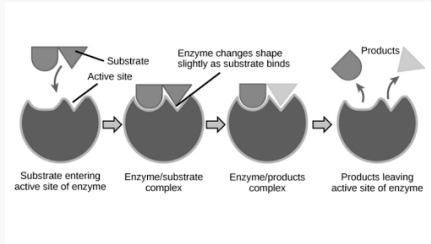


Enzymes



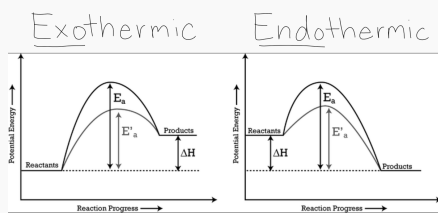
- **enzyme:** macromolecule that acts as a biological catalyst to speed up reactions by lowering E_A
- **substrate:** molecule that can interact with an enzyme
- **active site:** spot to specially interact with the substrate
- **cofactor:** non-protein bound to the active site to allow for the substrate to properly bind
- **coenzyme:** organic molecule serving as a cofactor
- *enzymes are reusable*

Enzyme Lowers Activation Energy

- Proper Alignment~** active site allows place for reactants (substrates) to come together
- Pulls Reactants~** breaks chemical bonds before reaction
- More Conducive~** chemical/physical properties better than those in surrounding environment
- Form Temporary Bonds~** amino acids in active site bond with the substrate molecule

- catalyze either the forward or reverse reaction --- depends on the concentration of reactants/products

Enzyme Reaction Graphs



Enzyme Structure

- same as structure of proteins: primary, secondary, tertiary, & quaternary
- shape denatures at...
 - high temperature~ (thermal agitation) bonds disrupted
 - ideal at: 35-40 degrees
 - graph: wide parabola
 - low pH~ (too acidic) hydrogen bonds disrupted
 - ideal at: pH 6-8
 - graph: steep parabola (log scale)
 - substrate concentration~ determine rate of collision
 - ideal at: below saturation level
 - graph: logistic growth (levels off)

Enzyme Activity

- **competitive inhibitors:** enter the active site in place of the substrate
- **noncompetitive inhibitors:** bind to a location that isn't the active site (allosteric site), change enzyme shape, & block substrate
- **allosteric regulation:** binding of a regulatory molecule at a site that affects the function at a different site
 - ex) allosteric deactivation & allosteric activation
- **feedback inhibition:** end product of metabolic pathway acts as an inhibitor of an enzyme within the pathway

C

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ATP Background

main 3 kinds of work performed:

1. chemical work- start reactions
2. transport work- moving substances
3. mechanical work- movement of cilia, contract muscles, etc.

ATP synthesis 2 ways:

1. substrate level phosphorylation
 - ↳ phosphate group removed from substrate & added to ADP to form ATP
2. chemiosmosis (electron transport chain)
 - ↳ H⁺ ions move across membrane moving e⁻ & uses that energy for ATP synthesis

- uncouplers: chemical in liquid membrane that moves H⁺ across the membrane (blocks ATP synthesis)

Energy

- metabolic pathway: series of chemical reactions that has a starting molecule and results in a product

- catabolic pathway: pathway that breaks down complex molecules/polymers into simpler molecules/monomers (releases energy)

- anabolic pathway: pathway that uses simple molecules/monomers to form complex molecules/polymers (consumes energy)

Energy (cont)

- 1st Law of Thermodynamics~ conservation of energy

↳ energy can be transferred/transformed, but can't be created or destroyed

2nd Law of Thermodynamics~ increases entropy/disorder (heat)

↳ usable forms of energy are changed to useless forms

Free Energy

- free energy (ΔG): portion of a system's energy that can perform work

↳ must be *negative* for reaction to be spontaneous

	gravitational position	solutes in solvent	molecules (size & #)
higher ΔG	high altitude	clustered	large, few
lower ΔG	low altitude	dispersed	small, many

define	how ΔG changes	example



Free Energy (cont)

exergonic reaction:	spontaneous reaction with a net release of free energy	- ΔG	cellular respiration
endergonic reaction:	nonspontaneous reaction with free energy absorbed	+ ΔG	photosynthesis

Photosynthesis Background

equation: $6\text{CO}_2 + 6\text{H}_2\text{O} (+\text{energy}) \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2$

two processes:

