Carbohydrates

- Composed of CHO
- Used for energy storage (glycogen in liver or starch in plants)
- Used for structural support(chitin in exoskeletons or cellulose in plant cell walls)
- Monomer: monosaccharides

Proteins

- Composed of CHON(S)
- Used for enzymatic, defensive, storage, transport, hormonal, receptor, contractile/motor, or structural proteins
- Monomer: amino acids (amine group, carboxyl group, hydrogen, and central carbon)

1.2: Elements of Life

Nucleic Acids

- Composed of CHONP
- Used for genetic information storage
- Monomer: nucleotide (sugar, nitrogenous base, and phosphate)
- DNA/RNA

Lipids

- Composed of CHO
- Used for energy storage (fat), membrane structure (phospholipid), or signaling molecules (steroids)
- NO monomer
- Nonpolar group

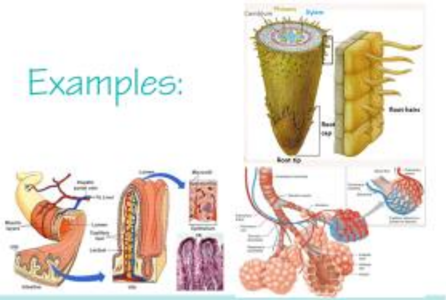
SA:V Ratios

- obtain necessary resources
- eliminate waste products
- acquire or dissipate thermal energy
- exchange chemicals and energy with the environment.

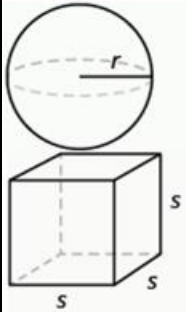
Growth Problems

- As volume ⇧, the surface area ⇩ and the demand for internal resources ⇧
- As organisms ⇧ in size, their SA:V ratio ⇩
- affects properties like rate of heat exchange with the environment.

Examples:



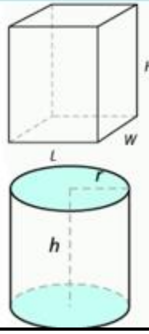
2.3: Cell Size



Volume: $V = \frac{4}{3}\pi r^3$
Surface Area: $S = 4\pi r^2$

Volume: $V = s^3$
Surface Area: $S = 6s^2$

Smaller cells typically have a higher surface area-to-volume ratio and more efficient exchange of materials with the environment.



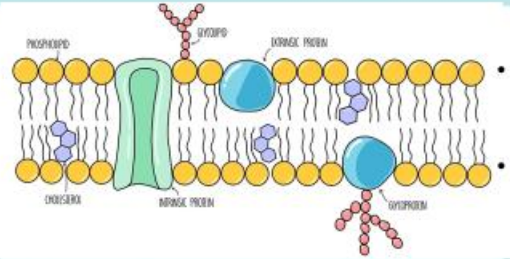
Volume: $V = LWH$
Surface Area: $S = 2LH + 2LW + 2WH$

Volume: $V = \pi r^2 h$ or $V = Bh$
Surface Area: $S = 2\pi r^2 + 2\pi rh$

2.4 Plasma Membrane

Composition

- Phospholipids
- Membrane Proteins
- Glycolipids/Glycoproteins
- Cholesterol



Properties

- hydrophilic (phosphate) region: oriented toward the aqueous external or internal environments
- hydrophobic regions: fatty acid regions face each other within the interior of the membrane.

2.5 Membrane Permeability

Selective Permeability

FREELY PASS

- Small non-polar materials
  - Example: CO_2, O_2, N_2

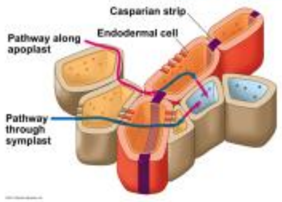
REQUIRE ASSISTANCE

- Hydrophilic substances
  - Example: large polar molecules (glucose) or ions (Na^+)

DID YOU KNOW?

