AP Bio Unit 3: Cell Energetics Cheat Sheet

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Enzymes

proteins (and RNA)

organic catalysts that lower the required activation energy to get reactants to products

facilitate chemical reactions:

~ increase rate of reaction without being consumed

~ reduce activation energy

~ do not change free energy released or required

substrate:

~ reactant which binds to enzyme

~ enzyme-substrate complex: temporary association

product:

~ end result of reaction

active site:

~ enzyme's catalytic site: substrate fits into actives site

pH

changes in pH:

~ adds or removes H+

~ disrupts bond, disrupts 3D shape

~ disrupts attractions between charged amino acids

~ affects 2' and 3' structure

~ denatures protein

Activators

cofactors:	coenzymes:
small, inorganic compounds and ions	organic compounds
binds with enzyme	bind to enzymes near active site
Mg, K, Ca, Zn, Fe	vitamins (NAD, FAD, Coenzyme A)

Allosteric Regulation

conformational changes by regulatory molecules

inhibitors: keeps enzyme in inactive form

activators: keeps enzyme in active form

Metabolic Pathways

catabolic pathways:	metabolic pathways:
release energy	consume energy
cellular respiration	photosynthesis

Transformation of Energy

sunlight -> chemical bonds during photosynthesis

Exergonic vs. Endergonic Reactions

	exergonic:	endergonic:
positive / negative G free energy:	negative	positive
released / absorbed	released	absorbed
cellular respiration / photosynthesis	cellular respiration	photosynthesis
uphill / downhill	downhill	uphill
spontaneous	spontaneous	not spontaneous

Endotherms

regulate internal body temperatures through metabolism

balancing heat loss and gain

five adaptations help animals thermoregulate:

1) insulation

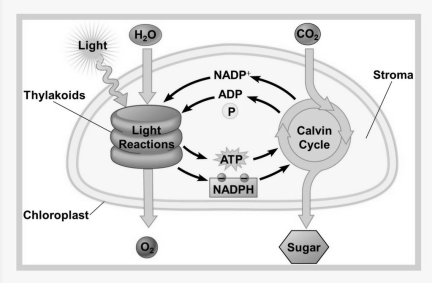
2) circulating adaptations

3) cooling by evaporative heat loss

4) behavioral responses

5) adjusting metabolic heat production

Overview of Photosynthesis



Glycolysis

location:	cytoplasm
reactants:	~ glucose
	~ 2 ADP +2 Pi
	~ 2 NAD+
products:	~ 2 pyruvate
	~ 2 ATP
	~ 2 NADH
	~ 2 H2O
transfer of energy:	NADH (electrons and Hydrogen) <- C6H12O6 -> ATP
purpose:	~ convert glucose to pyruvate
	~ initial breakdown of sugar
	~ generating ATP
	~ shuttling e- and H+ to ETC

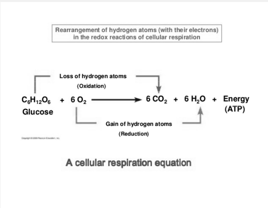
REDOX Reactions

molecular exchange of an electron

oxidation: lose electrons

reduction: gain electrons

REDOX reactions image



Photosynthesis

transformation of solar light energy trapped by chloroplasts into chemical bond energy stored in sugar and other organic molecules

1) synthesizes energy rich molecules

2) uses CO2 as carbon source

3) directly or indirectly supplies energy

CO2 + H2O + sunlight -> C6H12O6 + O2

Steps of Light Reactions

1) H2O splits

~ H+: pump into thylakoid out of ATP synthase

~ e-: 2 ETCs

~ O2: released out of stomata

2) light excites e- in Photosystem II

3) e- to primary electron acceptor (PEA)

4) the e- travels down the ETC and replaces the e- from Photosystem I

5) the e- travels down another ETC and combines with NAHP+

meanwhile...

