

Alberts • Johnson • Lewis • Morgan • Raff • Roberts • Walter

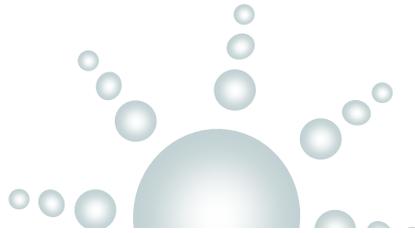
Molecular Biology of the Cell

Seventh Edition

Chapter 14

Energy Conversion:

Mitochondria and ~~Chloroplasts~~



Energy Conversion (Mitochondria) (I)

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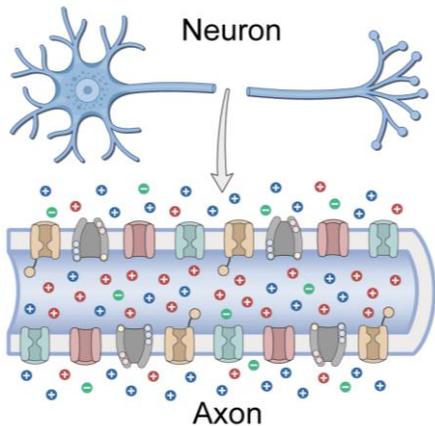
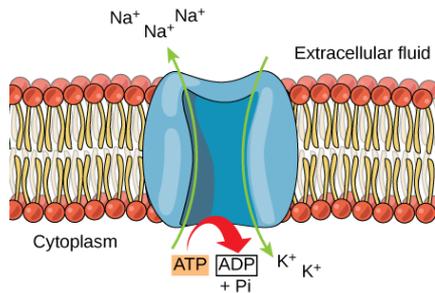
Phone : 031-219-4560

Why energy is critical in cell survival?

5분 동안 쓰지 X => ATPx => 뇌 세포 파괴, 심장 못 뛰

Numerous biological processes are dependent on **ATP**

Ion channels



Anabolism

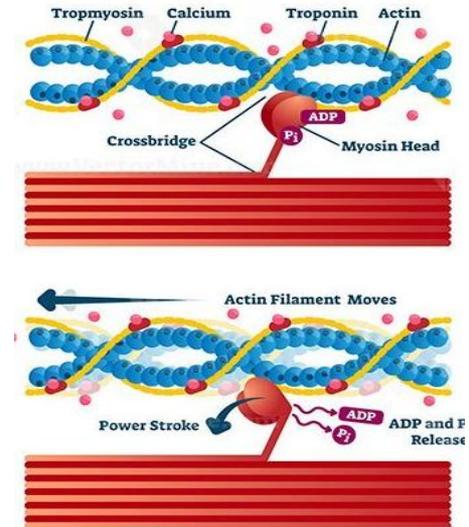
Protein synthesis: enzymes, skeletal fibers, etc.

Lipid synthesis: membranes, fat stores, etc.

Hormones: insulin, estrogen, etc.

-
-
-

Muscle contraction



Heart, Skeletal muscles, Smooth muscles, etc.



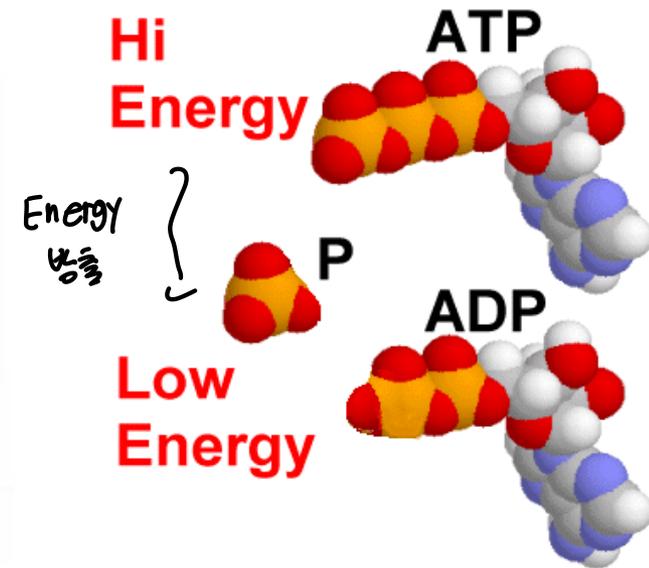
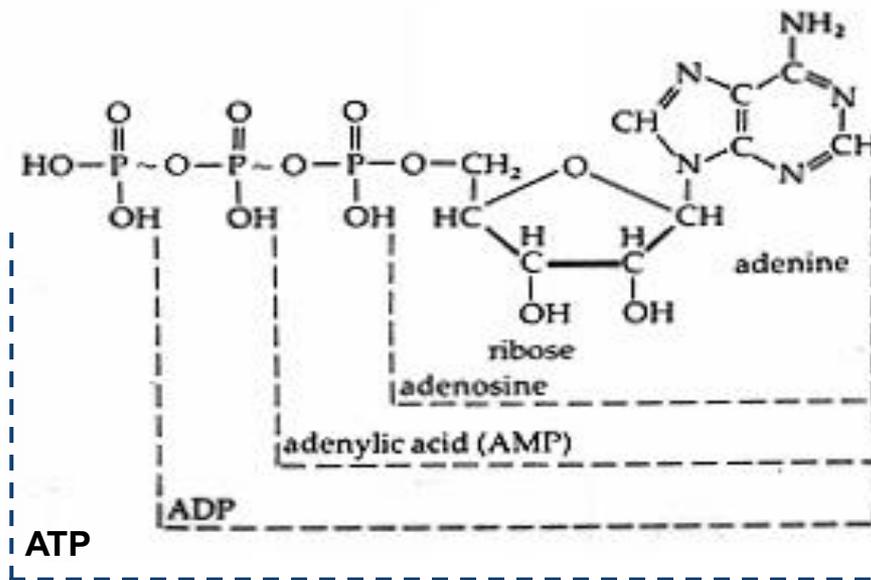
What is the energy in biological systems and how does it work?

How the energy is generated?