- Polar uncharged molecules, including H_2O, pass through the membrane in small amounts.

Cell Wall



Plants: Cellulose

Prokaryotes: Peptidoglycan

Fungi: Chitin

Transport Materials

- charged and large polar molecules through a membrane—
- large quantities of water pass through aquaporins.
- charged ions, including Na^+ and K^+, require channel proteins to move through the membrane.

Membrane Proteins

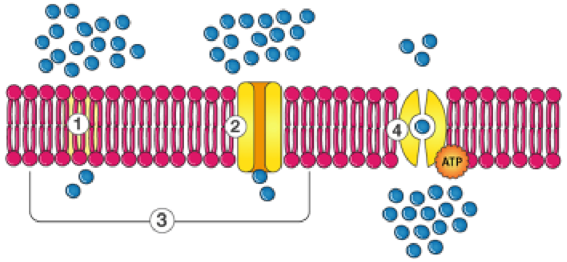
- Carrier: Binds & shape change to shuttle across membrane
- Channel: Passage for materials

Active Transport

- Establish concentration gradient
- Requires transport protein (carrier protein)
- Na^+/K^+ maintains membrane potential

2.7 Facilitated Diffusion

requires membrane proteins



1. Diffusion
2. Facilitated Diffusion
3. Passive Transport
4. Active Transport

Hypertonic Solution

- HIGH solute concentration
- LOW free water concentration
- GAINS water from hypotonic solution

Isotonic Solution

- EQUAL solute concentration (as other solution)
- EQUAL free water concentration (as other solution)
- Equal water movement into and out of solution

Hypotonic Solution

- LOW solute concentration
- HIGH free water concentration
- LOSES water to hypertonic solution

2.8 Tonicity & Osmoregulation

Water Potential:

$\Psi = \Psi_p + \Psi_s$

$\Psi_p =$ pressure potential

$\Psi_s =$ solute potential

Practice Problem

cell in 0.5M NaCl solution at 25°C

$$\varphi_s = -(2)(0.5M)\left(0.0831\ \frac{L \cdot bars}{mol \cdot K}\right)(25 + 273K)$$

$$\varphi_s = 24.8\ bars$$

$\Psi_s = -iCRT$

where:

$i =$ ionization constant

$C =$ molar concentration

$R =$ pressure constant

$\left(R = 0.0831\ \frac{L \bullet bars}{mol \bullet K}\right)$

$T =$ temperature in Kelvin (°C + 273)

HIGH water potential
LOW osmolarity
LOW solute concentration
HYPOtonic

water movement →

LOW water potential
HIGH osmolarity
HIGH solute concentration
HYPERtonic

Simple Diffusion

- Passive Transport, No NRG
- Down concentration gradient
- Small, Nonpolar
- No transport protein needed
- Examples: CO_2, O_2, N_2, steroids
- Small amount of H_2O leak through membrane

Facilitated Diffusion

- Passive Transport, No NRG
- Down concentration gradient
- Small Molecules
- Requires transport protein Channel vs. Carrier protein
- Example: water, Na^+, K^+, Ca^+

Active Transport

- Requires input of NRG
- Against concentration gradient
- Requires transport protein (carrier protein)
- Example: Na^+, K^+, Ca^+, H^+

2.9 Mechanisms of Transport

Endocytosis

- Import of materials
- Phagocytosis: Cellular Eating
- Pinocytosis: Cellular Drinking
- Receptor-Mediated: Endocytosis

Bulk Transport

Exocytosis

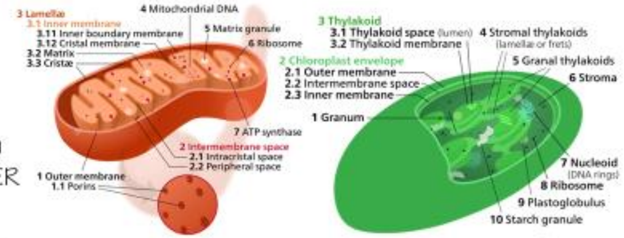
- Export of materials
- Rough ER (synthesize) → Golgi complex (package/modification) → Plasma Membrane

