

Reactions and enzymes

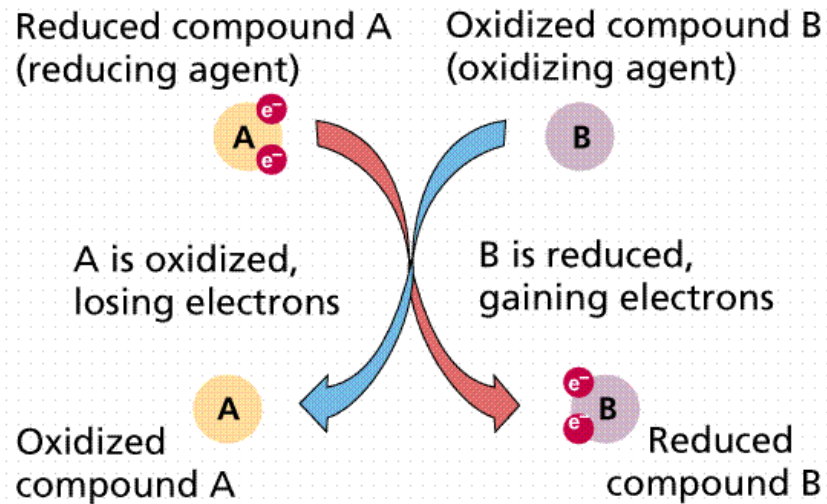
1. Energy is transferred
2. Electron is transferred
3. Water molecule can be a participant
4. Metabolic pathways
5. Enzymes

Energy is transferred

- **Exergonic reaction:** energy-generating reaction (reaction gives energy)
- **Endergonic reaction:** energy-consuming reaction (reaction uses energy)

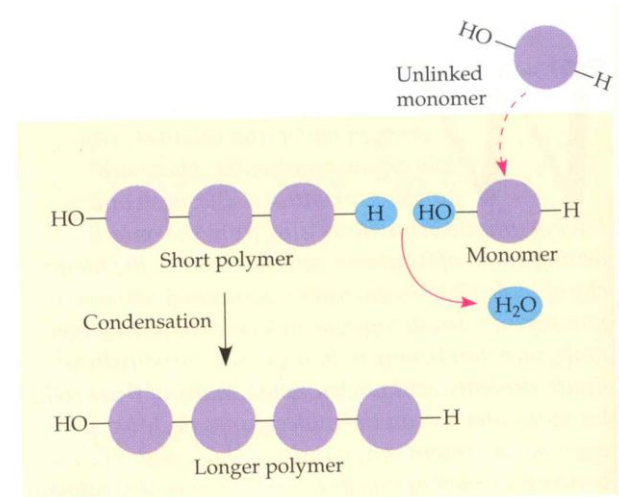
Electron is transferred

- **Oxidation:** reactant (A) loses electrons, reactant is oxidized
- **Reduction:** reactant (B) gains electrons, reactants is reduced
- **Oxidant= oxidizing agent (B):** reactant gaining electron
- **Reductant (A):** reactant losing electron

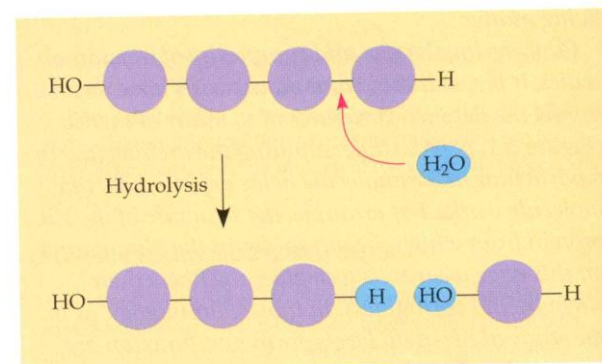


Water molecule can be a participant

- **condensation (dehydration):**
formation of a bond between 2 reactants accompanied by formation of a H_2O molecule, eg. peptide bond formation, ester bond formation
- **hydrolysis (hydration):**
breakdown of a bond accompanied by breakdown of a H_2O molecule, eg. breakdown of peptide bond, breakdown of ester bond



(a) Condensation synthesis (dehydration) of a polymer



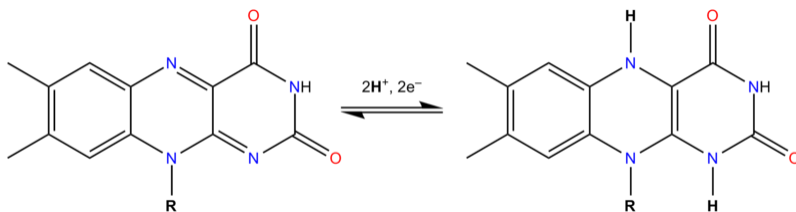
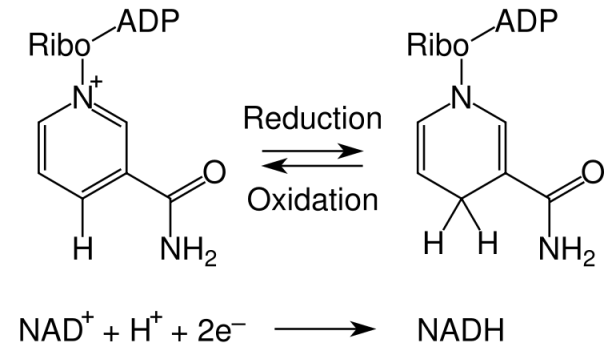
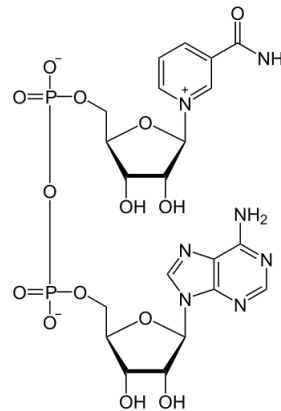
(b) Hydrolysis of a polymer