1. light dependent reaction (light reaction)
2. light independent reaction (dark reaction)

light reaction

- pigments trap light energy to transform into chemical energy

- breaks down H_2O to release O_2 ($2\text{H}_2\text{O} \rightarrow \text{O}_2 + 4\text{H}^+ + 4\text{e}^-$)

- produces ATP from ADP

- unites H^+ with NADPH^+

dark reaction

- forms glucose from CO_2 , ATP, & NADPH^+

- light energy stored in bonds of glucose

Chloroplast Structure

- light & dark reactions occur in chloroplasts
 - inner membrane organized into structures that photosynthesis reactions are located

↳ *light* reactions occur in the *thylakoid*

↳ *dark* reactions occur in the *stroma*

Pigments

pigments absorb certain light wavelengths and reflect others

↳ *blue/violet:* shortest & more energy

↳ *red:* longest & less energy

- chlorophyll appears green due to reflecting green and absorbing red/blue

- chlorophyll has at least 5 forms that vary:

Chlorophyll type~

1. Chl. A

2. Chl B

3. Chl. C

4. Chl. D

5. bacteriochlorophyll

- accessory pigments trap light wavelengths different from chlorophyll

carotenoids~

↳ carotene & xanthophylls

↳ yellow, brown, orange colors

Found in~

all plants & algae

all plants & green algae

brown algae

red algae

some bacteria

(increase the amount of light used)

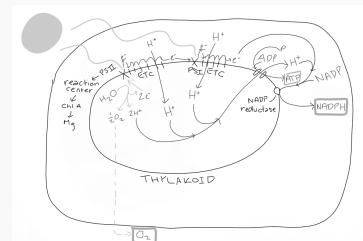
phycobilin~

↳ in red algae & blue-green bacteria

↳ absorb violet, blue, and green light

↳ allow red algae to live deeper than other types

Light Dependent Reaction



- scaffolds to reaction center → chlorophyll molecules → excited

element e^- (higher energy level) → e^- out of photosystem II

- H_2O breakdown only PS II

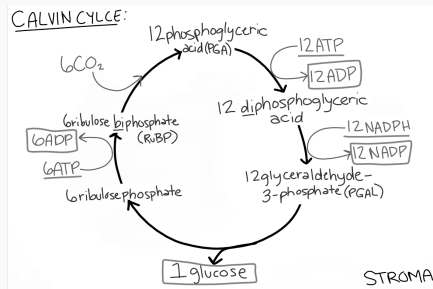
- $2e^-$ replaces lost e^- in PS II

- e^- lost by PS I is replaced by e^- from PS II

- ETC taking steps to keep releasing energy for H^+ to pass through

- **products:** O_2 , NADPH , & ATP

Light Independent Reaction



- RuBP carboxylase.*

- ↳ a.k.a. rubisco
- ↳ enzyme changes inorganic to organic
- ↳ 6 diphosphate (6C) -- split in half -- 12 phosphate (3C)

- ATP equivalents:

- ↳ 18 ATP (total) = 18 (1 each)
- ↳ 12 NADPH = 36 (3 each)
- ↳ TOTAL = 54 ATP used

- ADP & NADPH used from light dependent reaction

- **products:** ADP, NADP, & glucose

Cellular Respiration Background

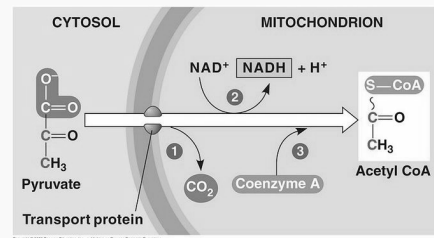
equation: $C_6H_{12}O_6 + 6O_2 \rightarrow 6H_2O + 6CO_2$ (+energy)

- three stages (w/ O₂):
1. glycolysis
 - (pyruvate processing)
 2. krebs cycle
 3. electron transport chain

