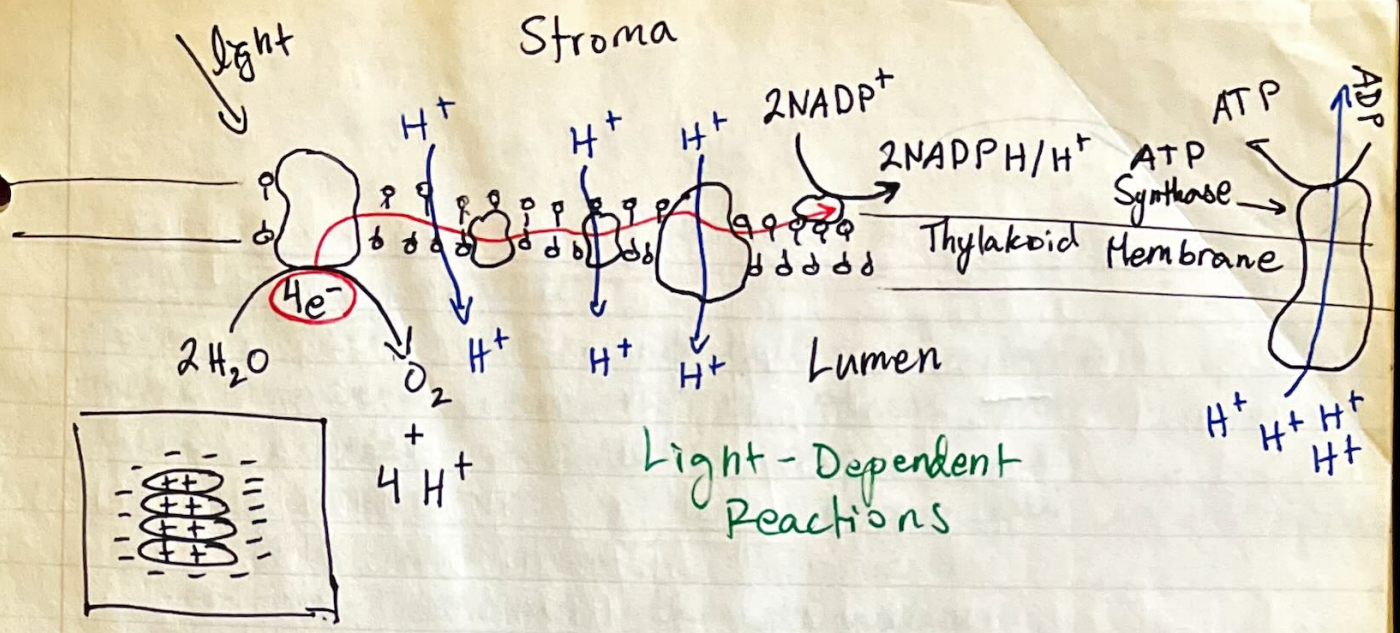
- Electron carriers (NADH and $FADH_2$) move electrons to electron transport chain (ETC)
- High energy electrons are passed down a series of protein carrier molecules embedded in the christae
- Electrons travel down chain until they combine with oxygen and hydrogen ions to form water
- Energy released from ETC is used to pump H^+ into the inter membrane space
  - ↳ establishes pH or proton gradient
- As H^+ diffuses back into matrix, it allows ATP synthase to combine ADP and P_i
- Each NADH from glycolysis produces 1.5 ATP and all other NADH molecules produce 2.5 ATP
- Every $FADH_2$ produces 1.5 ATP

<u>ANAEROBIC RESPIRATION</u>

- occurs in the absence of oxygen

1 glucose $\xrightarrow{\text{glycolysis}}$ 2 pyruvic acid + 2NADH $\xrightarrow{\text{fermentation}}$ 2 lactic acid + $2NAD^+$

2 pyruvic acid $\xrightarrow{\text{fermentation}}$ 2 ethanol + CO_2 + $2NAD^+$



Light-Dependent Reactions

CELL COMMUNICATION AND CELL CYCLE

CELL COMMUNICATION

- Quorum sensing - using cell communication to make their numbers known to other membranes of their species (unicellular organisms)
- Taxis - movement of an organism in response to a stimulus
  - → +ive - toward the stimulus
  - → -ive - away from the stimulus
  - → chemotaxis - movement in response to chemicals
- Signalling can be long range (affecting cells throughout the organism) or short range (affecting only nearby cells)
  - → done through cell junctions or ligands (signalling molecules) that bind to receptors and trigger a response
- Signal Transduction - the process by which an external signal is transferred to the inside of a cell
  - → 1. Signalling molecule binds to specific receptors
    2. Activation of a signal transduction pathway
    3. Production of a cellular response