Biological energy ATP

65kg ATP/70kg Body weight

=> 먹어서 ATP 보충 불가



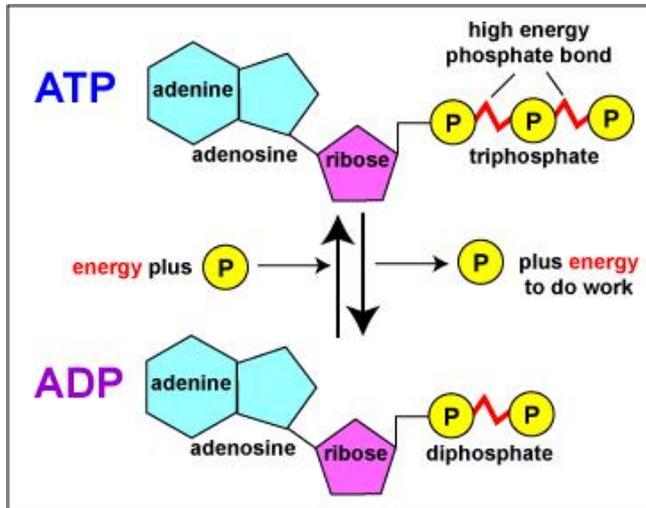
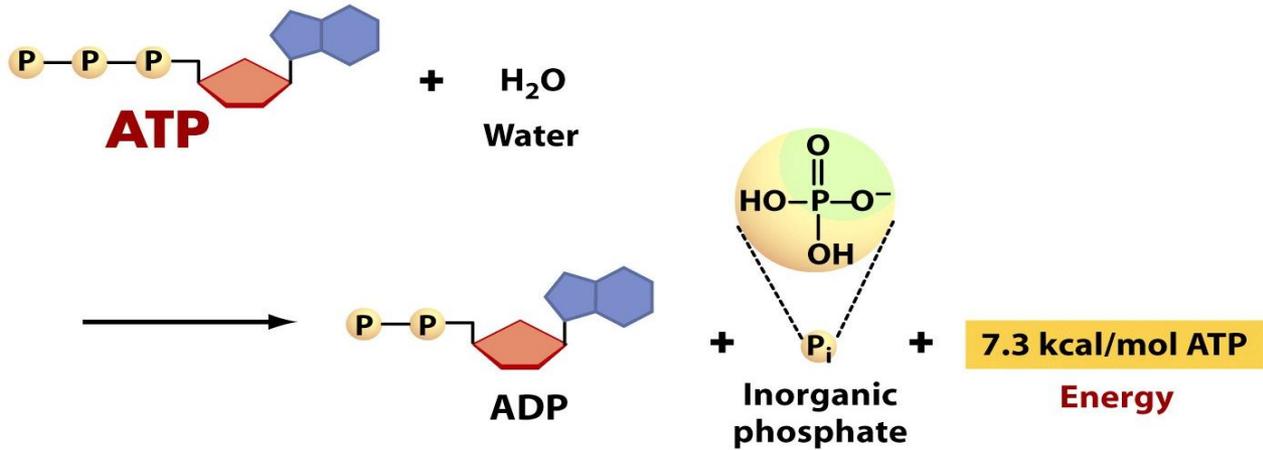
ATP : Adenosine-Tri-Phospate

↳ RNA의 ADP : Adenosine-Di-Phospate

ATP, GTP, CTP, UTP AMP : Adenosine-Mono-Phospate

중 1개

Biological energy ATP



= ATP 형성



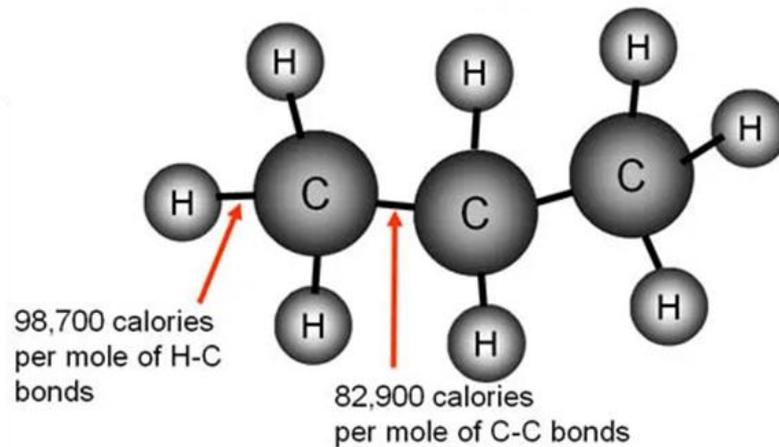
배터리 충전과 같음

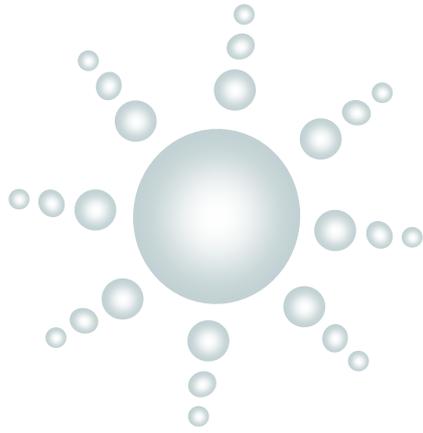
Complex molecules have higher energy level

