Cellular Energy

Potential Energy	stored energy
chemical energy	energy stored in chemical bonds, more bonds, greater potential energy
Kinetic Energy	moves
heat	thermal energy is transfered from one object to another
light	another form of energy
first law of thermodynamics/law f conservation	energy cannot be destroyed or created
exergonic/exothermic	energy is released during the chemical reaction, ΔG is < 0 (negative), reaction is spontaneous.
endergonic/endothermic	energy is absorbed during chemical reaction, ΔG is > 0 (positive)
complex cellular reactions	exergonic and endergonic chemical reactions are coupled.

inhibition of enzymatic reactions

Enzymes that have already been produced are regulated by competitive or noncompetitive inhibition

competitive inhibition	compeitive inhibitors, by preventing or limiting the substrate from binding to the enzyme.
Noncompetive Inhibition/allosteric regulators	binding of the inhibitor to the alternative site, changing the shape of the enzye, inhibiting the enzyme from catalyzing substrate into product. **Feedback inhibition**: the end product of the pathway is the allosteric inhibitor for an enzyme that catalyzes an early step in the pathway. (graph)

inhibition of enzymatic reactions (cont)

Cooperativity	type of allosteric activation, cause the enzyme to atbilize in active form, amplifying response of the enzyme. (graph)

Photosynthesis

light energy is converted to chemical bond energy, and carbon is fixed into organic compounds.

$6CO_2+12H_2O \xrightarrow{light} C_6H_{12}O_6+6H_2+6O_2$

Photosynthesis is a reduction reaction because CO_2 gains hydrogen from water.

two main processes of photosynthesis: the **light-dependent** and the **light-independent** reactions.

light dependent reaction	use light energy directly to produce ATP.
Light Independent reaction	consist of the Calvin cycle, use ATP formed by light reactions to produces sugar.
Photosynthetic pigments	chlorophylls and carotenoids. **Chlorophyll a and chlorophyll b** are green and absorb all wavelengths of light in the red, blue, and violet ranges. The **carotenoids** are yellow, orange, and red. They absorb light in the blue, green, and violet ranges. Different types of chlorophyll give a plant greater flexibility to exploit light as an energy source.
	Chlorophyll a : participates directly in the light reactions of photosynthesis; head surrounded by alternating double and single bonds, attached to a long hydrocarbon tail. (graph) The double bonds within the head. They are the source of the electrons that flow through the electron transport chains during photosynthesis.

Photosynthesis (cont)

Chloroplast	enclosed by double membrane. contains **grana** (light-dependent reactions occur), and **stroma** (light-independent reactions occur). grana consist of layers of membranes called **thylakoids**, the site of photosystems I and II.
	contains photosynthetic pigments that, along with enzymes, carry out photosynthesis.
Photosystems	few hundred photosystems in each thylakoid.
	consists of a **reaction center** containing chlorophyll a and a region containing several hundred antenna pigment molecules that funnel energy into chlorophyll a.
	PS II(P680) operates first, followed by **PS I**(P700).
Light dependent reactions	electron flow
Noncyclic Photophosphorylation	electrons enter two electron transport chains. The products are ATP and NADPH.
	1. light energy absorbed by **PHOTOSYSTEM II—P680**. electrons captured by **primary electron acceptor**.
	2. **Photolysis**: splitting of water. It provides electrons, $H_2O \rightarrow 2H^+ + 2e^- + O_2$ ↑(waste product)
	3. **ETC**: This flow of electrons is exergonic and provides energy to produce ATP by chemiosmosis, **photophosphorylation**.
	4. **Chemiomosis**: **ATP synthase channels**, provides energy for calvin cycle later.

Photosynthesis (cont)

	5. **NADP**: reduced, formed NADPH carries hydrogen to the Calvin cycle to make sugar in the light-independent reactions.
	6. Photosystem I - P700**: Energy is absorbed by P700, this ETC produces NADPH, not ATP.
Cyclic Photophosphorylation	only produce ATP (bc calvin cycle later comsumes a lot)
Light Independent - Calvin Cycle	CO2 enters, then produces the 3-carbon **sugar PGAL**
	occurs only in the light.
photorespiration	Unlike normal respiration, no ATP is produced. Unlike normal photosynthesis, no sugar is formed. **peroxisomes** break down the products of photorespiration.

Metabolism

sum of all chemical reactions

catabolism: break down molecules

anabolism: build up molecules

Enzyme-controlled reactions

enzyme serve as catalytic proteins that speed up reactions by lowering the **energy of activation**, EA (the amount of energy needed to begin a reaction).

The **transition state** is the reactive (unstable) condition of the substrate after sufficient energy has been absorbed to initiate the reaction.

Endergonic vs. Exergonic (graph)

Enzyme Characteristics

- enzymes: **globular proteins, teritary structure**
- substrate specific
- **induced-fit model** (change confrontaton)
- **enzyme substrate complex**
- are not destroyed during a reaction, but reused.
- are named after their substrate, ends in the suffix "ase." (ex: lactase for lactose, sucrase for sucrose)
- catalyze reactions in both reactions

Enzyme Characteristics (cont)

- require assistance from **cofactors** (inorganic) or **coenzymes** (vitamins)
- will not catalyze a reaction that would not occur otherwise.
- effciency is affected by temperature and PH. favor low temperature and low PH

Cell respiration

cells extract energy stored in food and transfer that energy to molecules of ATP.

anaerobic respiration(no oxygen(	glycolyisis + alcoholic fermentation or lactic acid fermentation.
Aerobic respiration (oxygen)	Glycolysis + Krebs cycle + electron transport chain + oxidative phosphorylation

reduction: gain of electrons (e –) or hydrogen (H+), while **oxidation** is the loss of electrons or protons. In any **redox reaction**, one substance is reduced while the other is oxidized.