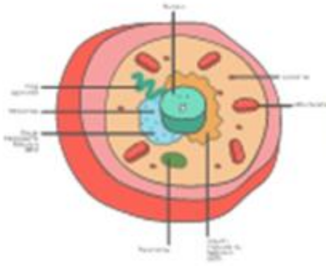
2.10 Compartmentalization

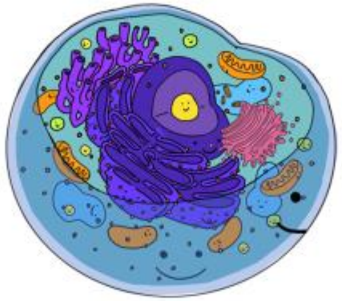
Membrane-Bound Structures

Membranes and membrane-bound organelles in eukaryotic cells compartmentalize intracellular metabolic processes and specific enzymatic reactions.

- Rough ER: Protein synthesis for membrane & secretion
- Golgi: Package & modify protein products from Rough ER
- Lysosome: Cellular digestion with hydrolytic enzymes
- Mitochondria: site of cellular respiration (Krebs cycle & oxidative phosphorylation)





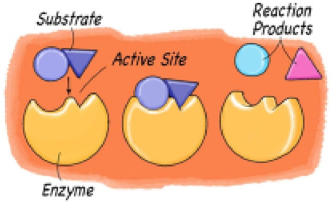


Internal Membrane

Internal membranes facilitate cellular processes by minimizing competing interactions and by increasing surface areas where reactions can occur.

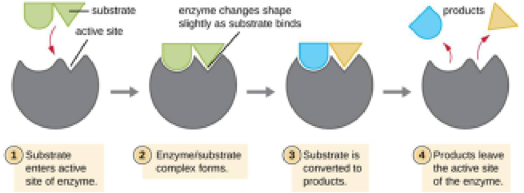
- Mitochondria: cristae increases SA for oxidative phosphorylation
- Chloroplast: thylakoid increases SA for light reactions

3.1 Enzyme Structure



Structure

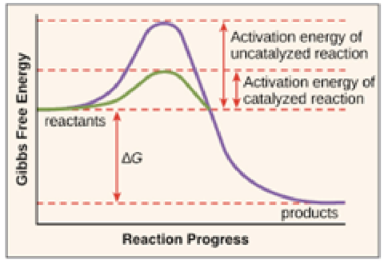
- Active Site: location for substrate to bind
- Allosteric Site: another binding location on the enzyme



3.2 Enzyme Catalysis

Important Notes:

- Enzymes are PROTEINS
- Are NOT consumed by the reaction
- Have no effect on the change in Gibbs Free Energy



Function

- Biological catalyst
- Speeds up chemical reactions
- Reduces the activation energy

Shape Changes

Change in structure could lead to change in function

Changes shape of active site due to bonds breaking/reforming

Denaturation

Denaturation of an enzyme occurs when the protein structure is disrupted, eliminating the ability to catalyze reactions

Cause of Denaturation

Environmental Temperatures (increase in kinetic energy)
pH changes outside of optimal range (changes bonding with R groups)
Salinity

3.3 Env. Impacts on Enzyme Function

RELEVANT EQUATION

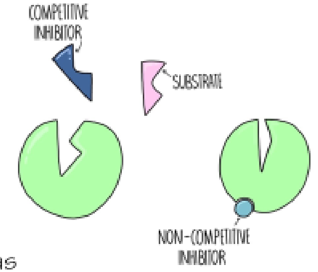
$$pH = -\log[H^+]$$

- As concentration of hydrogen ions ⇧, the pH ⇩
- As concentration of hydrogen ions ⇩, the pH ⇧

Inhibitors

Competitive:
- Binds to active site

Noncompetitive:
- Binds to allosteric site



What will happen?