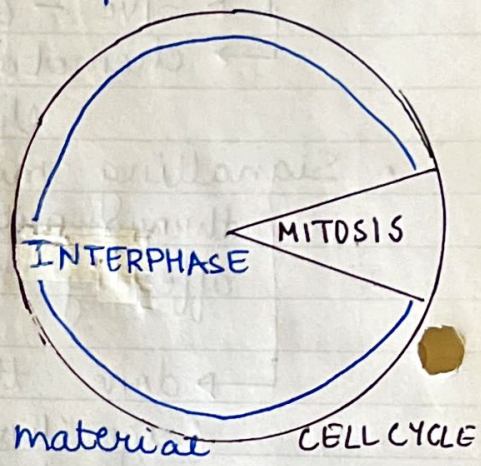
CLASSES OF MEMBRANE RECEPTORS

- Ligand-gated ion channels - open an ion channel upon binding a particular ligand
- Catalytic (enzyme-linked) receptors - ligand binding initiates enzymatic activity on active site of enzyme (located inside cytoplasm)
- G-protein-linked receptor - binds a different version of a G-protein (often GTP or GDP) on the intracellular side when ligand is bound

- Signal transduction cascades amplify a signal
- Homeostatis – the set of conditions under which living things can successfully survive
  - → -ive feedback pathway (feedback inhibition)
    - – uses end product of pathway which inhibits the process from beginning
  - → +ive feedback pathway – end product further stimulates pathway

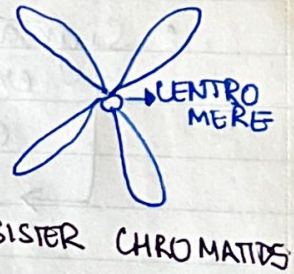
CELL DIVISION

- Cells lifecycle is known as cell cycle



INTERPHASE

- Time span from one cell division to another
- S Stage
  - → cell replicates genetic material
- G_1 and G_2 Stages
  - → cell cycle check points – control mechanisms that make sure cell division is happening properly
  - → Highly regulated by check points, 'cylins'; and cylin-dependant kinases (CDKs)
    - → to inhibit cell cycle progression, CDKs and cyclins are kept separate
  - → If DNA damage cannot be repaired, cell can undergo apoptosis (programmed cell death)



CANCER

- Mutated genes that induce cancer are called oncogenes
- Tumor suppressor genes produce proteins that prevent the conversion of normal cells into cancer cells

MITOSIS

PROPHASE

- Cell prepares to divide
- Diffused chromatin condenses into chromosomes
- Nucleolus and nuclear envelope disappear
- Centrioles produce spindle fibers that attach to the kinetochores (part of the centromere)

METAPHASE

- Chromosomes align on metaphase plate
  - → Metaphase plate akin to equatorial plane

ANAPHASE

- Chromatids are pulled apart
- Sister chromatids separate at centromere and move to opposite poles of the cell
- Non-kinetochore microtubules elongate the cell

TELOPHASE

- Nuclear membrane forms around each set of chromosomes and nucleoli re-appear
- Cytokinesis - cell splits along clevage furrow
  - ↳ In plant cells cell doesn't split, cell plate forms down middle of cell

- occurs in every cell except gametes

HEREDITY.

- Diploid cell – Has two sets of chromosome (2.n)
- Haploid cells – Has one set of chromosomes (n)
- Homologous chromosomes – duplicate versions of each chromosome
- Gametes – sex cells, are haploid

GENETICS.