Metabolic pathways

- a series of individual chemical reactions in a living system
- product of one reaction in a pathway serves as the reactant for the following reaction
- always accompanied by energy transfer and electron transfer (electron transporters are involved eg. NAD)

Nicotinamide adenine dinucleotide

Wikipedia

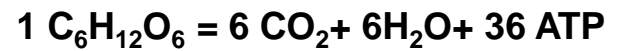
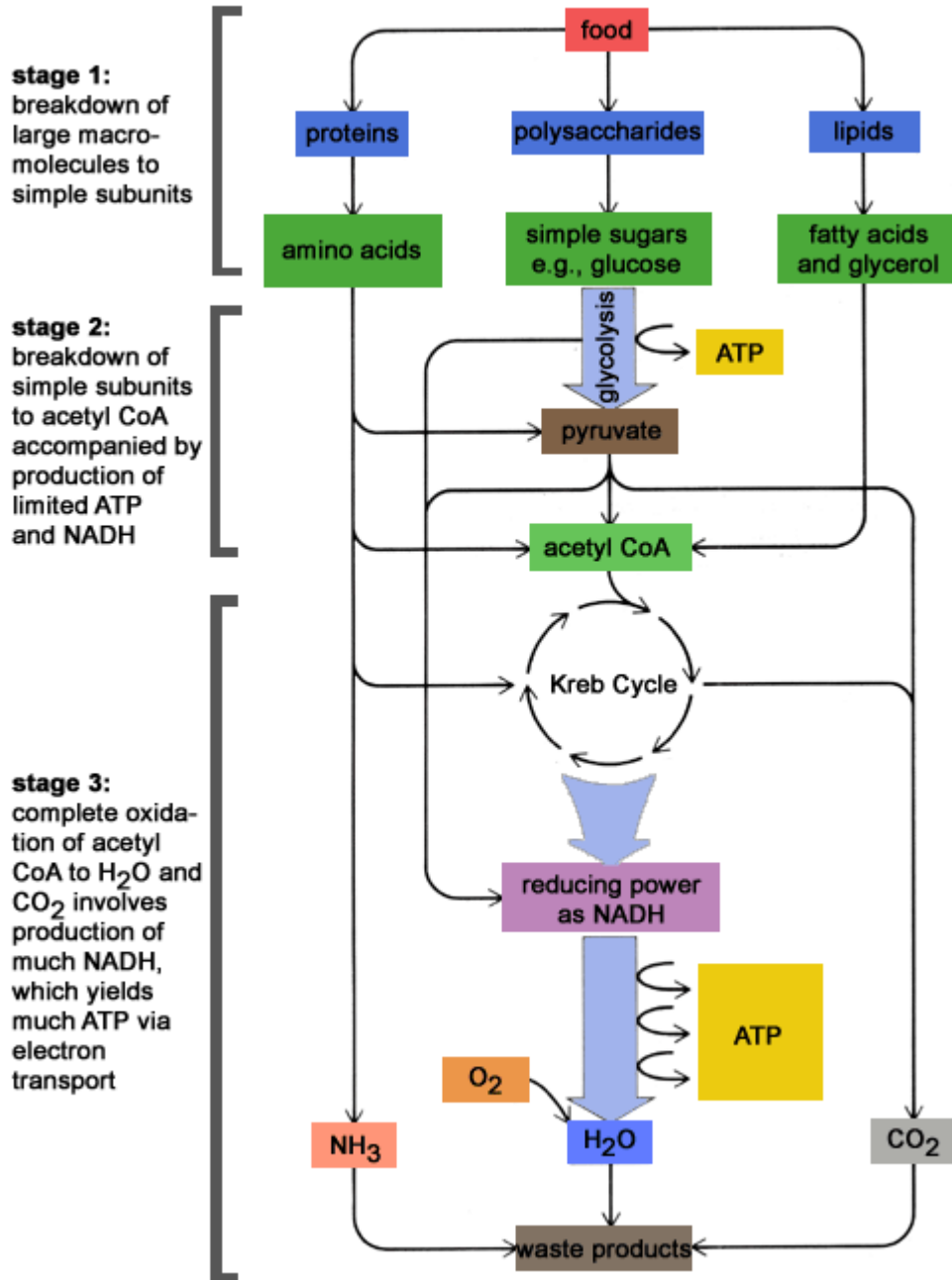


flavin adenine dinucleotide (FAD)