↪ 같이 있을 때 energy level ↑

Bond energy

Energy required to maintain chemical bond





***How ATP is used as
biological energy?***

Spontaneous and non-spontaneous reactions

Spontaneous reaction

Chemical reaction which decrease energy level of products

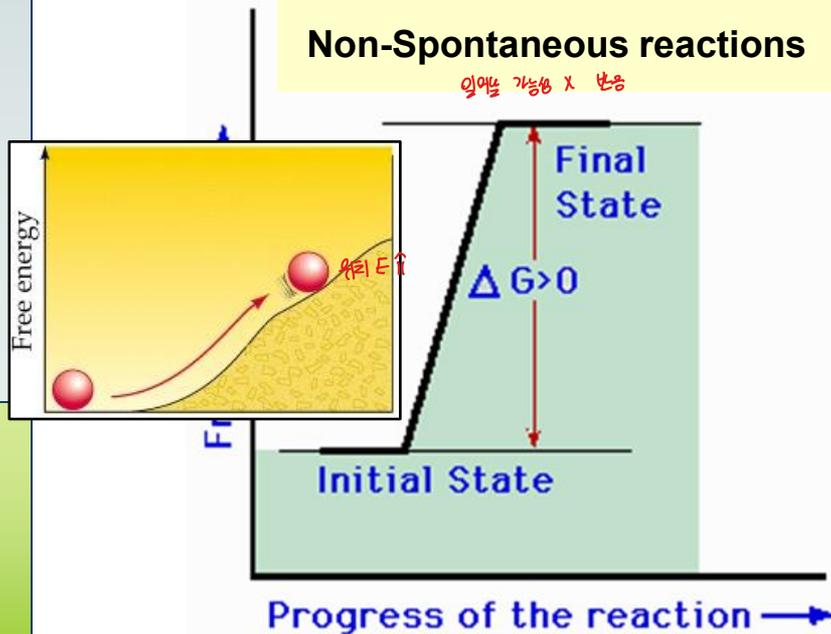
Non-spontaneous reaction

Chemical reaction which increase energy level of products

$$\Delta G = \Delta H - T\Delta S$$

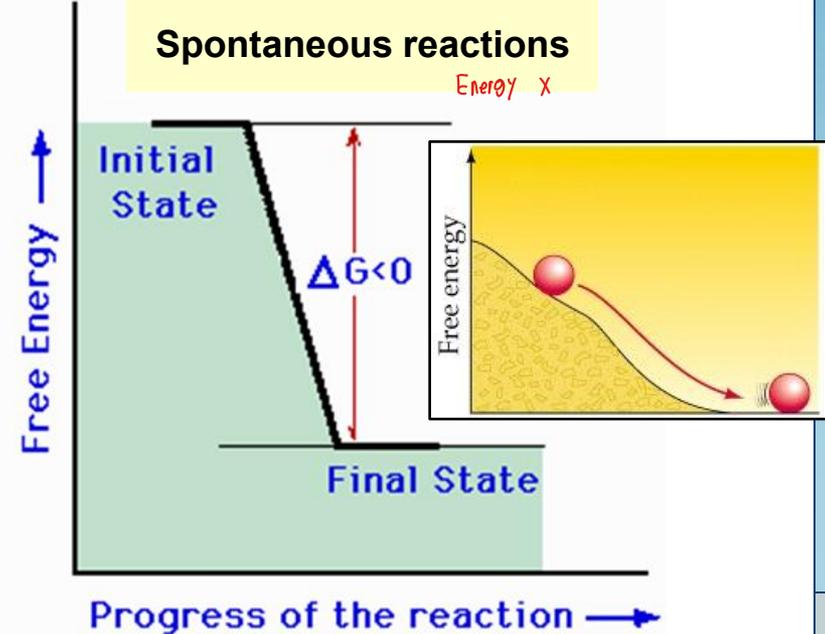
Non-Spontaneous reactions

일어날 가능성 X 반응

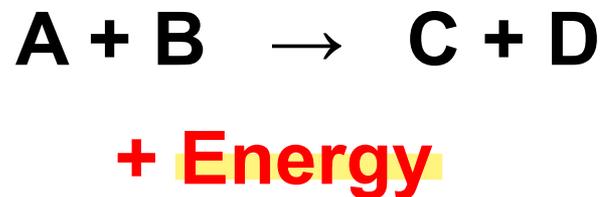
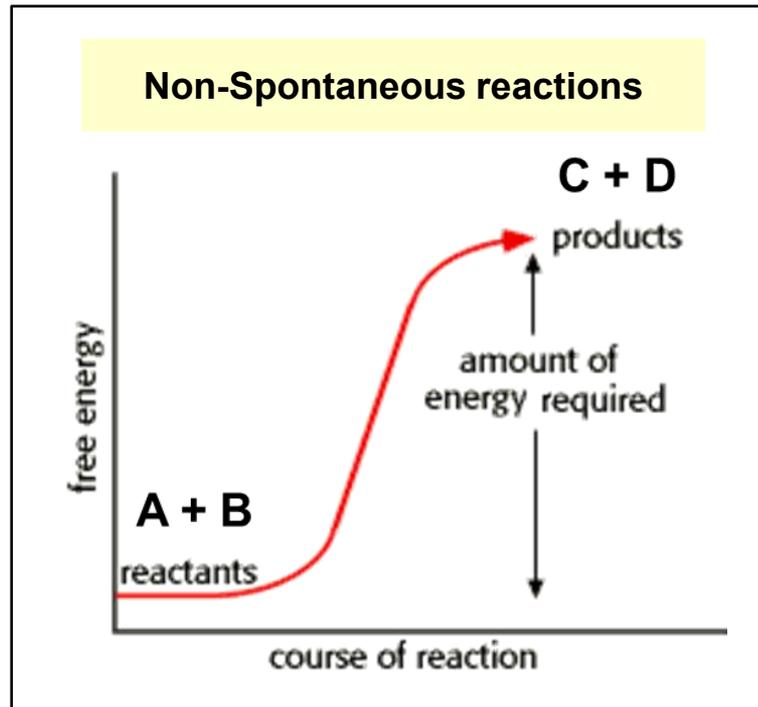


Spontaneous reactions

Energy X



Most of biological reactions are non-spontaneous



Biological reactions

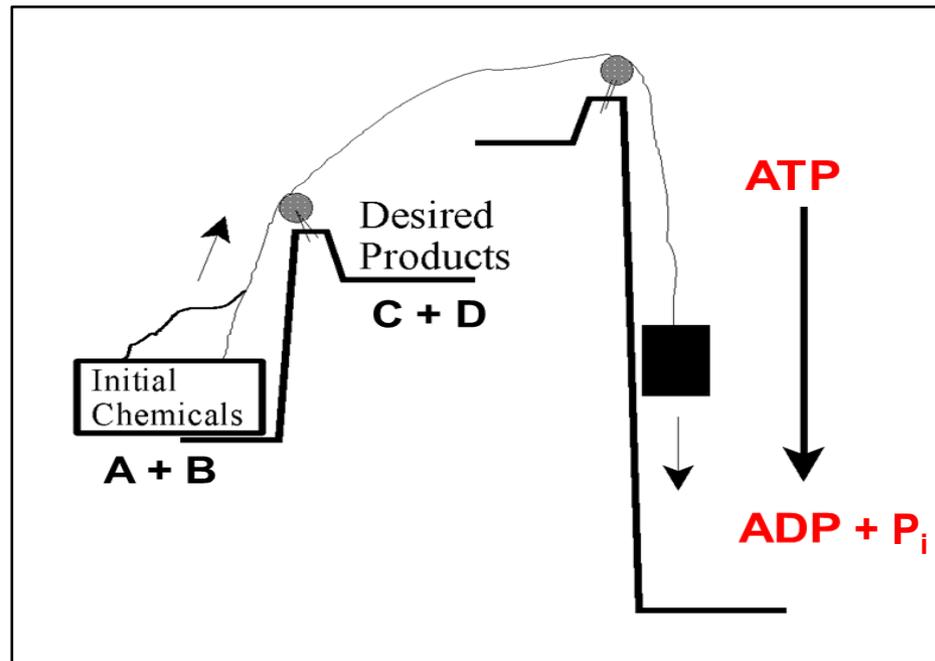
- Protein synthesis
- DNA synthesis
- Hormone synthesis
- Physical activities
-
-
-