- Traits – expressed characteristics, influenced by genes
  - ↳ Position of a gene on a chromosome is called a Locus
- Alleles – alternate versions of the same gene
  - ↳ Homozygous – Two identical alleles for a given trait
  - ↳ Hetrozygous – Two different alleles for a given trait
- Phenotype – what the organism looks like
- Genotype – which alleles the organism has
- Dominant allele (capital letter) is expressed over recessive allele (lowercase letter)
- First generation in an experiment is called parent or P generation
- Next generation is called n filial generation (F_n)

LAW OF DOMINANCE

- Dominant allele masks recessive allele
- Monohybrid cross – two individuals are crossed and one gene is being studied
  - ↳ DRAW PUNNETT SQUARE

LAW OF SEGREGATION

- Each gamete gets only one of two copies of a gene

LAW OF INDEPENDENT ASSORTMENT

- The two alleles for each trait are sorted independently of the two alleles for other traits
  - Dihybrid cross - same as monohybrid but studies two genes
- Test cross is used to determine genotype of organism by crossing with another organism we know the genotype of.
- Linked genes are inherited together
- Off spring from recombination events are called recombinants
- Sex chromosomes determine the sex of an individual
- Some traits are carried on sex chromosomes (sex-linked traits)
- Barr body - condensed inactive x chromosome in female cells

NON-MENDELIAN INHERITANCE PATTERNS

- Incomplete dominance - neither allele is dominant over the other
  - Codominance the expression of one allele doesn't prevent the expression of the other
  - Polygenic inheritance - a trait results from the interaction of many genes
  - Non nuclear inheritance - Genetic material from mitochondric or chloroplasts
    - ↳ Alway through maternal line
- Phenotypic plasticity - two individuals with the same genotype have different phenotypes because of different enviornments

MEIOSIS

- Production of gametes

MEIOSIS I.

PROPHASE I.

- Mostly same as prophase and mitosis
- Synapsis – Chromosomes lie up with their counterparts (homologs)
- Homologous chromosomes exchange alleles (crossing over)
- Two sets of chromosomes that come together form a tetrad

METAPHASE I.

- Tetrads line up at metaphase plate
- Alignment during metaphase is random

ANAPHASE I.

- Homologs separate with their centromeres in tact
  - ↳ Move to opposite poles

TELOPHASE I.

- Nuclear membrane forms around each set of chromosomes
- Nucleous contains haploid number of chromosomes, but each chromosome is duplicated (two chromatids)

MEIOSIS II

- Virtually identical to mitosis

MEIOTIC ERRORS

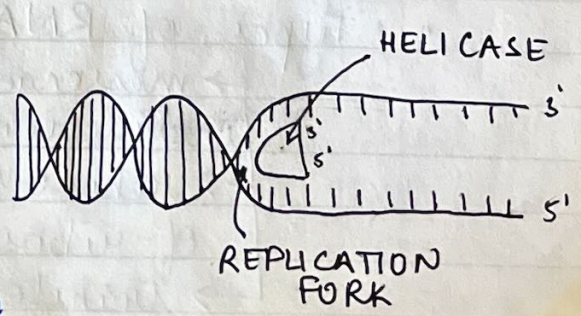
- Nondisjunction – chromosomes fail to separate properly during meiosis
  - ↳ can occur in Anaphase I or Anaphase II
  - ↳ can lead to aneuploidy – presence of an abnormal number of chromosomes in a cell
- Translocation – a segment of a chromosome moves to another non-homologus chromosome

GENE EXPRESSION & REGULATION

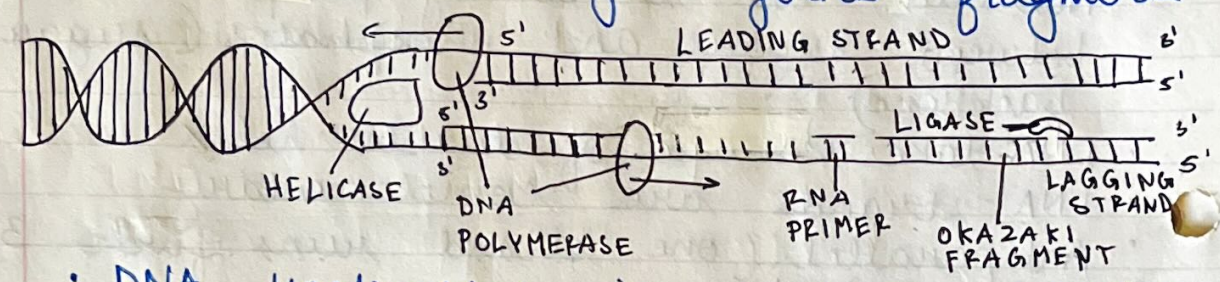
- Nucleotides are made up of a 5 carbon sugar, a phosphate and a nitrogenous base
  - ↳ DNA nitrogenous bases
    - ↳ Purines — double ringed
      - ↳ Adenine (paired with thymine)
      - ↳ Guanine (paired with cytosine)
    - ↳ Pyrimidine — single ringed
      - ↳ Thymine (paired with adenine)
      - ↳ Cytosine (paired with guanine)
- Nucleotides are linked by phosphodiester bonds between sugars and phosphates (sugar-phosphate backbone)
- DNA takes shape of double helix
- DNA strands are complementary
- Antiparallel (one strand runs 5' ~~to~~ 3', other runs 3' ~~to~~ 5')
- Bases pair with hydrogen bonds
- Genes encode for proteins
- DNA is wrapped around proteins called histones and histones are bunched together in groups called nucleosomes
- When genetic material is loose (euchromatin), genes are active
- When genes are condensed into coils (hetrochromatin) genes are generally inactive