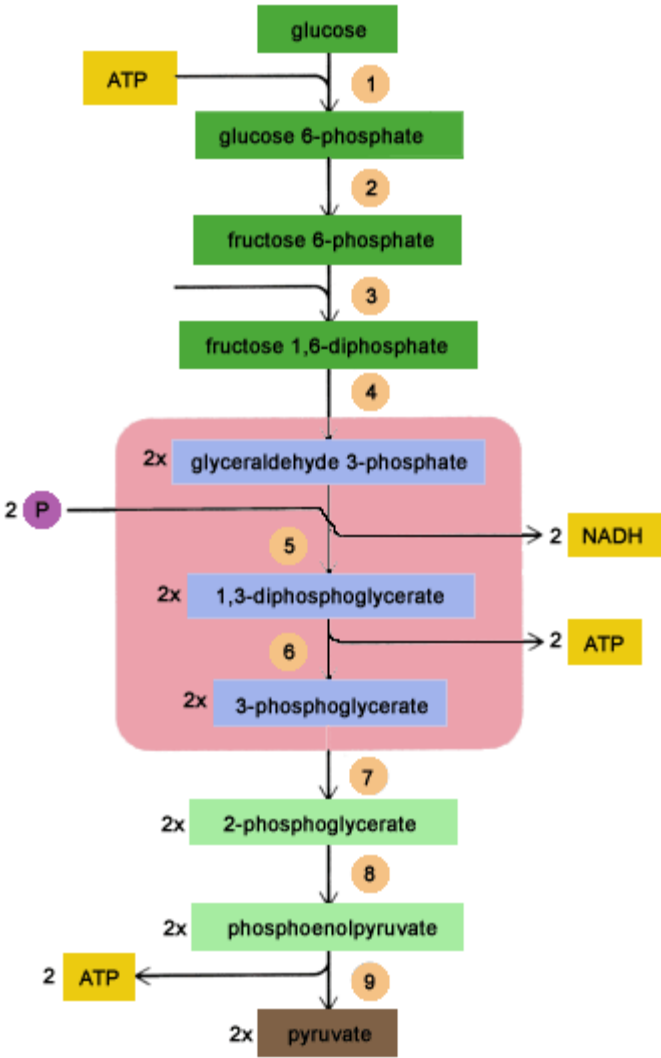
Wikipedia

Metabolic pathways

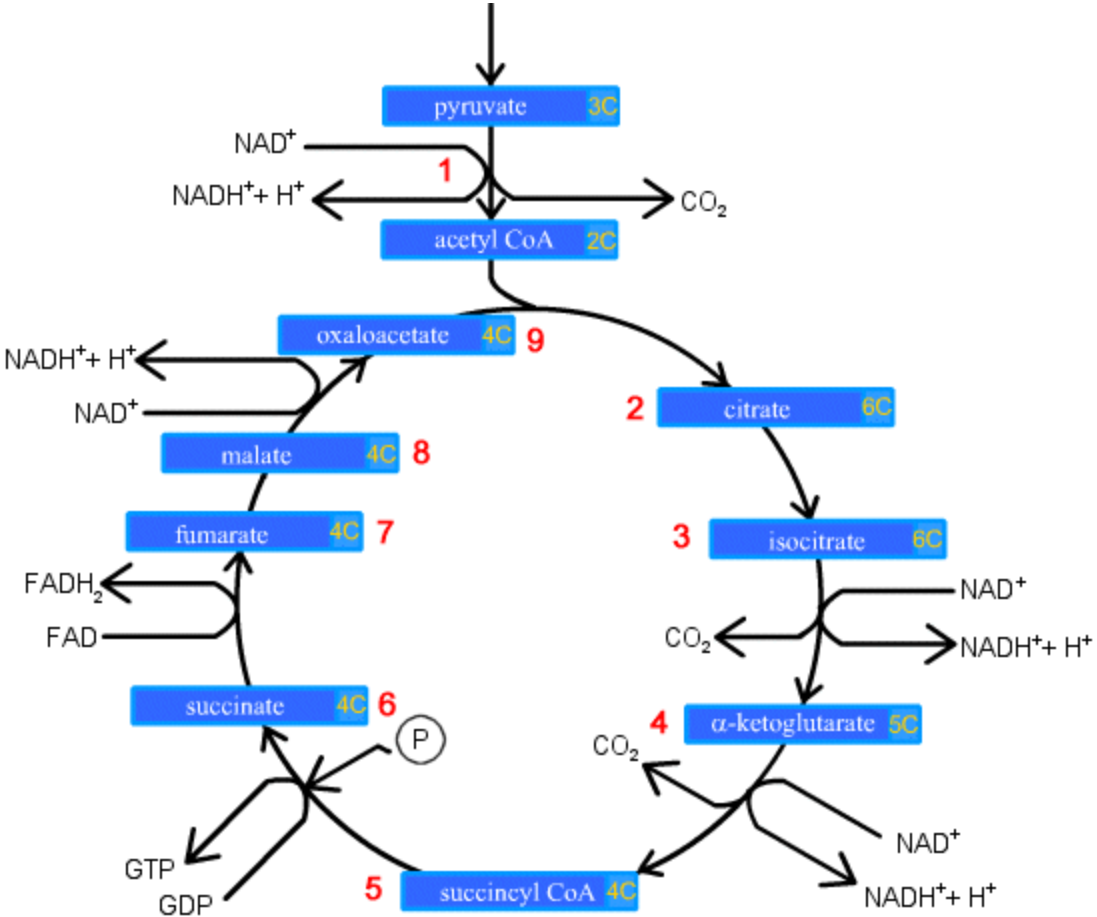
- **anabolic pathway**= **biosynthetic pathway**: synthesis (production) of a molecule
 - needs energy (eg. energy of sunlight or ATP)
 - reactants are reduced
 - example:
 - photosynthesis: synthesis of glucose from CO₂ and water in plants (needs energy of sunlight)
- **catabolic pathway**: breakdown of a molecule
 - produces energy (ATP, heat)
 - reactants are oxidized
 - examples:
 - biological oxidation of glucose (aerobic cellular respiration): breakdown of glucose into CO₂ and water
 - Fermentation (anaerobic cellular respiration): breakdown of glucose into lactate and CO₂