세포에서 mostly
non-spontaneous reaction

Spontaneous biological reactions

ATP hydrolysis makes biological reaction spontaneous

Combination of two reactions through mediator



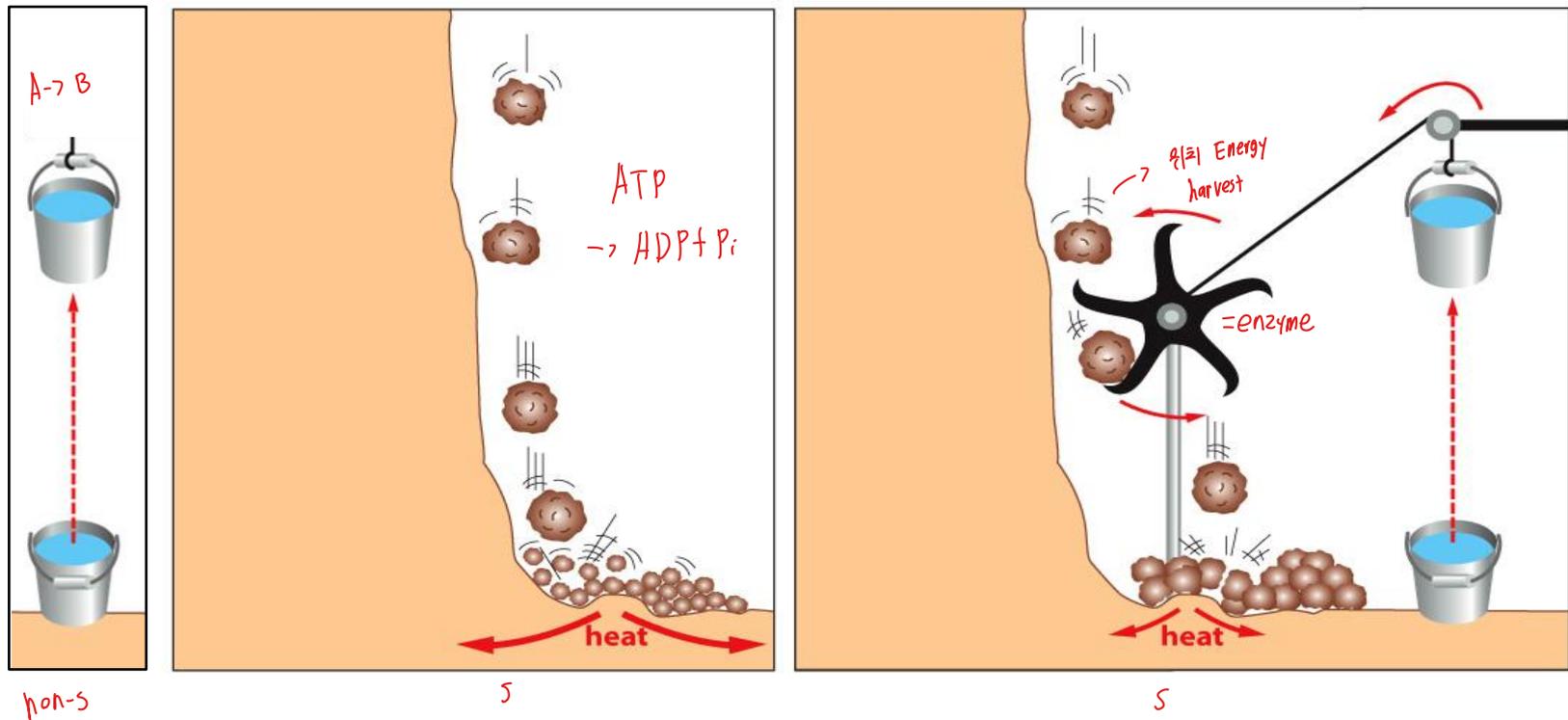
ATP 추가 하면
=> spontaneous reaction



Spontaneous biological reactions

ATP hydrolysis makes biological reaction spontaneous

Combination of two reactions through mediator

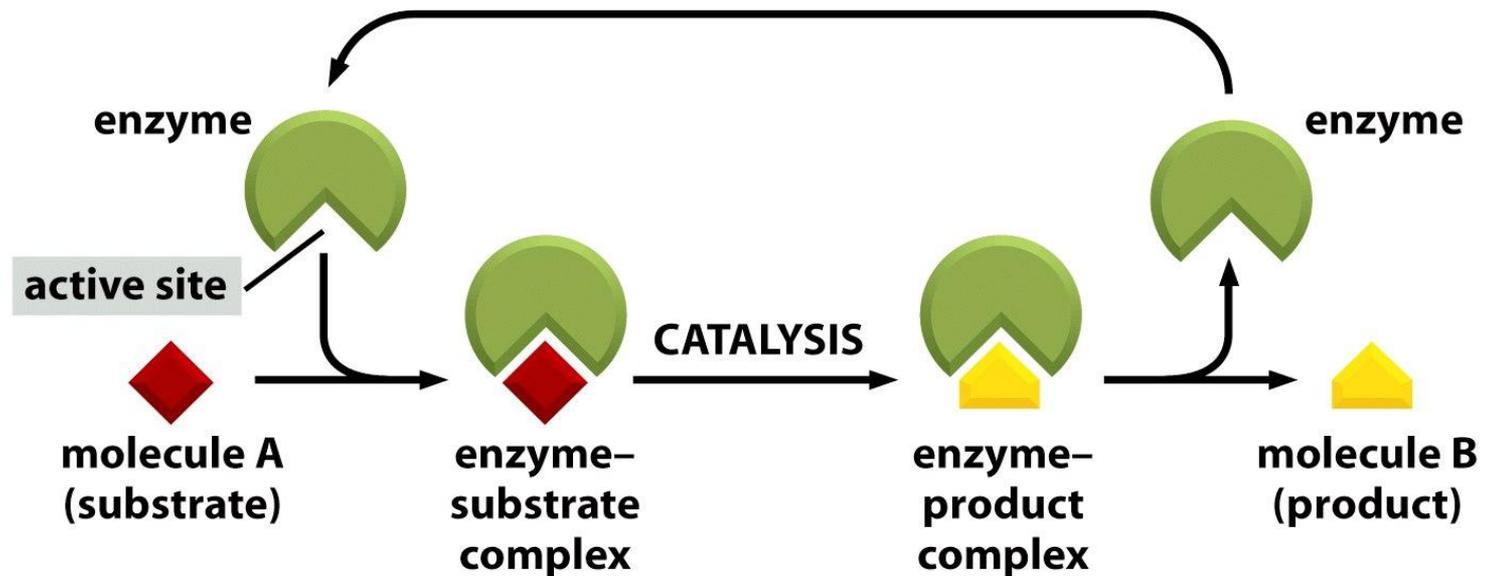


Biological energy ATP

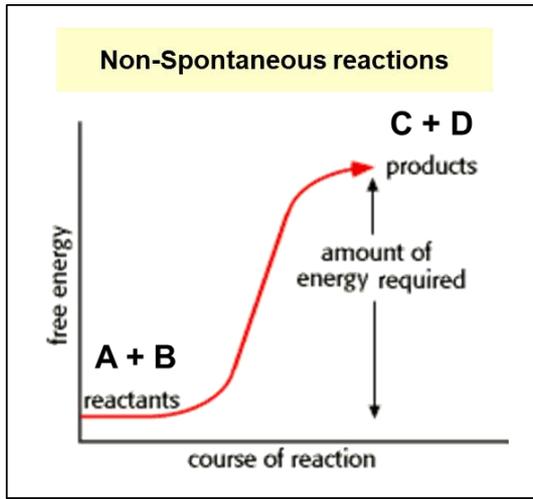


Enzyme (or protein) combine ATP hydrolysis and non-spontaneous reaction

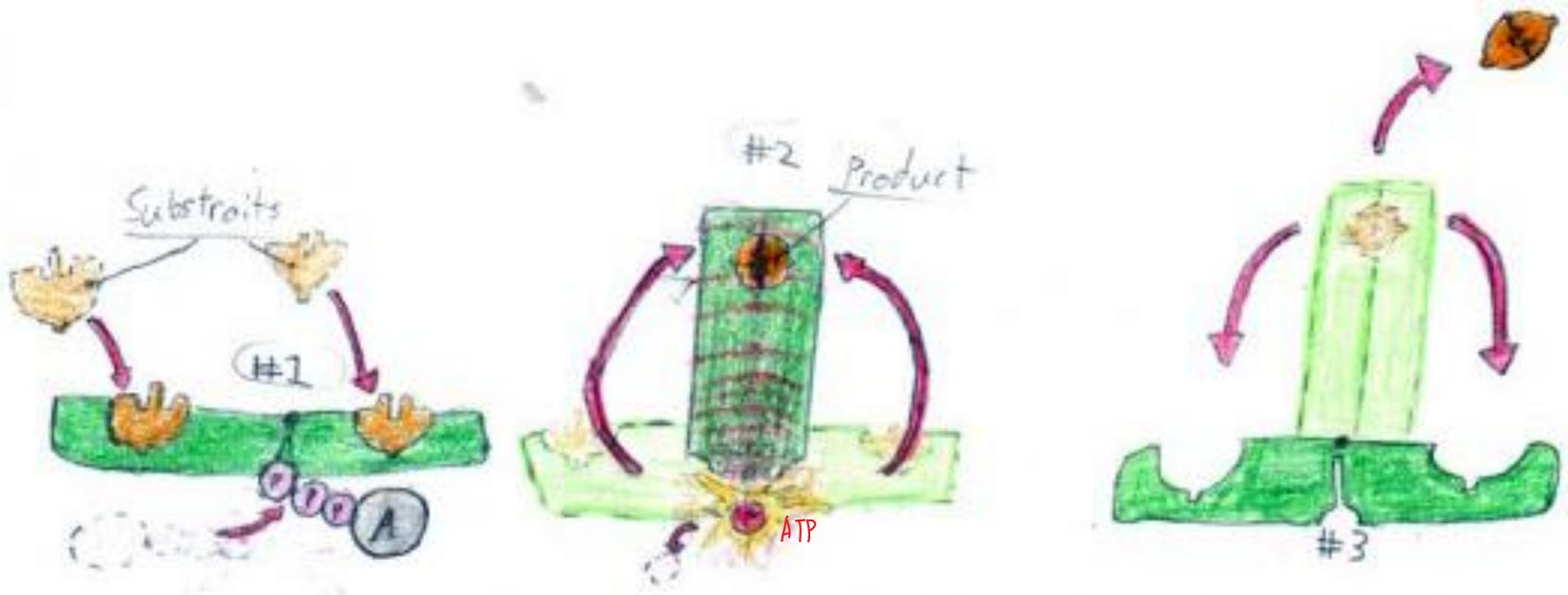
Combination of two reactions by enzyme (or protein)