- two stages (w/o O₂):
1. glycolysis
 2. fermentation

Glycolysis

Pyruvate Processing



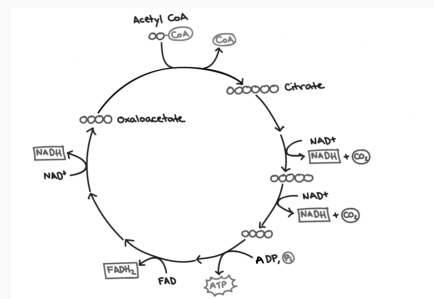
* occurs twice (once per pyruvate)

- **location:** mitochondria

- **reactants:** pyruvic acid, NAD⁺, & coenzyme A

- **products:** CO₂, NADH, & acetyl CoA

Krebs Cycle



* occurs twice

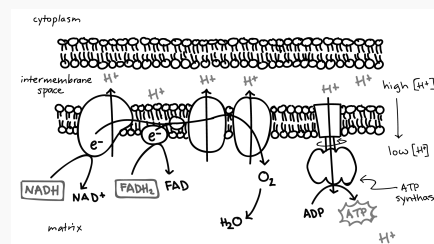
* a.k.a. citric acid cycle

- **location:** mitochondria

** - **reactants:** pyruvic acid, FAD, NAD⁺, & ADP

- **products:** CO₂, NADH, FADH₂, & ATP

Electron Transport Chain



* occurs constantly

* a.k.a. oxidative phosphorylation

- e- from NADH & FADH₂ passed along chain = release energy every step

- H⁺ moves through channel (energy released)

↳ ADP + P → ATP

- e- combine with O = O₂

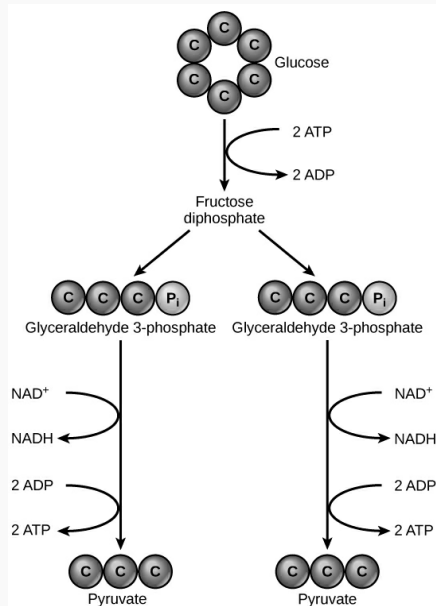
↳ O₂ + 2H⁺ → 2H₂O

- makes 32 ATP from 1 glucose

- **location:** inner membrane of mitochondria

- **reactants:** NADH, FADH₂, O₂, & ADP

- **products:** ATP, H₂O, NAD, & FAD



* occurs once

* all cells do this

* does NOT require O₂

- **location:** cytoplasm

- **reactants:** glucose, 2 ATP, 2 NAD⁺, & 4 ADP

- **products:** 2 pyruvic acids, 2 NADH, & 4 ATP (*net gain 2*)



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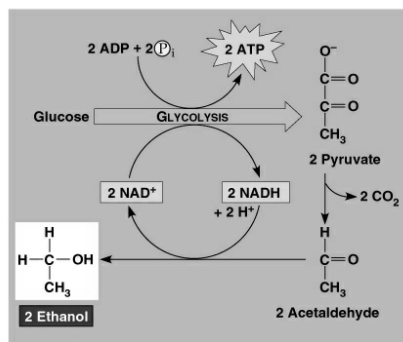
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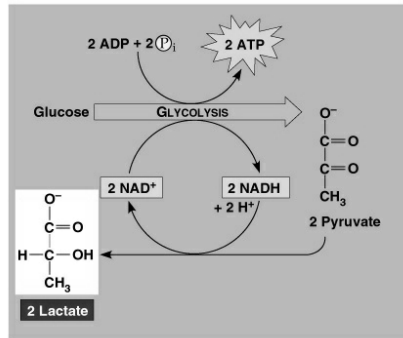
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Fermentation



(a) Alcohol fermentation



(b) Lactic acid fermentation

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* NO O₂

* a.k.a. anaerobic cellular respiration

* no ATP production

* recycles NAD for glycolysis

- location: cytoplasm

Alcoholic Fermentation

- reaction: pyruvic acid + NADH → ethanol + CO₂ + NAD

Lactic Acid Fermentation

- reaction: pyruvic acid + NADH → lactic acid + NAD

C

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