Glycolysis



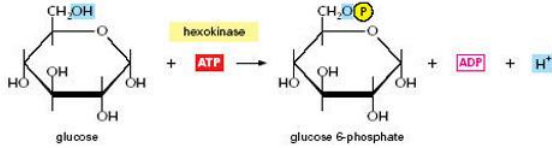
Krebs cycle/citrate cycle



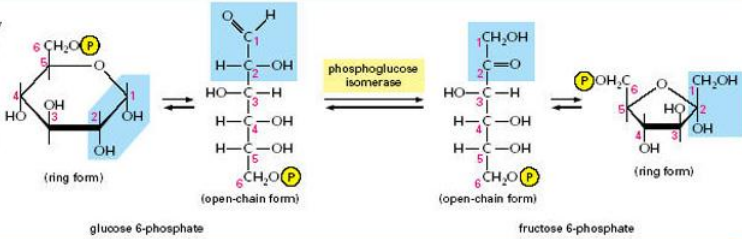
Panel 13-1 Details of the 10 steps of glycolysis

For each step, the part of the molecule that undergoes a change is shadowed in blue, and the name of the enzyme that catalyzes the reaction is in a yellow box.

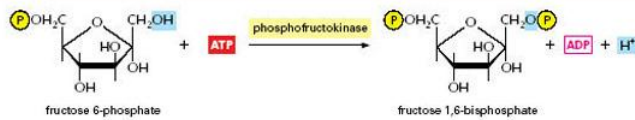
Step 1 Glucose is phosphorylated by ATP to form a sugar phosphate. The negative charge of the phosphate prevents passage of the sugar phosphate through the plasma membrane, trapping glucose inside the cell.



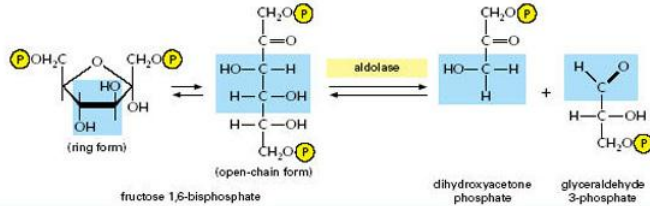
Step 2 A readily reversible rearrangement of the chemical structure (isomerization) moves the carbonyl oxygen from carbon 1 to carbon 2, forming a ketose from an aldose sugar. (See Panel 2-3, pp. 70-71.)



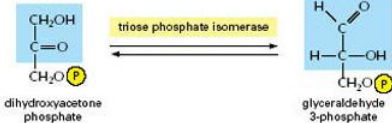
Step 3 The new hydroxyl group on carbon 1 is phosphorylated by ATP, in preparation for the formation of two three-carbon sugar phosphates. The entry of sugars into glycolysis is controlled at this step, through regulation of the enzyme phosphofructokinase.



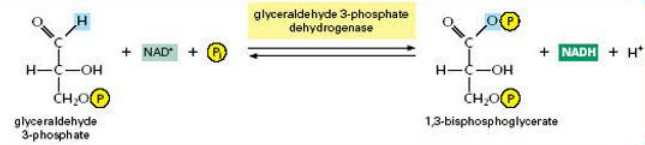
Step 4 The six-carbon sugar is cleaved to produce two three-carbon molecules. Only the glyceraldehyde 3-phosphate can proceed immediately through glycolysis.



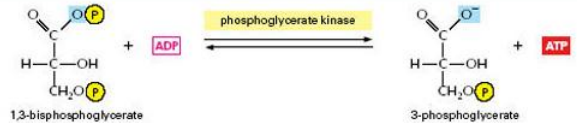
Step 5 The other product of step 4, dihydroxyacetone phosphate, is isomerized to form glyceraldehyde 3-phosphate.