Enzyme reactions (synthesis)



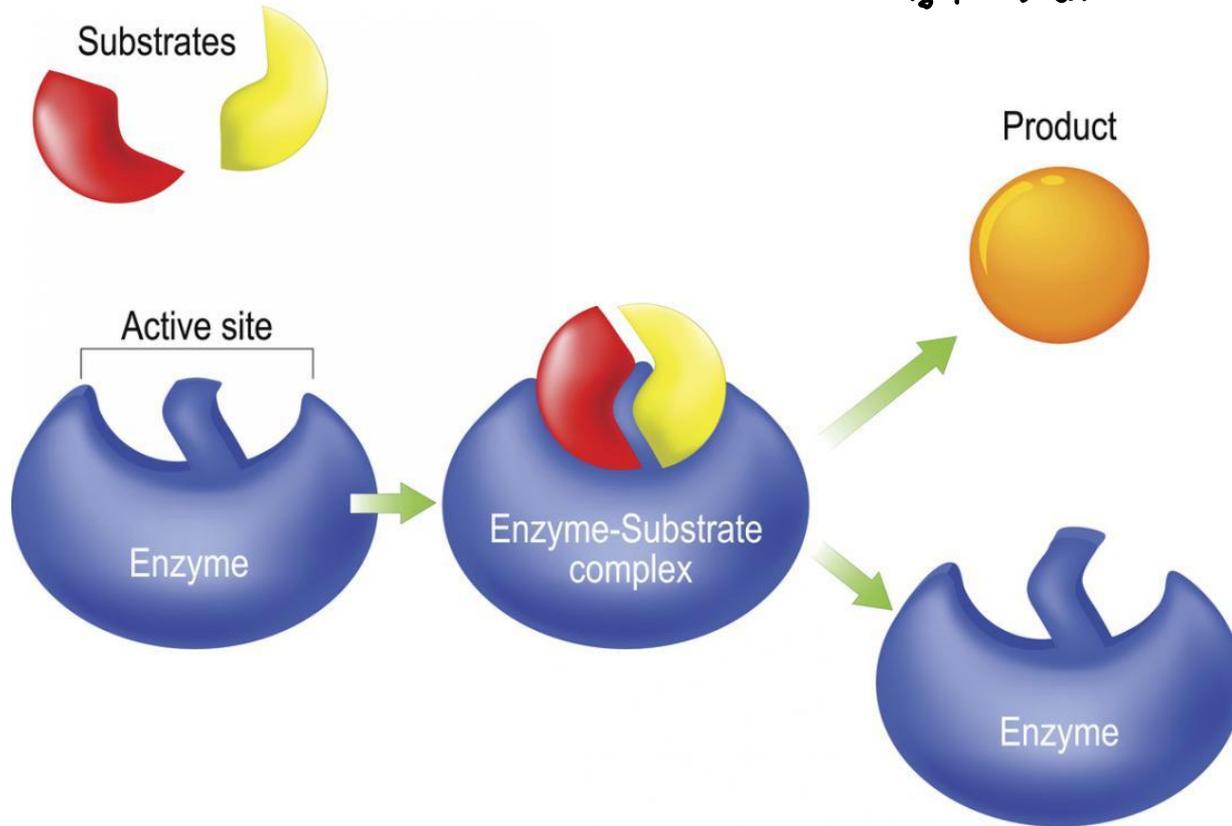
대부분의 Energy use
= enzyme에 의한 것



Enzyme reactions (synthesis)



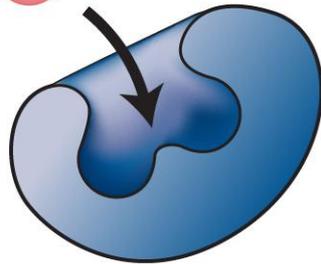
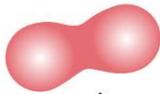
스테인플러 = enzyme
손 = ATP
공이 = substrate



Enzyme reactions (degradation)

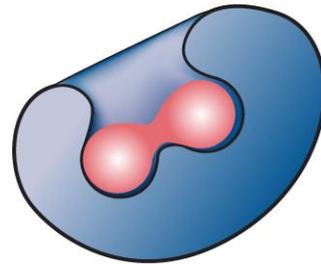


Substrate

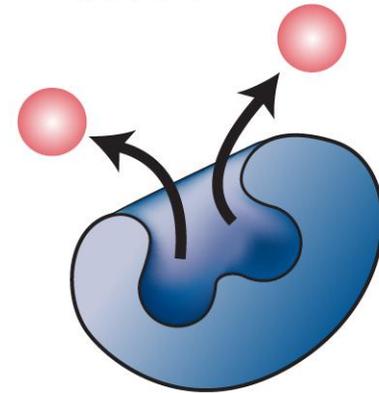


Enzyme

Enzyme-substrate
complex



Products

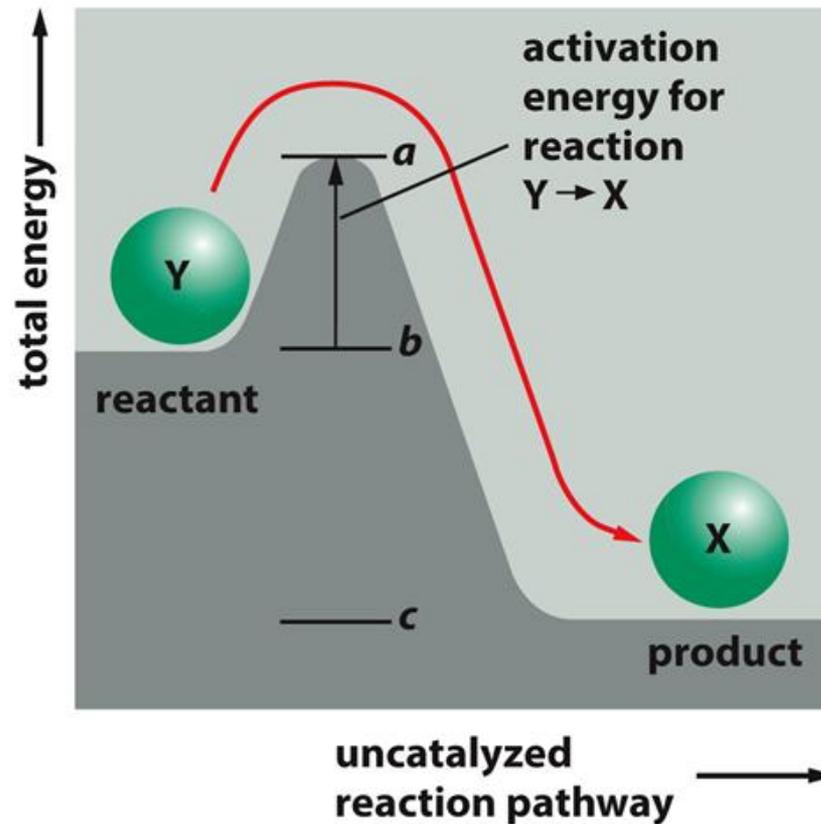


Enzyme

Spontaneous reaction
(activation energy가 필요함)