Increased Temperature:
- Increase reaction rate as increased molecular collisions

Decreased Substrate:
- Decrease reaction rate as less reactant available

Increased Enzyme:
- Increase reaction rate as each enzyme decreases activation energy

First Law of Thermodynamics

Energy cannot be created or destroyed, it is transferred or transformed

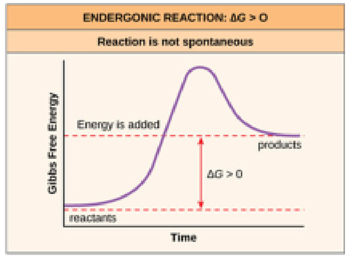
Second Law of Thermodynamics

Energy reaction increases the entropy (disorder) of the universe

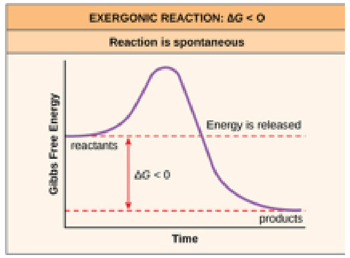
- energy input > energy loss (maintain order & power cell processes)
- energy coupling
- Loss of order or energy flow

3.4 Cellular Energy

Endergonic Reaction



- Not spontaneous
- ABSORB energy
- Example: ADP + P_i → ATP



- Spontaneous
- RELEASE energy
- Example: ATP → ADP + P_i

Exergonic Reaction

3.5 Photosynthesis

Light Reactions

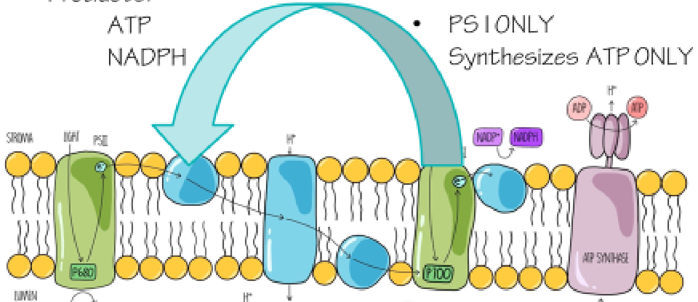
- Location: Thylakoid Membrane
- Starting Material:
  - Water (electrons)
  - Photons (energy)
- Products:
  - ATP
  - NADPH

Linear Electron Flow

- PS I & PS II
- Synthesizes ATP & NADPH

Cyclic Electron Flow

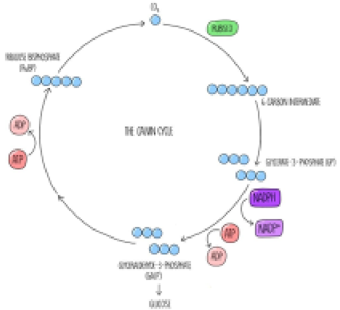
- PS I ONLY
- Synthesizes ATP ONLY



Electron Transport Chain
- Protons are pumped into the thylakoid space

Calvin Cycle

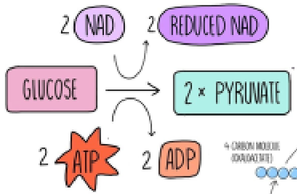
- Location: Stroma
- Starting Material:
  - 3 CO_2
  - 9 ATP
  - 6 NADPH
- Products:
  - G3P

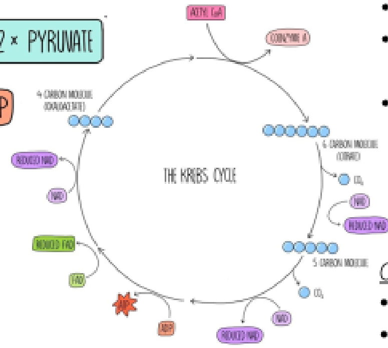


3.6 Cellular Respiration

Glycolysis

- Location: Cytosol
- Starting Material:
  - Glucose
- Products:
  - 2 Pyruvate
  - 2 NADH
  - 2 ATP