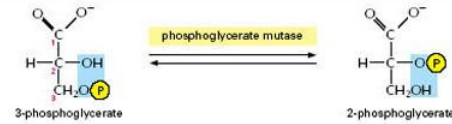
Step 6 The two molecules of glyceraldehyde 3-phosphate are oxidized. The energy-generation phase of glycolysis begins, as NADH and a new high-energy anhydride linkage to phosphate are formed (see Figure 13-5).



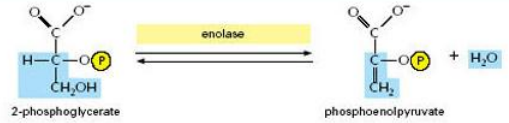
Step 7 The transfer to ADP of the high-energy phosphate group that was generated in step 6 forms ATP.



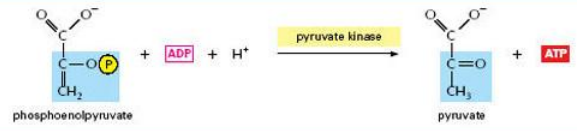
Step 8 The remaining phosphate ester linkage in 3-phosphoglycerate, which has a relatively low free energy of hydrolysis, is moved from carbon 3 to carbon 2 to form 2-phosphoglycerate.



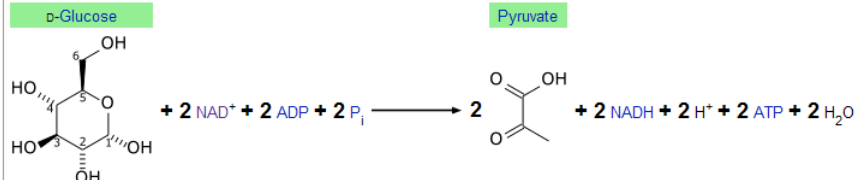
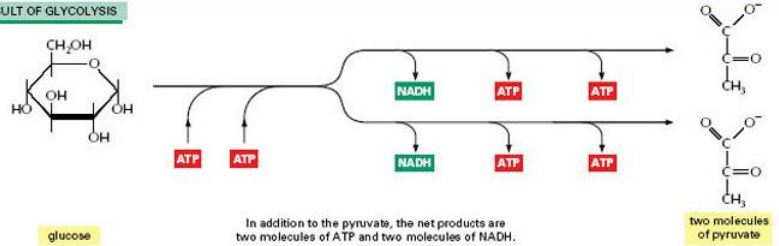
Step 9 The removal of water from 2-phosphoglycerate creates a high-energy enol phosphate linkage.

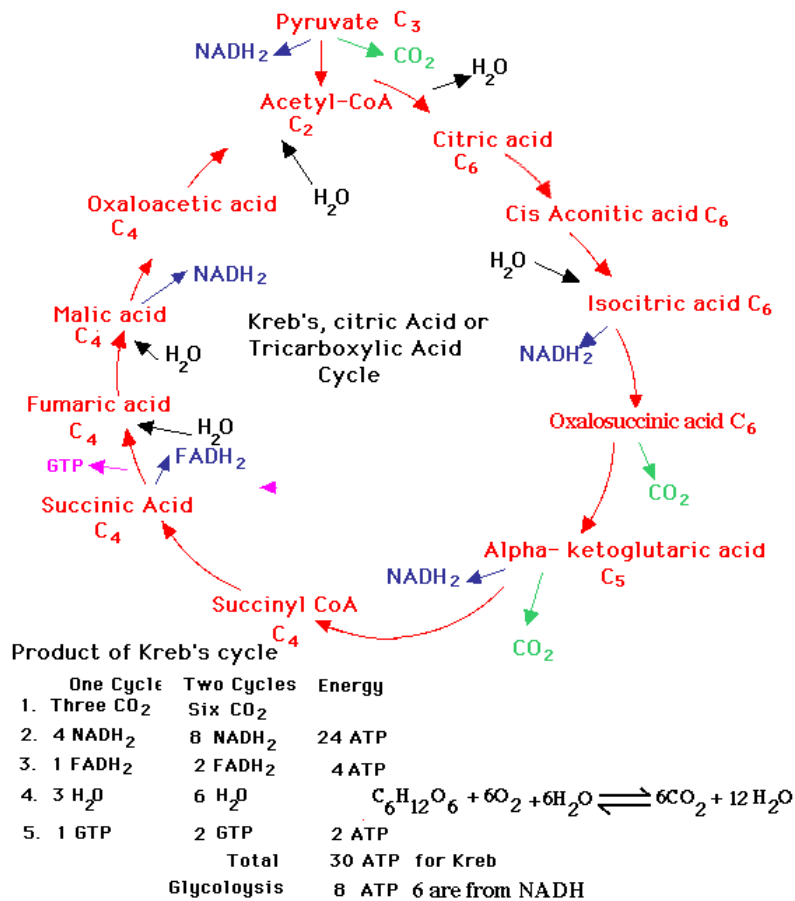
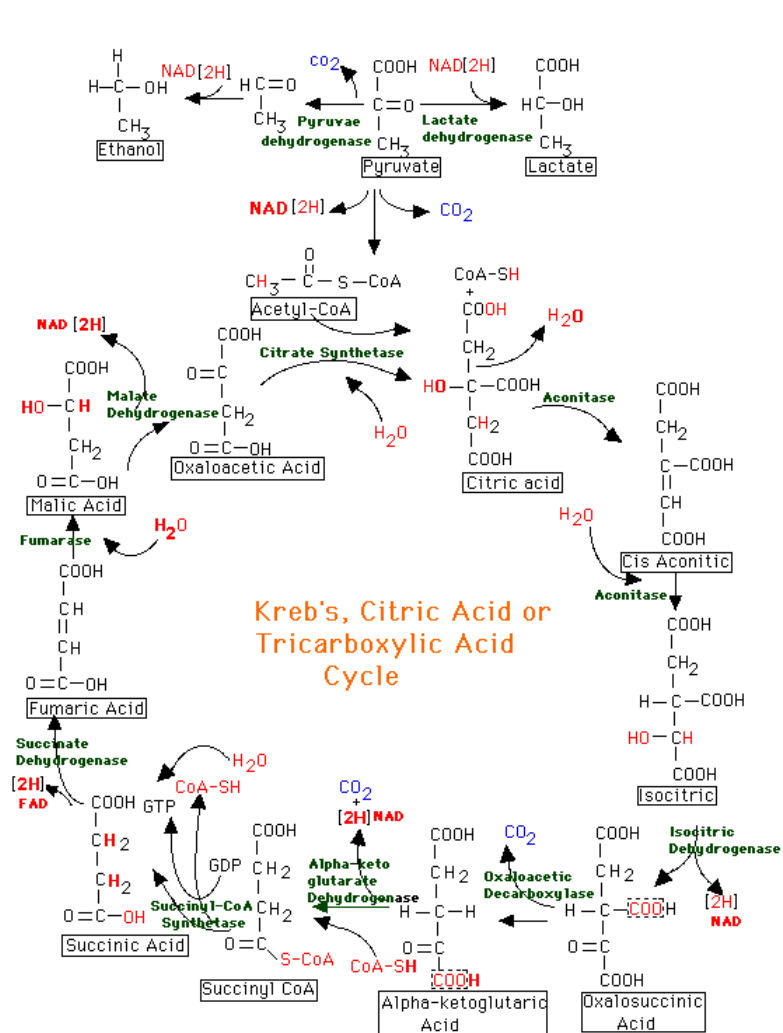