Most of biological reactions need activation energy

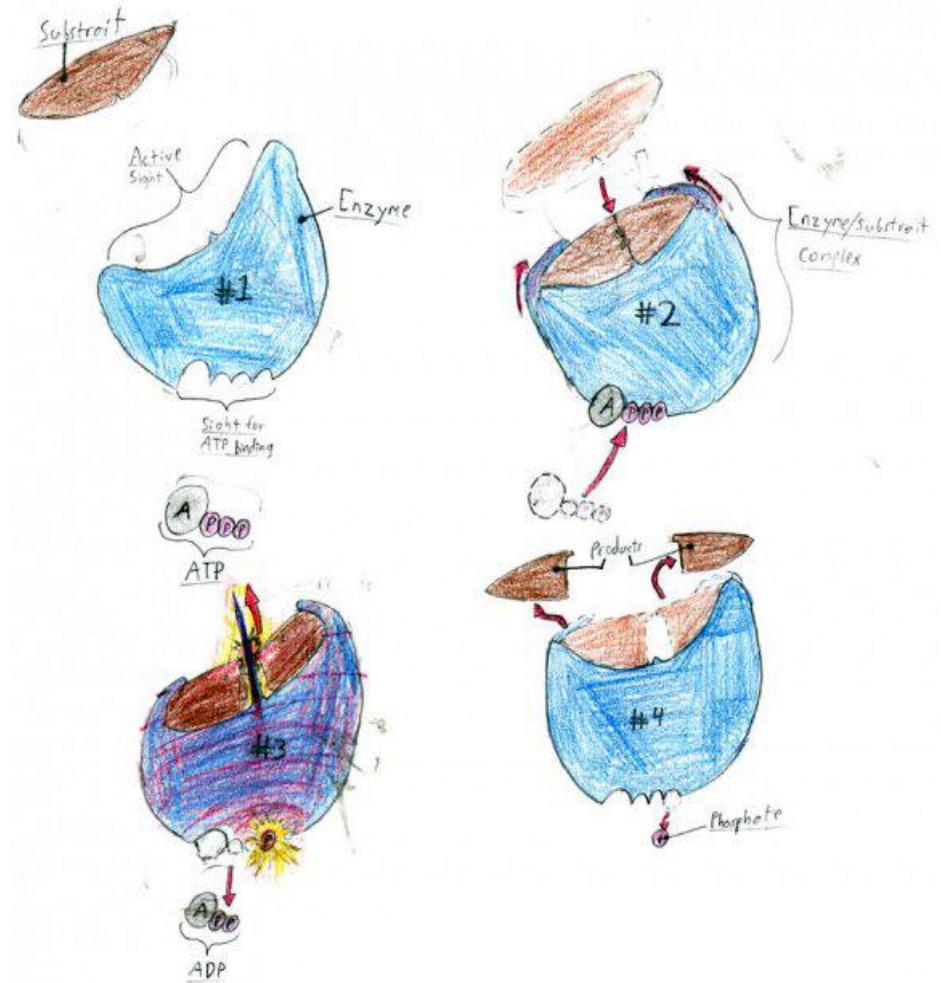
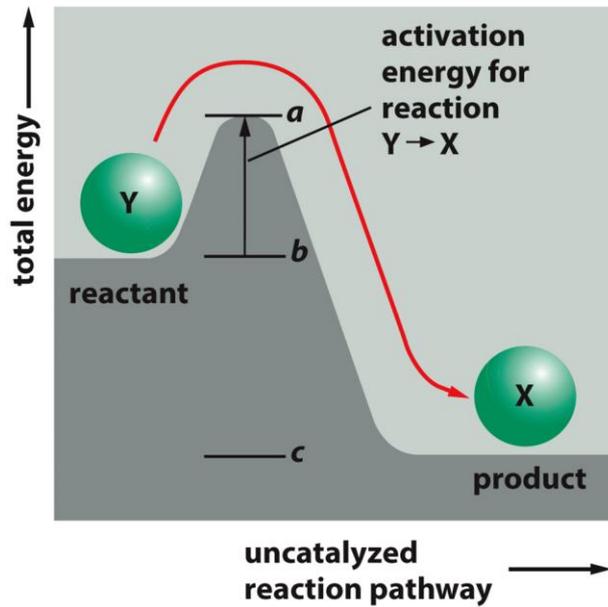
Why spontaneous reaction require energy? *activation Energy*



Enzyme reactions (degradation)

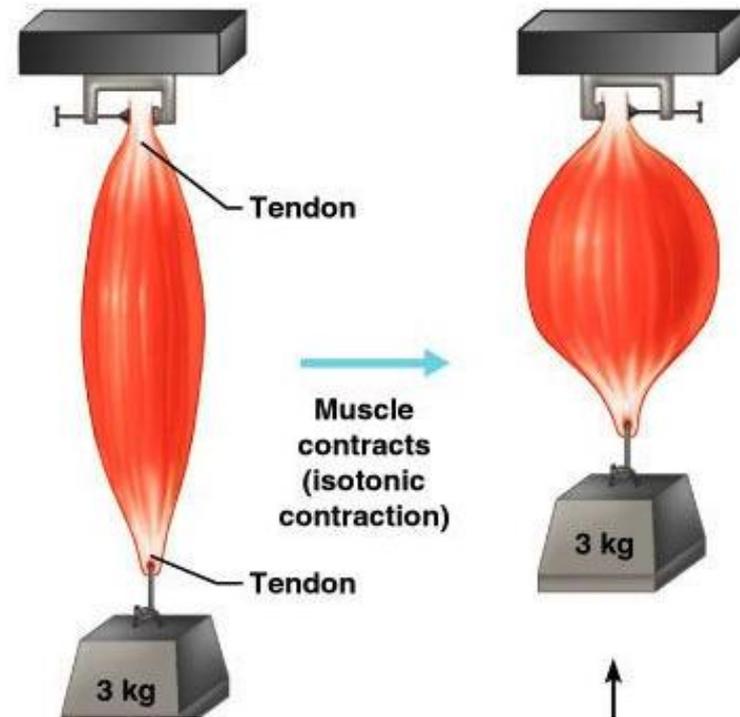
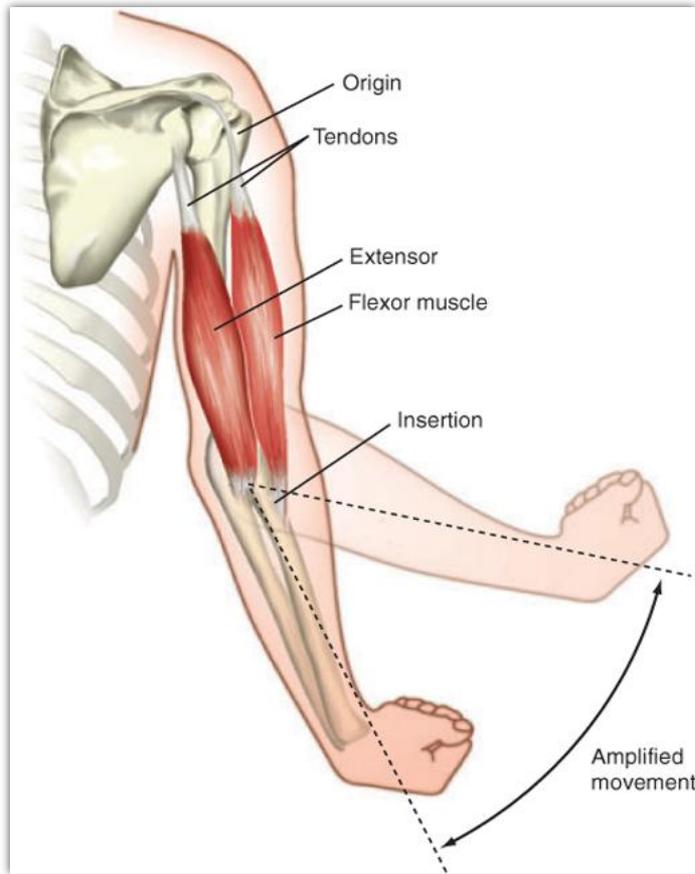
Activation energy