DNA REPLICATION

- Copying of DNA
- Helicase breaks H bonds and unwinds DNA
- DNA replication begins at origins of replication



- DNA topoisomerases rejoin helix
- DNA polymerase adds nucleotide
  - ↳ can only work 5'→3'
  - ↳ RNA primase adds RNA primer to lagging strand
    - ↳ RNA primer replaced with DNA later
- Leading strand – made continuously
- Lagging strand – made discontinuously
  - ↳ made of Okazaki fragments
    - ↳ DNA ligase joins fragments



- DNA replication is semi conservative
- Telomeres – less important DNA at the end of DNA strands

<u>CENTRAL DOGMA</u>

- Transcription – DNA turned into mRNA
  - ↳ in the nucleus
- Translation – mRNA turned into polypetide
  - ↳ in cytoplasm
- RNA is single stranded
- RNA has uracil instead of thymine (pairs with adenine)
- Types of RNA
  - ↳ messenger (mRNA) – carries DNA instructions to ribosome
  - ↳ ribosomal (rRNA) – makes up part of ribosomes
  - ↳ transfer (tRNA) – brings amino acids to ribosomes

TRANSCRIPTION

- Polycistronic – one gene encodes for several proteins
- Monocistronic – one gene encodes for one protein
- Transcription begins at promoters
- RNA is complementary to antisense strand, non coding strand, minus strand, template strand
  - Other strand is called sense strand or coding strand
  - RNA polymerase builds RNA
  - Start site – where RNA polymerase starts transcription
- RNA processing
  - → RNA contains introns and extrons
    - → extrons will be turned into protein
    - → introns are non coding regions
  - → Splicing – spliceosome removes introns
  - → PolyA tail added to 3' end and 5' GTP cap added to 5' end

TRANSLATION

- Codon – group of three nucleotides
- Each codon corresponds to an amino acid (an amino acid can be specified by more than one codon)
- One end of tRNA carries amino acid
- anticodon part of tRNA molecule that binds to codon
- wobble pairing – third position of codon may bind two nucleotide not its pair

- Initiation
  - Ribosome contains three binding sites
    - A-site - new tRNA attaches
    - P-site - amino acid on tRNA bonds to polypeptide
    - E-site - tRNA exits
  - Start codon - AUG
- Elongation
  - Amino acids carried by tRNA bond to polypeptide
- Termination
  - when ribosome reaches stop codon translation stops

GENE REGULATION

- Operons - set of genes under the control of a single promoter
- four parts of operon
  - structural genes - code for enzymes needed in a chemical reaction
  - Promoter gene - where RNA polymerase binds
  - operator - where repressor binds
  - regulatory gene - codes for repressor

Promoter	Operator	Structural and Regulatory Genes

- Inducer binds to repressor, causing it to fall off the operator
- Post transcriptional regulation - RNAi binds to RNA, creating double stranded RNA and is destroyed

- Post transational regulation - protein is made, but is deactivated until needed
- Mutation - error in DNA
  - Base substitution (point)
    - nonsense - codon becomes stop codon
    - missense - original codon produces different amino acid
    - silent - codon codes for same amino acid
  - Gene rearrangements
    - insertion and deletion - gain or loss of DNA
      - frameshift mutation
    - duplication extra copy of genes
    - inversions - changes in orientation of chromosomal regions
    - translocations - DNA breaks and rejoins in a way that causes it to be lost, repeated or interrupted
    - transposons - gene segments that can cut and paste themselves through out the genome
- Viruses
  - lytic cycle - replicates until cell bursts
  - lysogenic cycle - incorporates itself into the host genome until triggered to switch into lytic cycle
- Transduction - transfer of DNA between bacterial cells with lysogenic virus