Step 10 The transfer to ADP of the high-energy phosphate group that was generated in step 9 forms ATP, completing glycolysis.



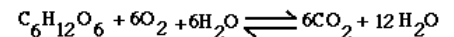
NET RESULT OF GLYCOLYSIS





Product of Krebs' cycle

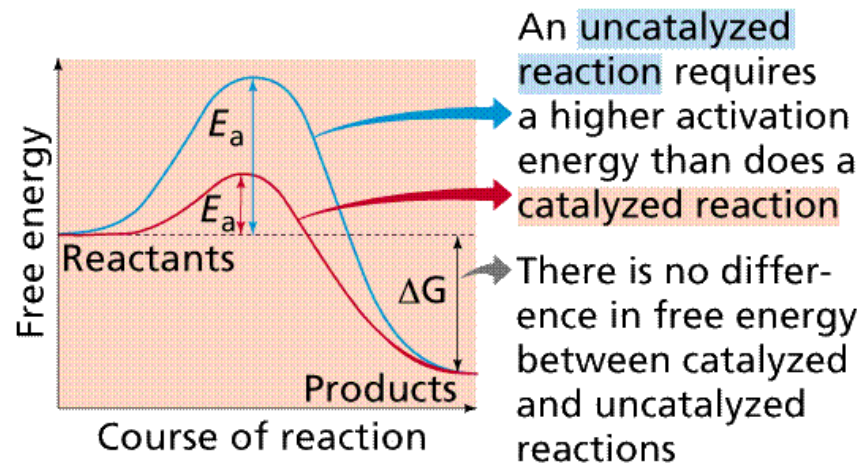
One Cycle	Two Cycles	Energy
1. Three CO ₂	Six CO ₂	24 ATP
2. 4 NADH ₂	8 NADH ₂	4 ATP
3. 1 FADH ₂	2 FADH ₂	
4. 3 H ₂ O	6 H ₂ O	
5. 1 GTP	2 GTP	2 ATP