Krebs Cycle

- Location: Mitochondrial Matrix
- Staring Material:
  - Acetyl CoA
- Products:
  - 2 CO_2
  - 3 NADH
  - 1 $FADH_2$
  - 1 ATP

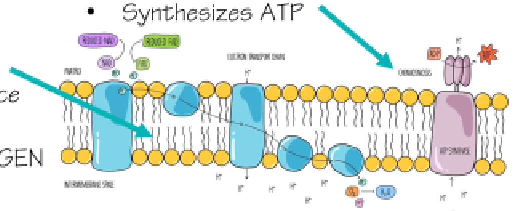
Chemiosmosis
- ATP Synthase uses proton gradient
- Synthesizes ATP

Oxidative Phosphorylation

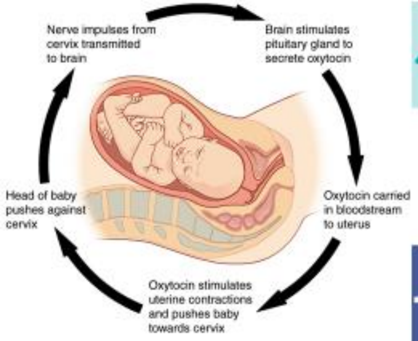
- Location: Mitochondrial Cristae
- Starting Material:
  - NADH/$FADH_2$ (electrons)
- Product:
  - ATPs
- Two Parts:

Electron Transport Chain & Chemiosmosis

Electron Transport Chain
- Protons pumped into IM space
- Generates proton gradient
- Final electron acceptor: OXYGEN



4.5 Feedback



- amplify responses/processes
- variable initiating the response is moved farther away from the initial set point
- amplification occurs when the stimulus is further activated, which initiates additional response to produce system change.

Positive Feedback

POSITIVE FEEDBACK LOOPS
VERSUS
NEGATIVE FEEDBACK LOOPS

POSITIVE FEEDBACK LOOPS	NEGATIVE FEEDBACK LOOPS
A feedback mechanism resulting in the amplification or growth of the output signal	A feedback mechanism resulting in the inhibition or the slowing down of a process
Breakdown the homeostasis of the system	Always maintain the conditions of homeostasis
Less common but, occur in specific situations	Occur more often in the body, helping in maintaining various conditions of the body
Ex: childbirth, blood clotting, and fruit ripening	Ex: regulation of body temperature, blood pressure, and fluid content

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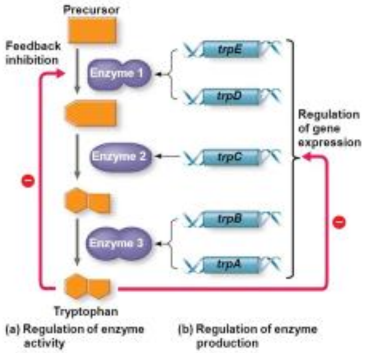
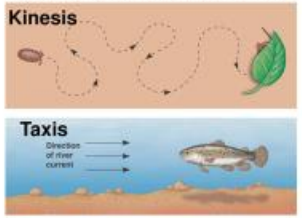
Negative Feedback

- maintain homeostasis
- regulates processes
- return the system back to its target set point.
- molecular and cellular levels



8.1 Responses to the Environment

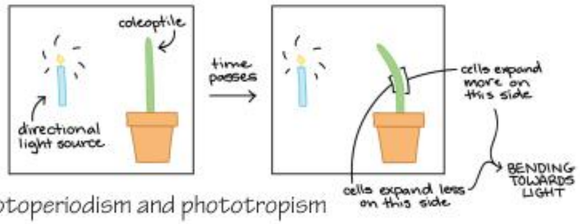
Taxis and kinesis in animals



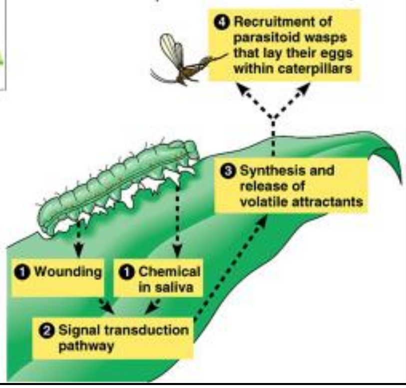
Organisms respond to changes in their environment through behavioral and physiological mechanisms