BIOTECHNOLOGY

- Recombinant DNA - DNA generated by combining DNA from multiple sources

- Polymerase chain reaction (PCR) - lab technique used to make many copies of genes (amplification)
- Transformation - giving bacteria foreign DNA
- Transfection - putting a plasmid into a eukaryotic cell
- Gel Electrophoresis - DNA fragments can be separated according to their molecular weight and charge with this
- DNA sequencing - determining the order of nucleotide in a DNA molecule

Retrovirus:

RNA → DNA → RNA → Protein

Regular Virus:

RNA → Protein

NATURAL SELECTION

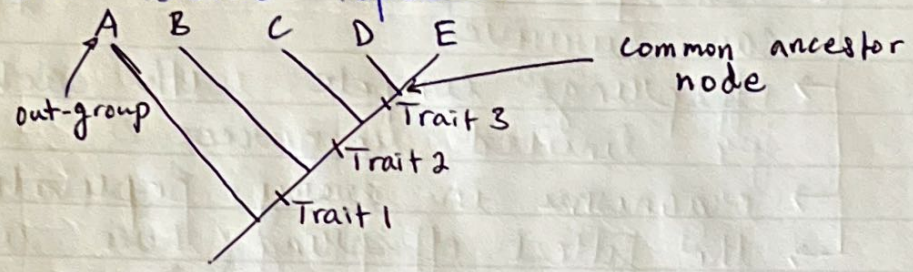
- Evolution - a change in population over time
- Natural selection - driving force of evolution
- Darwin's main observations
  - → Each species produces more offsprings than can survive
  - → offsprings compete with each other for limited resources
  - → organisms in every population vary
  - → the fittest offspring (those with the most favorable traits) are most likely to survive and therefore, produce a second generation
- Lamarck's Theory of Acquired Traits is wrong

EVIDENCE FOR EVOLUTION

- Paleontology - study of fossils
- Biogeography - study of distribution of flora and fauna in the environment
- Embryology - study of development of an organism
- Comparative Anatomy - study of anatomy of various animals
  - → Homologous structures - same appendage evolved to serve different purposes
  - → Analogous structures - structures with the same function that have evolved independently
- Molecular Biology - similarity at molecular level
- Continuing Evolution - evolution is still occuring

COMMON ANCESTORY.

- Phylogenetic trees / Cladograms - charts used to study relationships between organisms
  - out-group - species least related to all the other species



GENETIC VARIABILITY

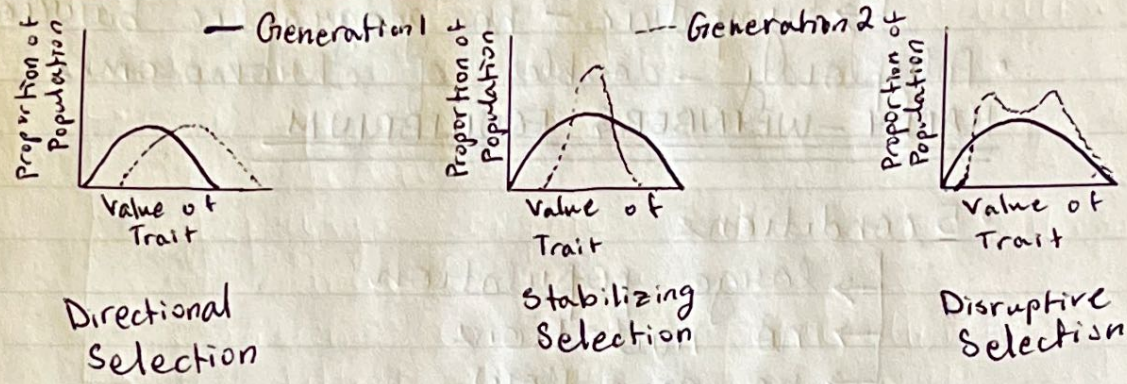
- Genetic variability - no two individuals in a population have identical sets of alleles except identical twins
  - ↳ Allows species to evolve
  - ↳ Caused by mutations
- Evolution - change in the gene pool of a population over time

CAUSES OF EVOLUTION

- Natural selection requires genetic variation and environmental pressure that gives some individuals an advantage
- Adaptation - a variation favored by natural selection
- Sexual selection - helps organism attract a mate
- Genetic drift - random events drastically reduce the number of individuals in a population
  - ↳ bottle neck effect or founder effect

- Geneflow – occurs between different populations if individuals migrate to/from the populations

TYPES OF SELECTION



Directional Selection | Stabilizing Selection | Disruptive Selection

- Artificial selection – humans directly affect variation in different species

SPECIES.