As hydrogen (with its electron) is transferred from glucose to oxygen, it is moving from a higher energy level to a lower one, releasing energy in stages. This free energy powers the synthesis of ATP.

ATP	adenosine (the nucleotide adenine plus ribose) plus three phosphates.
substrate level phosphorylation	direct enzymatic transfer of phosphate to ADP.

When one phosphate group is removed from ATP by hydrolysis, a more stable molecule, ADP results, releasing energy

Cell respiration (cont)

Glycolysis (graph)	2 ATP + 1 Glucose (6 carbon) → 2 Pyruvate (3 carbon) + 4 ATP, produce 2 ATP; occurs in cytoplasm, releases ATP without using oxygen. The end product, pyruvate, is the raw material for the Krebs cycle, the next step in aerobic respiration. Without glycolysis to yield pyruvate, aerobic respiration could not occur; ATP is produced by substrate level phosphorylation—by direct enzymatic transfer of a phosphate to ADP; If ATP is enough, it uses allosteric inhbition (inhibits PFK by althering the confrontation of the enzyme, thus stopping glycolysis), if ATP is less (as more cell activities uses), less less ATP is available to inhibit PFK and glycolysis continues, ultimately to produce more ATP.
Mitochondrion(graph)*	Double membrane; outer membrane is smooth, but the inner or **cristae membrane** is folded. Inner membrane has two: **outer compartment** and **matrix**.

Aerobic respiration :glycolysis(anaerobic) + Krebs cycle and oxidative phosphorylation (aerobic).

Cell respiration (cont)	
Krebs Cycle	in **matrix of mitochondria**, requires pyruvate (product of glycolysis), completes the oxidation of glucose to CO2, turn twice, generates 1 ATP per turn, the remainder of the chemical energy is transferred to NAD+ and FAD, then the reduced coenzymes, NADH and FADH2 , shuttle high-energy electrons into the electron transport chain in the cristae membrane.
	coenzyme A (a vitamin) to form **acetyl-CoA**, which does enter the Krebs cycle. The conversion of pyruvate to acetyl-CoA produces **2 NADH**, 1 NADH for each pyruvate.
	Each turn of the Krebs cycle releases **3 NADH, 1 ATP, 1 FADH**, and the waste product **CO2**, two turns total
NAD+ and FAD	
	coenzymes that carry protons or electrons from glycolysis and the citric acid cycle to the electron transport chain.
	NAD/FAD facilitates the transfer of hydrogen atoms from a substrate to its coenzyme NAD+.
	Without NAD+ to accept protons and electrons from glycolysis and the Krebs cycle, both processes would cease and the cell would die.
	NAD+ is the oxidized form. NADre or NADH is the reduced form.
electron transport chain (ETC) (graph)	
	proton pump in **cristae membrane** of the mitochondrion.

Cell respiration (cont)
thousands ETC due to the extensive folding of the cristae membrane.
final electron acceptor, through a series of **redox reactions**.
highly **electronegative** oxygen pulls electrons through the electron transport chain.
NADH provides more energy for ATP synthesis than does FADH2 .
cytochromes used to trace evolutionary relationships.
coenzyme Q, **mobile electron carrier**, diffuses within and along the membrane. If the cristae membrane were not fluid, Q could not move through it, and the ETC could not operate.
Exergonic reactions are coupled with endergonic ones. The exergonic flow of electrons toward the highly electronegative oxygen provides the energy for the endergonic pumping of protons.
oxidative phosphorylation/chemiomosis (graph)
proton (H+) gradient from NADH and FADH2 to phosphorylate ADP and produce ATP (ADP + P → ATP).
Protons are pumped from the **matrix** to the **outer compartment**, against a gradient, by the electron transport chain.
As protons flow down through the **ATP synthase channel**s, they generate energy to phosphorylate ADP into ATP.

Cell respiration (cont)	
	Oxygen is the **final hydrogen acceptor**, combining and forming **water**, which is the waste product of cell respiration
Summary of ATP production	Substrate level phosphorylation + Oxidative phosphorylation
Glucose → NADre and FADre → electron transport chain → chemiosmosis → ATP	
The **catabolism (breakdown) of glucose** under aerobic conditions occurs in three sequential pathways: glycolysis, pyruvate oxidation, and the citric acid cycle.	
Anaerobic respiration - fermentation (glycolysis + alcohol/lactic acid fermentation)	
2 types of anaerobes	**Facultative**: tolerate the presence of oxygen, **Obligate**: cannot live in an environment containing oxygen.
When there is an adequate supply of NAD+ to accept electrons during glycolysis, fermentation can generate ATP. Without some mechanism to convert NADH back to NAD+ , glycolysis would shut down.	
Alcohol Fermentation	convert pyruvate from glycolysis into **ethyl alcohol** and **carbon dioxide**, oxidize NADH back to NAD+. (ex: bread baking to rise)
Lactic Acid Fermentation	pyruvate from glycolysis is reduced to form **lactic acid or lactate**, NADH gets oxidized back to NAD+. (ex: yogurt and cheese)
	Ex: **Human skeletal muscles**, when the blood cannot supply adequate oxygen to muscles during strenuous exercise. Lactic acid in the muscle causes fatigue and burning. The, continues to build up until the blood can supply the muscles with adequate oxygen to repay the oxygen debts.