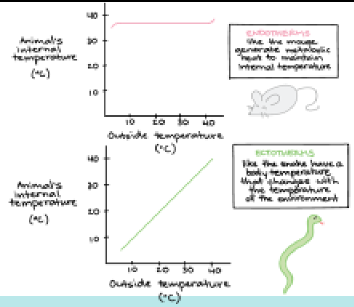
Organisms exchange information with one another in response to internal changes and external cues, which can change behavior

- Fight-or-flight response
  - Predator warnings
- Plant responses to herbivory



Photoperiodism and phototropism





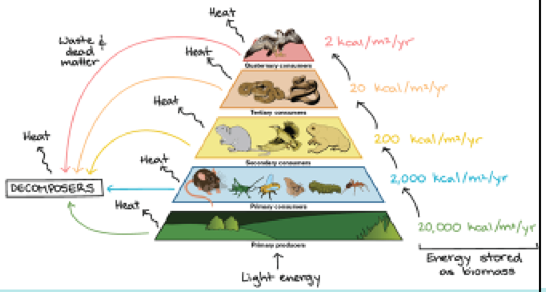
Body Temperature

Endotherm

Maintains body temperature through metabolism

Ectotherm

Maintains body temperature through behaviors (bask in sunlight, aggregation)



Species Diversity

Simpson's Index: measures biodiversity (species composition and diversity)

$$Simpson\ Diversity = 1 - \sum \left(\frac{n}{N}\right)^2$$

n = total number of organisms of particular species

N = total of organisms of all species

Species	Number
Sloth	18
Penguin	13
Total	31

$$1 - \left(\left(\frac{18}{31}\right)^2 + \left(\frac{13}{31}\right)^2\right)$$

$$1 - ((0.58)^2 + (0.42)^2)$$

$$1 - (0.34 + 0.18)$$

$$1 - 0.52 = 0.48$$

Keystone Species

Organism with disproportionate to their abundance effect, and when they are removed from the ecosystem, the ecosystem often collapses.

Examples: Sea Otter

8.2 Energy Flow Through Ecosystems

Trophic Structure

Autotroph

Capture energy from physical or chemical source

- Photosynthetic
  - sunlight
- Chemosynthetic
  - small inorganic molecules in environment (sometimes without oxygen)

energy

Heterotroph

Capture energy present in carbon compounds produced by other organisms

Metabolize carbohydrates, lipids, and proteins (notice: not nucleic acids) for energy through hydrolysis

Organisms use energy to maintain, organize, grow and reproduce

Changes in Availability

Change in Energy Resource

Affects number and size of trophic levels

Change in Producer Level

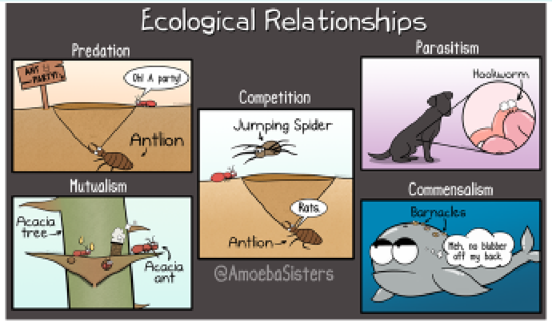
Affects number and size of trophic levels

8.5 Community Ecology

Interactions

Predator/Prey (+/-)
Herbivory (+/-)
Competition (-/-)

Symbiosis
Parasitism (+/-)
Mutualism (+/+)
Commensalism (+/0)



Invasive Species

Organism that is not indigenous, or native, to a particular area with no natural predators and unlimited resources

Examples:

- Zebra Mussel: clogging water way
- Lionfish: venomous species