- Species are reproductively isolated
- Divergent evolution – a species evolves in the two species
- Punctuated Equilibrium – divergent evolution occurs quickly after a period of stasis (little evolution)
- Gradualism – change that comes about after many smaller changes, takes long amount of time
- Adaptive radiation – species rapidly diversifies due to an abundance of available niches
- Pre-zygotic barriers prevent fertilization
- Post-zygotic barriers prevent hybrid from reproducing
- Convergent evolution – two unrelated and dissimilar species come to have analogous traits because they have been exposed to similar selective pressures.

- Speciation
  - → Allopatric – separated by a geographic barrier
  - → Sympatric – no geographic barrier
- Polyploidy – doubles of chromosomes

HARDY-WEINBERG EQUILIBRIUM

- 5 conditions
  - → large population
  - → no mutations
  - → no gene flow
  - → random mating
  - → no natural selection

$p+q=1$ $\qquad$ $p^2+2pq+q^2=1$

p - frequency of dominant allele
q - frequency of recessive allele
p^2 - frequency of homozygous dominant genotype
$2pq$ - frequency of heterozygous genotype
q^2 - frequency of homozygous recessive genotype

- RNA-world hypothesis – original life forms were simply molecules of RNA

ECOLOGY

INTERACTING WITH THE ENVIRONMENT

- Endotherms – generate their own body heat through metabolism
- Ectotherms – cannot control body temperature
- Larger animals have a slower metabolic rate per unit mass than smaller animals

BEHAVIOR

- Behavior – how organisms cope with their environment

INSTINCT

- Inborn unlearned behavior
- Inherited "circuitary" that directs and guides behavior
- Circadian rhythm – internal clock/cycle

LEARNING

- Change in a behavior brought about by experience

IMPRINTING

- Newly born animals accept the first moving object they see as their mother
- Occurs during a critical period

HIBITUATION

- occurs when an animal learns not to respond to a stimulus

ANIMAL COMMUNICATION

- Pheromones – chemical signals between members of the same species

SOCIAL BEHAVIOR

- Agonistic – aggressive behavior that occurs as a result of competition

- Dominance hierarchies (pecking orders) - members in a group have established which members are most dominant
- Territoriality - generally males will establish and defend their territories to protect resources
- Altruistic - unselfish behavior that benefits another organism in the group at the individual's expense because it advances the genes of the group

SYMBIOTIC RELATIONSHIPS

- Mutualistic - both organisms benefit
- Commenesalism - one organism benefits other is unaffected
- Parasitism - organism harms host

PLANT BEHAVIOR

- Photoperiodism - plant responds to daylight/darkness

TROPISMS

- Turning in response to a stimulus
- Phototropism - response to light
- Gravitropism - response to gravity
- Thigmotropism - response to touch

FUNCTIONS OF PLANT HORMONES

- Gibberellins - promotes stem elongation
- Cytokins - promotes cell division and differentiation
- Ethylene - promotes fruit ripening and induces leaf abscission
- Abscisic acid - promotes bud and seed dormancy and inhibits leaf abscission
- Auxins - promote plant growth and phototropism

ECOLOGY

- The study of interactions between living things and their environments

BIOSPHERE

- Divided into large regions called biomes
  - ↳ classified mainly on climate and plant life
- Entire part of Earth where living things exist

ECOSYSTEM

- Interaction of living and non living things
- Self contained regions that include both living and non living factors
  - ↳ living factors are biotic factors
  - ↳ non living factors are abiotic factors
- Carbon, nitrogen, water are recycled throughout the ecosystem in cycles

COMMUNITY

- A group of populations interacting in the same area
- Each organism has its own niche - its position or function in a community
- Food chain describes how different organisms depend on each other for food

LEVELS OF FOOD CHAIN

- Producers (autotrophs) - make their own food
  - ↳ primary producitivity - rate at which autotrophs convert light energy into chemical energy
    - ↳ gross producitivity just from photosynthesis can't be measured