~ energy from 1st ETC is used to pump H+ into the thylakoid space

~ a proton gradient forms and H+ leave through ATP synthase

~ H+ combines with e- and NADP+ to form NADPH

~ ATP synthase generates ATP

Properties of Enzymes

reaction specific:

~ each enzyme works with a specific substrate chemical fit between active site and substrate

~ H bonds and ionic bonds

not consumed in reaction:

~ single enzyme molecule can catalyze thousands or more reactions per second

~ enzymes are unaffected by the reaction

affected by cellular conditions

~ ex: temperature, pH, salinity, etc.

Substrate Concentration

as substrates increase, reaction rate increases and levels off

more substrate = more frequently collide with enzyme

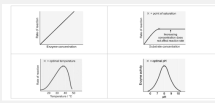
the reaction levels off because...

~ all enzymes have active site engaged

~ enzyme is saturated

~ maximum rate of reaction

Factors that Affect Enzyme Structure



Competitive Inhibitors

inhibitor competes with active site

substrate cannot bond

can overcome with substrate saturation

penicillin (competes with bacterial enzyme that builds cell wall)

directly blocks active site

Energy

the ability to do work

kinetic energy:	potential energy:
energy of motion	energy of position
heat	water behind a dam
light energy	chemical energy stored in cells

Free Energy and Equilibrium

free energy: energy available to do work

free energy decreases when reactions proceed toward equilibrium

Biosynthesis

building complex molecules out of simple molecules

amino acids -> proteins

glucose -> glycogen

Endotherms

regulate internal body temperatures through metabolism

balancing heat loss and gain

five adaptations help animals thermoreg-ulate:

1) insulation

2) circulating adaptations

3) cooling by evaporative heat loss

4) behavioral responses

5) adjusting metabolic heat production

Ectotherms

do not regulate internal body temperature

rely on environmental heat sources

less respiration/food

Cellular Respiration

catabolic

$C_6H_{12}O_6 + O_2 \rightarrow CO_2 + H_2O$ + energy

steps:

1) gylcolysis

2) intermediate step

3) citric acid cycle

4) oxidative phosphorylation

Intermediate Step

location:	mitochondrial matrix
reactants:	2 pyruvate
products:	~ acetyl CoA
	~ 2 NADH
	~ 2 CO_2
transfer of energy:	pyruvate (sugar) -> NADH (e- and H+)
purpose:	convert pyruvate into more reactive Acetyl CoA

Oxidative Phosphorylation

location:	~ inner membrane of mitochondria (ETC)
	~ inner membrane spare (chemiosmosis)
reactants:	~ NADH
	~ $FADH_2$
	~ ADP+P
	~ O_2
products:	~ NAD+H
	~ FAD+H
	~ ATP
	~ H_2O
transfer of energy:	NADH/$FADH_2$ -> proton gradient -> ATP synthase -> ATP

Oxidative Phosphorylation (cont)

purpose:	use REDOX reactions to make a large amount of ATP (34)

producers

autotrophic nutritional: nutritional made of synthesizing organic molecules from inorganic raw materials

photoautotrophs: uses light energy

chemoautotrophs: oxidation of inorganics for energy

Chloroplast

site of photosynthesis

double membrane system

thylakoids: flattened photocenters

granum: stacks of thylakoids

stroma: fluid outside thylakoid

Calvin Cycle

location: stomata

production of sugar

recognition of RUBP

reactants: CO_2, NADPH, ATP

products: $C_6H_{12}O_6$, NADP+, ADP+Pi, G3P

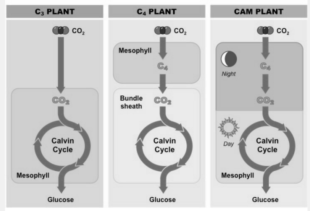
Pathways of Photosynthesis

noncyclic photophosphorylation produces ATP and NADPH

cyclic photophosphorylation is ATP production

calvin cycle consumes more ATP than NADPH

C3 vs. C4 vs. CAM plants



Induced Fit

"lock and key"

