

## energy

first law of thermodynamics energy cannot be created or destroyed, can only be transferred from one form to another, ATP CAN BE DESTROYED/CREATED

(aka law of conservation of energy)

second law of thermodynamics during energy conversions, entropy increases

More organized or built up compounds have more free energy and less entropy (i.e. glucose) and less organized have less free energy and more entropy (i.e. carbon dioxide).

can det how much free energy is available to do work in cell by calculating Gibbs free energy

if energy is released, reaction is exergonic, and triangle G is neg

if energy is absorbed, reaction is endergonic, G is positive

EXergonic reactions power ENDergonic ones

a. Organisms use free energy for organization, growth and reproduction. Loss of order or free energy flow results in death.

b. More free energy (ex. Food) than needed will be stored for growth (roots, glycogen, fat, etc.).

d. Reactions can be coupled to maintain a system, ex. Photosynthesis and cell respiration

redox: one substance is reduce, another is oxidized

oil rig

## metabolism

sum of all the chemical reactions that take place in cells

catabolism reaction that breaks down molecules

anabolism reaction the BUILD UP molecules

met reactions take place in pathways, each of which serves a specific function

multistep pathways controlled by enzymes

enable cells to carry out their chemical activities w remarkable efficiency

## enzyme controlled reactions

enzymes do NOT provide energy for a reaction or enable one to occur that wouldn't on its own

enzymes serve as catalytic proteins that speed up reactions by lowering the activation energy

activation energy amount of energy needed to begin a reaction

enzymes only affect activation energy and activated complex (how much potential energy this needs/is at)

transition state reactive (unstable) condition of the substance after sufficient energy has been absorbed to initiate the reaction

(is after reaches activated complex)

## characteristics of enzymes

induced fit model substrate enters the active site and induces enzyme to alter its shape slightly so substrate fits better

lock and key abandoned bc active site must change

enzyme binds to its substrate(s) to form enzyme-substrate complex

enzymes NOT destroyed during a reaction, are reused

named after their substrate, name ends in "ase"

ex: sucrase hydrolyzes sucrose

enzymes catalyze reactions in both directions, to put together AND break apart

often require assistance from cofactors (inorganic) or coenzymes (vitamins)

efficiency of enzymes affected by temp and pH

body temp too high, enzymes begin to denature and lose their unique conformation AND ability to function

## inhibition of enzymatic reactions

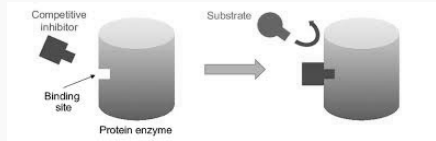
regulated by controlling when and where diff enzymes are active

can be done by switching on and off the genes that code for enzymes or by regulating them once r made

^(competitive or non competitive inhibition)



## competitive inhibition

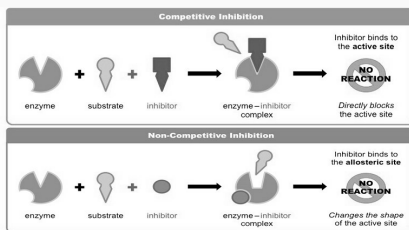


-some compounds resemble substrate molecules and compete for the same active site on the enzymes

-competitive inhibitors reduce amount of product by preventing/limiting the substrate from binding to the enzyme

-can be overcome by increasing the concentration of the substrate

## non competitive inhibition



## cooperativity

type of allosteric activation

binding of one substrate molecule to one active site of one subunit of the enzyme causes a change in the entire molecule

locks all subunits in the active position

amplifies response of an enzyme to its substrates

## negative feedback

## positive feedback

## hypothalamus/hormones

## noncompetitive inhibition

-allosteric: a change in shape alters their efficiency

-noncompetitive inhibitors/allosteric regulators bind to a site distinct and separate from the active site of the enzyme

-causes enzyme to change in shape which inhibits enzyme from catalyzing substrate into product

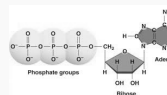
-active when product is formed (substrate binds)

-inactive when no product is formed (inhibitor attached to allosteric site)

-binding of either activator or inhibitor locks or stabilizes the allosteric enzymes in either the active or inactive form

-feedback inhibition can be used to regulate a lengthy metabolic pathway. the end product of the pathway is the allosteric inhibitor for an enzyme that catalyzes an early step in the pathway

## ATP



-adenosine is adenine + ribose

-atp is unstable, phosphates are all negatively charged and repel themselves

-when one phosphate group is removed from atp by hydrolysis, more stable adp is formed