↳ net productivity measures only organic materials left over after photosynthetic organisms have taken care of their own needs

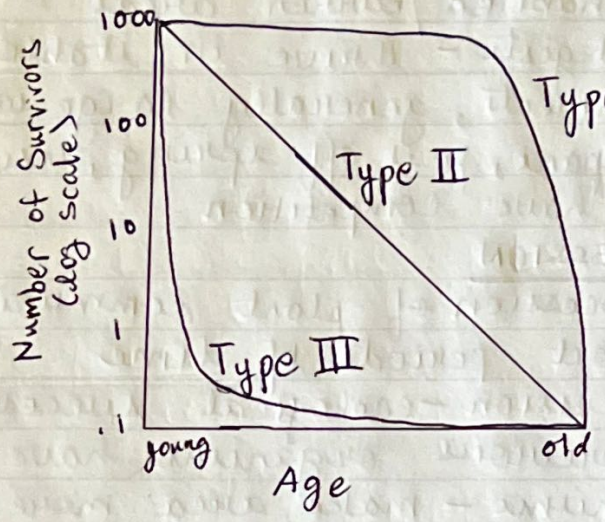
→ make up first trophic level and possess highest biomass (total weight of organisms in an area) and greatest numbers

- Consumers (Heterotrophs) – find their energy in the outside world
  - ↳ primary consumers (herbivores) directly feed on producers
  - ↳ secondary consumers feed on primary consumers
  - ↳ tertiary consumers feed on secondary consumers
- Decomposers – break down organic matter into simple products
- Keystone species – particularly important species to an ecosystem
- 10% rule – only 10% of energy is transferred from trophic level to the next, other 90% lost as heat
- Bioaccumulation – accumulation of toxins in an organism
- Biomagnification – toxin concentration increases with trophic level
- Simpson's diversity index – measures diversity of a community
  - ↳ $= 1 - \sum \left(\frac{n}{N}\right)^2$
  - ↳ n = the total number of organisms of a particular species

    N = the total number of organisms of all species

POPULATION ECOLOGY

- Study of how populations change

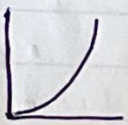


Survivorship Curves

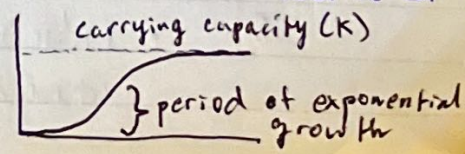
- Population growth
  - ↳ $r = (\text{births} - \text{deaths})/N$ or $\frac{dN}{dt} = B - D$
    - r - reproductive rate
    - N - population size
    - B - birth rate
    - D - death rate
- Carrying capacity - maximum number of individuals of a species that a habitat can support
  - ↳ most populations don't reach carrying capacity due to limiting factors
    - ↳ density - independent factors affect the population regardless of density
    - ↳ density - dependent factors dependend on population density

GROWTH TYPES

- Exponential growth - occurs when population is in an ideal environment
  - ↳ $\frac{dN}{dt} = r_{max} N$



- Logistic growth - population becomes restricted in size due to limited resources
  - ↳ $\frac{dN}{dt} = r_{max} N \left(\frac{K-N}{K}\right)$
    - K - carrying capacity



- r - strategists - reproduce as quickly as possible, produce lots of offspring, thrive in unhabited / barren areas
- k - strategists - thrive in stable environments, generally large with long life spans, few off spring, usually don't have competition

ECOLOGICAL SUCCESSION

- Predictable procession of plant communities over relatively short periods of time
- Primary succession - ecological succession in which no previous organism have existed
- pioneer organisms - make area more inhabitable
- sere - process of community being established (orderly)
  - ↳ climax community - final community
    - ↳ most stable
- secondary succession - new community develops where another has been destroyed or disrupted

HUMAN IMPACT

- Greenhouse effect - greenhouse gases produced, warm environment
- ozone depletion - depletion of ozone layer, less protection against UV rays
- acid rain - lowers pH of aquatic ecosystems and soil, damaging ecosystems
- desertification - land is over grazed by animals and reduces available habitats
- deforestation - forests are cleared
- pollution - toxic substances in environment
- reduction in biodiversity - extinctions
- introduction and spread of disease - act as immediate selective pressures