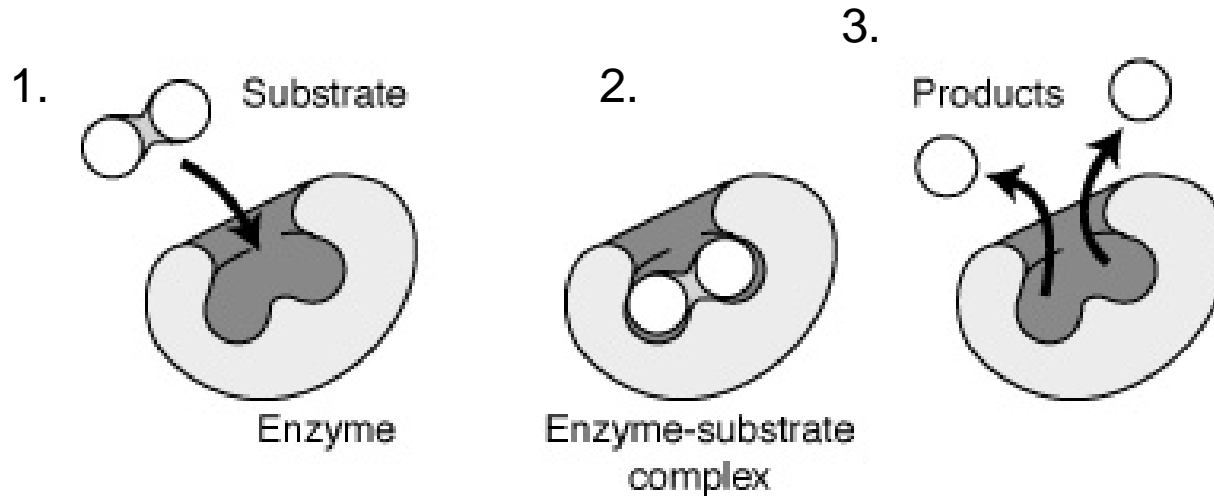
Total 30 ATP for Krebs
8 ATP 6 are from NADH

Enzymes=biocatalysts

- reaction is faster at the presence of an enzyme (even 10 000 times faster)
- reaction needs less activation energy at the presence of an enzyme (even 10 times less)

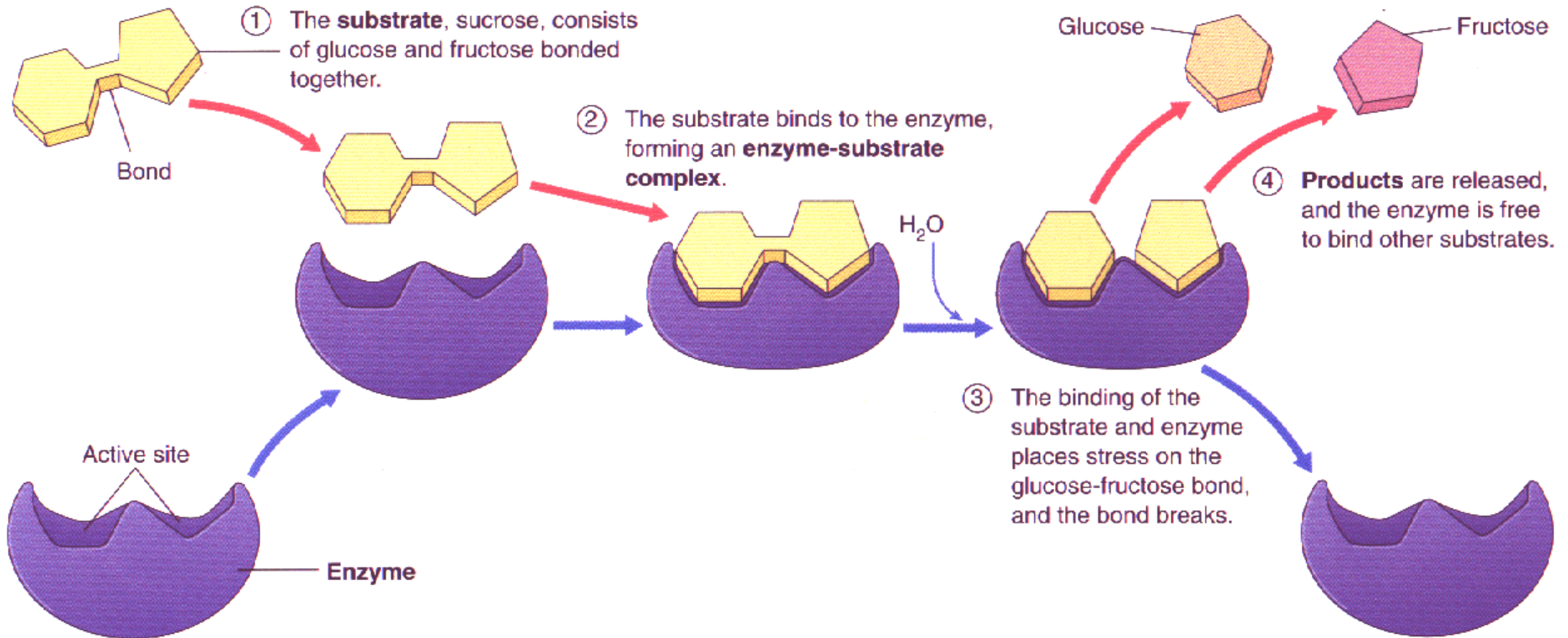


Mechanism of enzyme activity

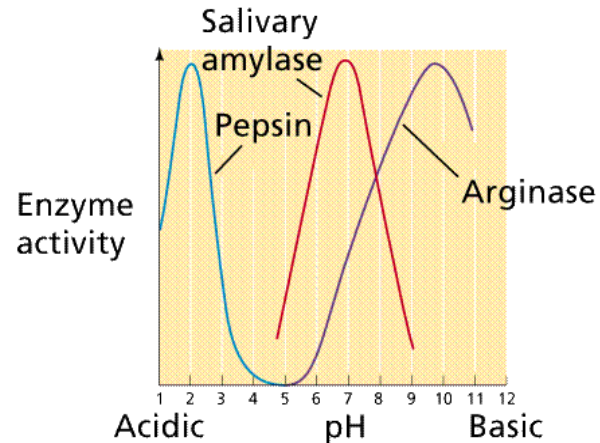


1. reactant (=substrate) binds to the active center (or site) of the enzyme („lock and key” model)
2. chemical reaction is performed (substrate is chemically modified) in enzyme-substrate complex: product is made
3. product leaves enzyme
4. enzyme can bind substrates again