-change from less stable molecule to more stable ALWAYS releases energy

-provides energy for all cellular activities by transferring phosphates to another molecules

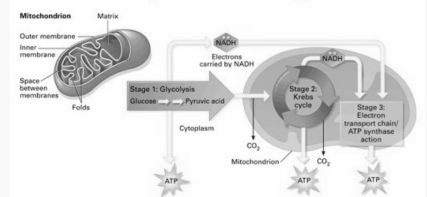
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## cellular respiration

### Cellular Respiration: Energy for Life

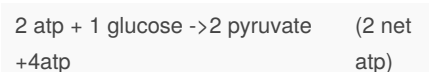


Makes ATP for cell use; uses glucose and oxygen makes waste products of carbon dioxide and water; occurs in mitochondria; NADH is electron carrier used

## glycolysis

(1) occurs in cytoplasm; anaerobic

(2) rearranges the bonds in glucose molecules, releasing free energy to form ATP from ADP through substrate-level phosphorylation resulting in the production of pyruvate.



enzyme that catalyzes third step, PFK is an allosteric enzyme

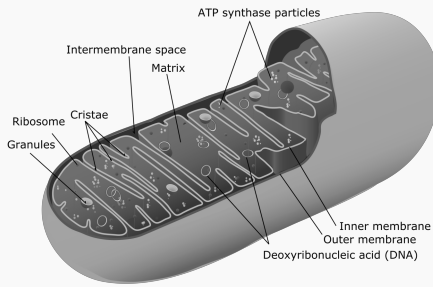
inhibits glycolysis when cell contains enough atp

if atp is present in large quantities, inhibits PFK by altering conformation of that enzyme and stops glycolysis

ex of how cell regulates atp production through allosteric inhibition

PFK is ENZYME

## mitochondria structure



matrix-krebs cycle  
cristae membrane (inner membrane)-etc  
outer compartment (inter membrane space)-proton concn builds up

## aerobic respiration: citric acid (krebs cycle)

- (1) occurs in mitochondrial matrix
- (3) occurs twice per molecule of pyruvate
- (4) Pyruvate is oxidized further and carbon dioxide is released; ATP is synthesized from ADP and inorganic phosphate via substrate-level phosphorylation and electrons are captured by coenzymes (NAD<sup>+</sup> and FAD).
- (5) NADH and FADH<sub>2</sub> carry electrons to the electron transport chain.

## aerobic respiration: electron transport chain

- (1) The electron transport chain captures electrons, pumping H<sup>+</sup> ions into the inter-membrane space of the mitochondria.
  - (2) Electrons are accepted by O<sub>2</sub> molecule forming H<sub>2</sub>O
- FINAL ELECTRON ACCEPTOR!!

## aerobic respiration: electron transport chain (cont)

(3) Concentration of H<sup>+</sup> builds up within inter-membrane space lowering the pH and ions rush through ATP synthase into the mitochondria matrix. Rush of ions "spins" ATP synthase protein, causing ADP and Pi to join forming ATP by oxidative phosphorylation

series of redox reactions

electroneg oxygen pulls electrons through the etc

NADH provides more energy for atp bc delivers elect to higher energy level in the chain

etc consists mostly of cytochromes

proteins structurally similar to hemoglobin

present in all aerobes

used to trace evolutionary relationships

## oxidative phosphorylation and chemiosis

## anaerobic respiration: fermentation

- a. No oxygen; cell only goes through glycolysis followed by fermentation
- b. Fermentation recycles NAD needed to restart glycolysis
- e. Fermentation does not make ATP but glycolysis does- 2ATP; very inefficient; sufficient for microorganisms

## alcohol fermentation

c. alcohol fermentation ex. yeast cells- glucose ethyl alcohol + CO<sub>2</sub>+ NAD<sup>+</sup>

## lactic acid fermentation

d. lactic acid fermentation ex. muscle cells- glucose lactic acid + NAD<sup>+</sup>

## photosynthetic pigments

a. Photosynthetic organisms capture free energy present in sunlight and use water and carbon dioxide to make carbon products and free oxygen.

## chloroplast structure

## photosystems

## light reactions

## noncyclic photophosphorylation

## cyclic photophosphorylation

## calvin cycle // light INdependent reactions

## photorespiration

## modifications for dry environments

## cinal link

<https://cheatography.com/fatbuttluver/cheat-sheets/photosynthesis-cellular-respiration/>

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