minimum energy required to cause a reaction to occur



Movement (physical reaction)

Muscle → 수축, 이온 이동 방향으로



Organization of Skeletal Muscle

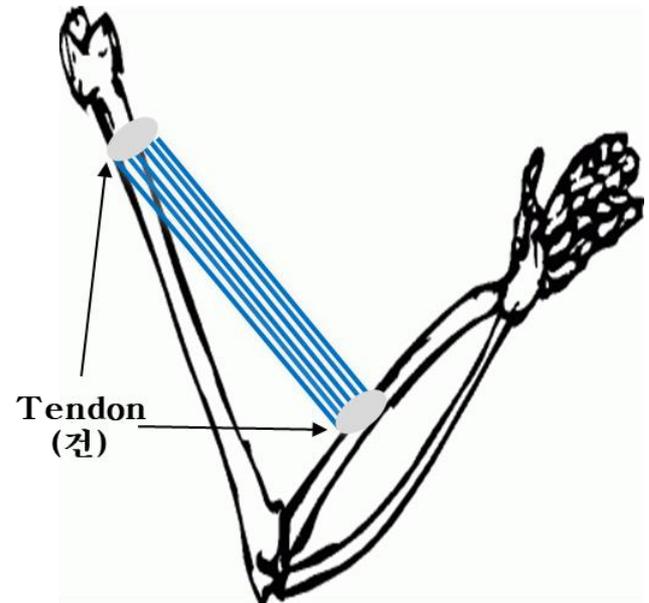
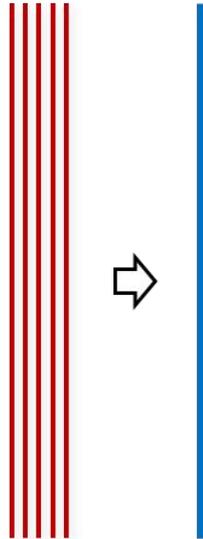
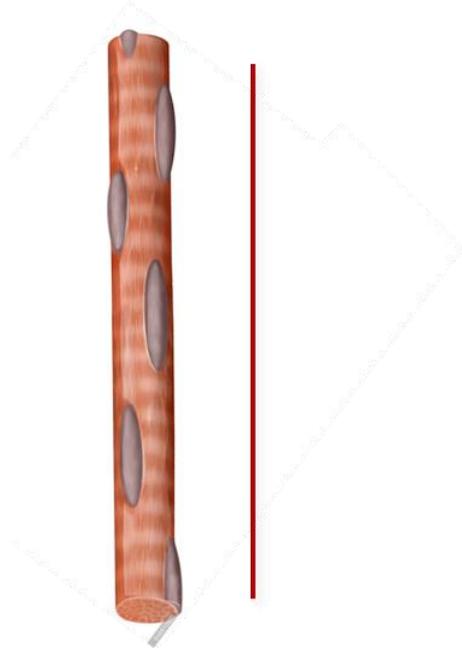
Muscle Fiber
(근섬유, 근세포)



Fasciculus
(근다발)

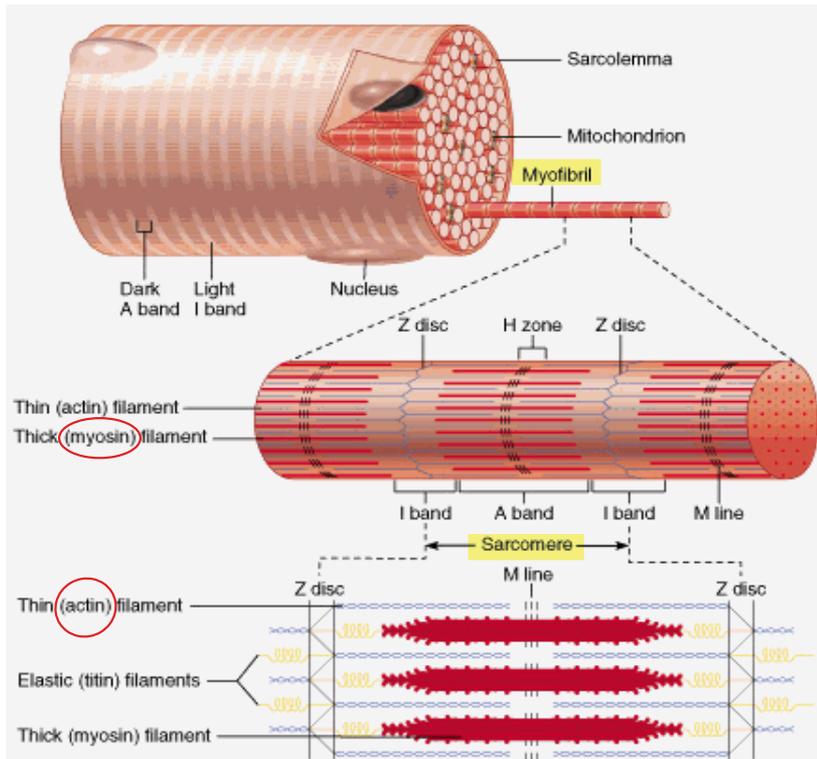


Skeletal muscle
(골격근)