Hydrolysis of sucrose

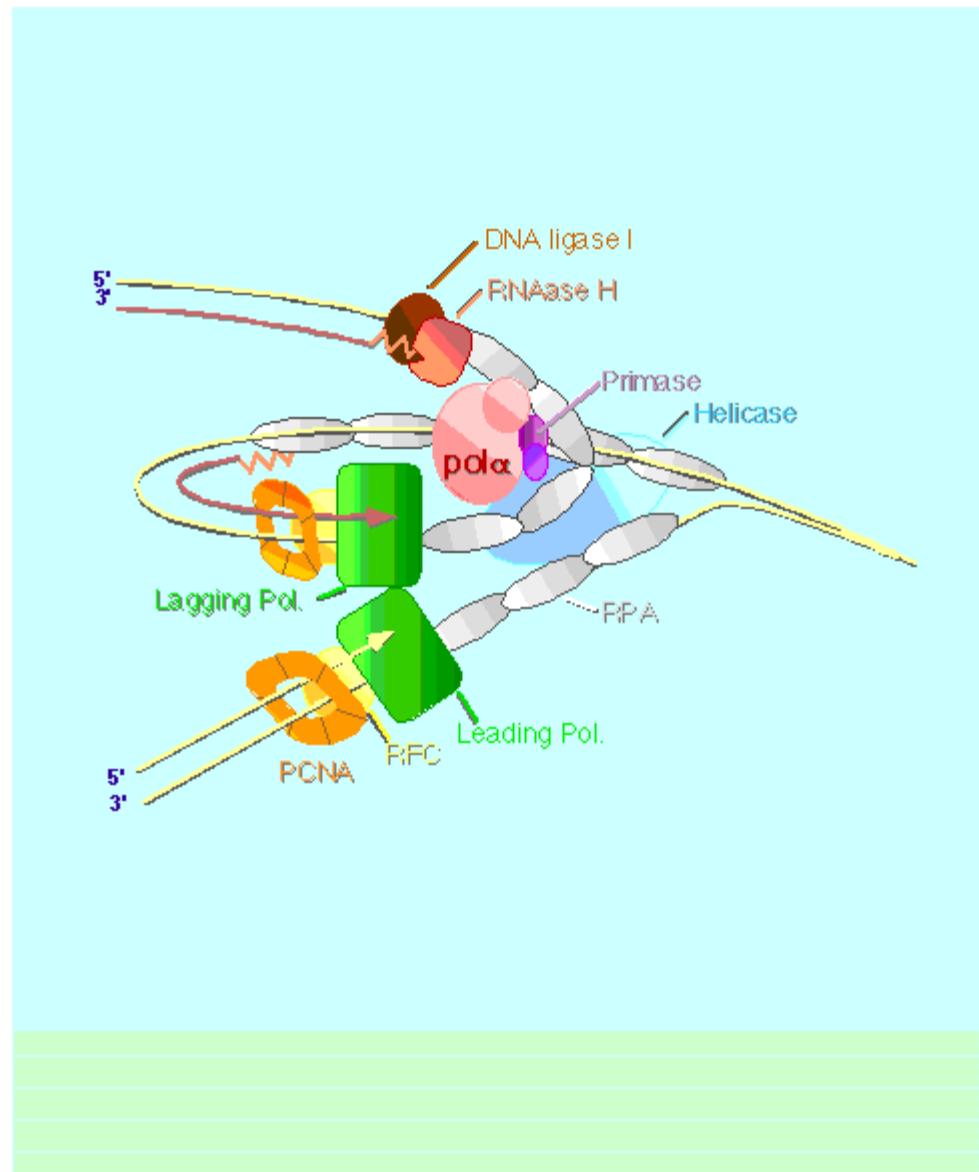


1. chemically proteins (some enzymes are chemically RNA, eg. peptidyl transferase)
2. Holoenzyme (eg. holoenzyme for DNA synthesis=replisome)
3. Coenzymes (eg. coenzyme A), electron transporters (eg. NAD, FAD)
4. sensitivity for pH and temperature



5. Scientific name: name of substrate+name of reaction+ASE (eg. Glycogensynthase)
6. examples:
 - digestive enzymes: catalyze breakdown of nutrients in digestive system eg.: amylase (breakdown of carbohydrates) pepsin (breakdown of proteins), lipase (breakdown of lipids)
 - biosynthetic enzymes: DNA polymerase (synthesis of DNA), RNA polymerase (synthesis of RNA), peptidyl transferase (synthesis of proteins)

replisome



Albinism=hypomelanism



Connie Chiu