3-D structure of enzyme fits substrate

substrate binding cause enzyme to change shape leading to a tighter fit

"conformational change": slight change in shape

bring chemical groups in position to catalyze reactions

Enzyme Concentration

as enzymes increase, reaction rate increases

more enzymes = more frequently collide with substrates

Temperature

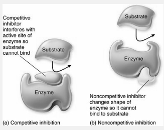
optimum temperature:	
~ as temp increases, reaction rate increases	~ greater number of molecular collisions
cold temperature:	
~ molecules move slower	~ decrease collisions between enzymes and substrates
heat (beyond optimum)	
~ increased energy level disrupts weak bond in 2' and 3' structure	~ denaturation: loses 3D shape

Noncompetitive Inhibitors

inhibitor binds to allosteric site (not active site) which changes the shape of the active site

ex: anti-cancer drugs, cyanide, poisoning, DDT

Competitive vs. Noncompetitive Inhibitors



Thermodynamics

study of energy transformation

first law: energy of the universe is constant

second law: every process increases the entropy of the universe

entropy: "quantity of energy in universe is constant, but quality is not"

ATP Powers Cellular Work

coupling endergonic/exergonic reactions

energy coupling: phosphorylated intermediates; regeneration of ADP to ATP

3 main types of work

1) mechanical work (motor protein)

2) transport work (Na/K pump)

3) chemical work

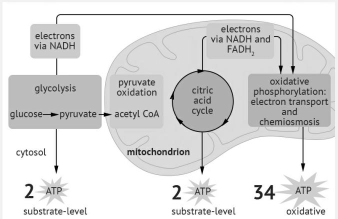
Size and Metabolic rate

larger mammals have more body mass and require more chemical energy (higher BMR)

smaller animals require more kcal/gram, have greater rate of O2 delivery, higher breathing rate

increase activity -> increase metabolic rate -> more ATP

Overview of Cellular Respiration



Citric Acid Cycle

location:	mitochondrial matrix
reactants:	~ acetyl CoA
	~ citric acid
	~ ADP + Pi
	~ NAD+ and FAD
products:	~ oxaloacetate
	~ ATP
	~ NADH and FADH2
	~ CO2
transfer of energy:	NADH and FADH2 (e- and H+) <- citric acid -> ATP
purpose:	~ complete the oxidation of glucose
	~ producing NADH/FADH2 (e- and H+)
	~ ATP

Phosphorylation

substrate-level: ATP is synthesized by enzymes

oxidative: ATP is synthesized by an ETC and chemiosmosis

Fermentation

anaerobic process (no O2)

produces small amounts of ATP

regenerates NAD+/NADH

alcoholic fermentation

~ yeast/bacteria

Fermentation (cont)

~ produces CO2 and alcohol

lactic acid

~ human muscles

~ yogurt

~ produces lactic acid

Consumers

heterotrophs: acquire organics to create energy from other creatures

~ consumers

~ decomposers

Light Reactions

occurs in the thylakoid

splitting of water

generation of ATP and NADPH

reactants: H2O, NADP+, ADP+Pi

products: O2, NADPH, ATP

Steps of Calvin Cycle

1) carbon fixation

~ ribulose biphosphate: RuBP

~ rubisco: RuBP carboxylase: most abundant protein

2) reduction

~ adding H+ and e- from NADPH to CO2 to make sugar

3) regeneration

~ G3P -> RuBP

Alternative Pathways of Carbon Fixation

photorespiration: fixing oxygen rather than CO2

C3 plants:	~ hot/dry days
	~ stomata close (prevents H2O, inc CO2, dec O2)
C4 plants:	~ spatial separation of calvin cycle into bundle sheath cell

Alternative Pathways of Carbon Fixation (cont)

	~ PEP carboxylase initially captures CO_2
CAM pathways:	~ temporal separation
	~ takes in CO_2 at night