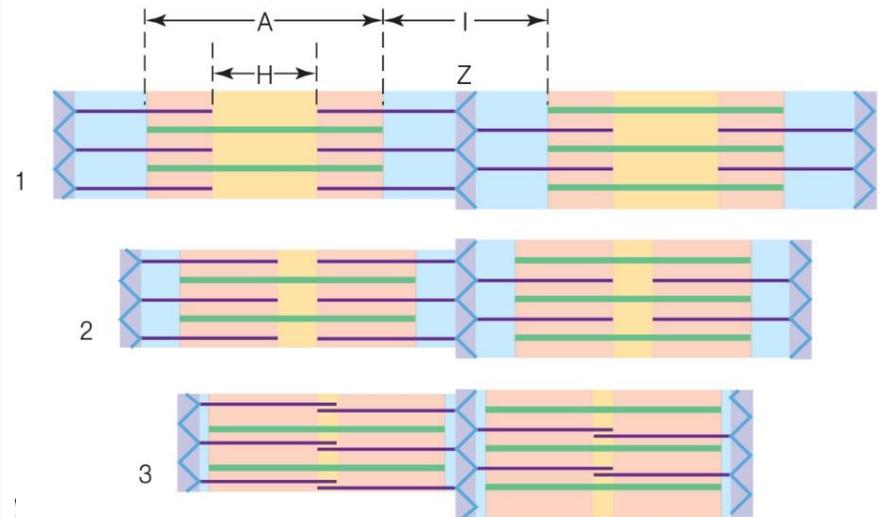


Organization of Skeletal Muscle

Muscle cell



Muscle contraction



Organization of Skeletal Muscle

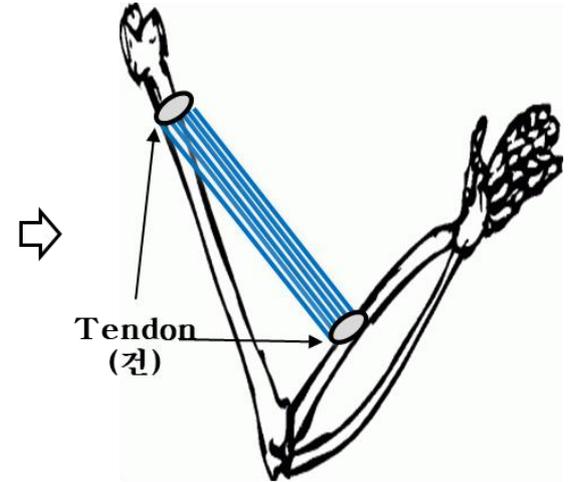
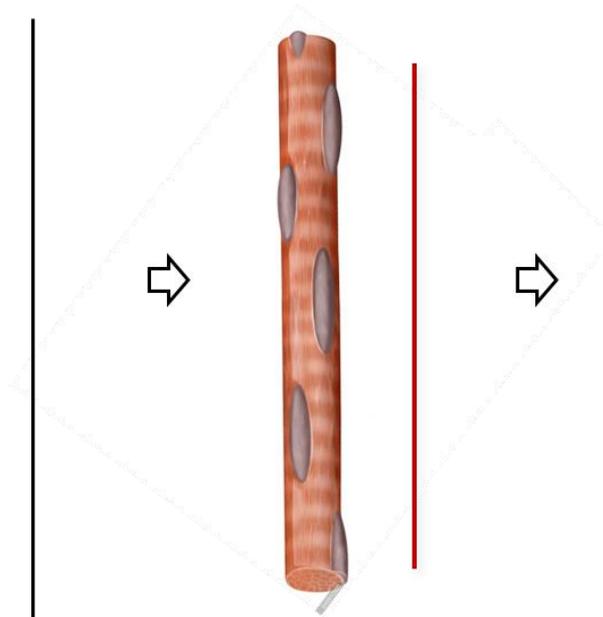
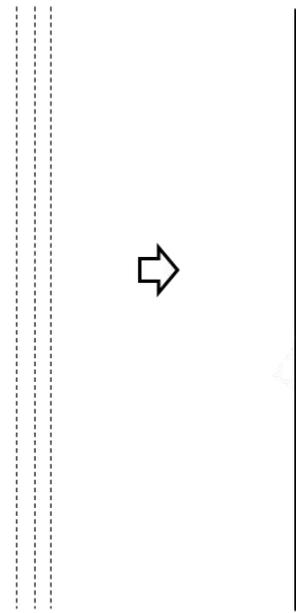
Myofilament
(근필라멘트)

Myofibril
(근원섬유)

Muscle Fiber
(근섬유, 근세포)

Fascicle
(근다발)

Skeletal muscle
(골격근)



Proteins

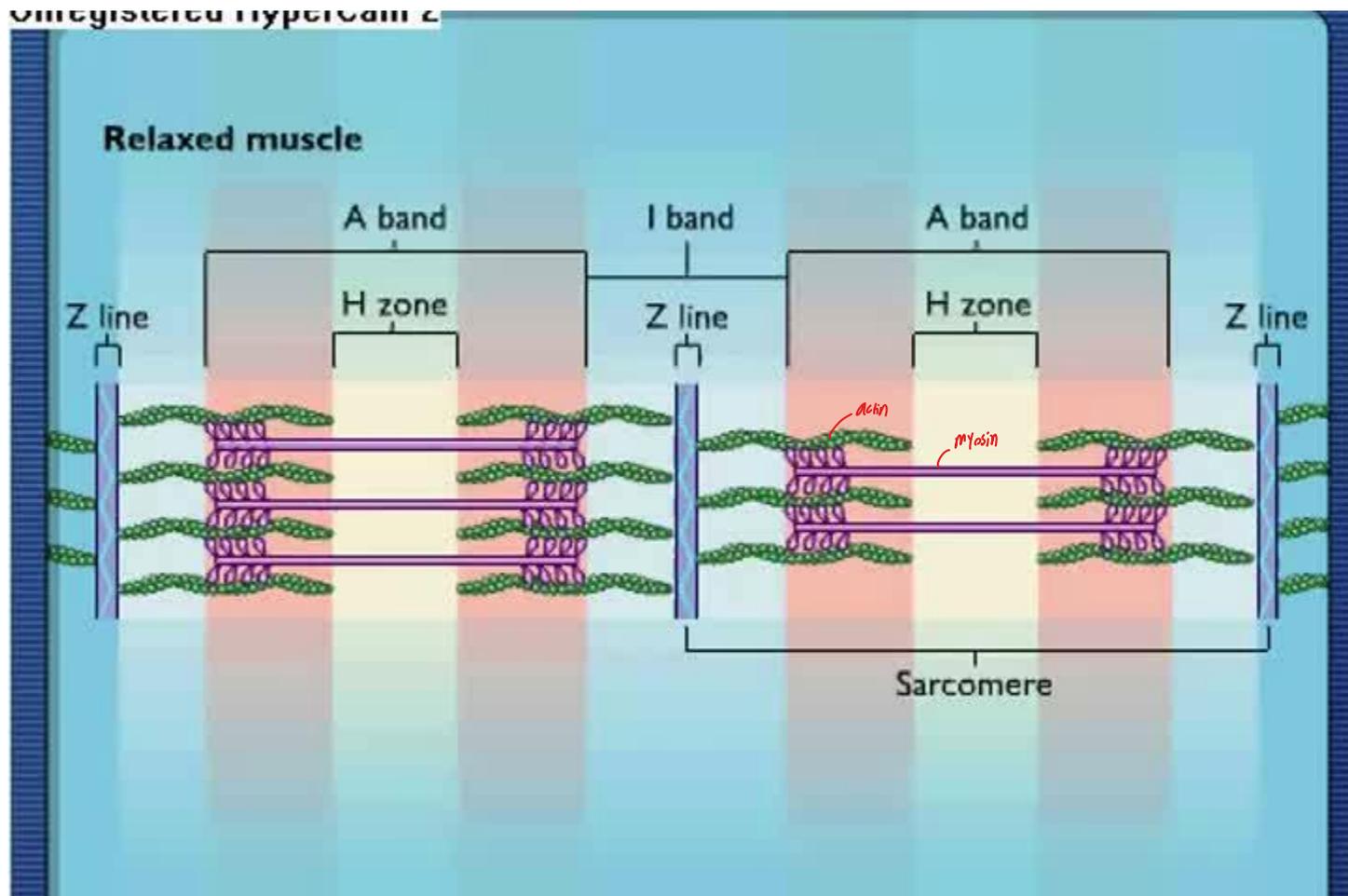
Cells

Tissue

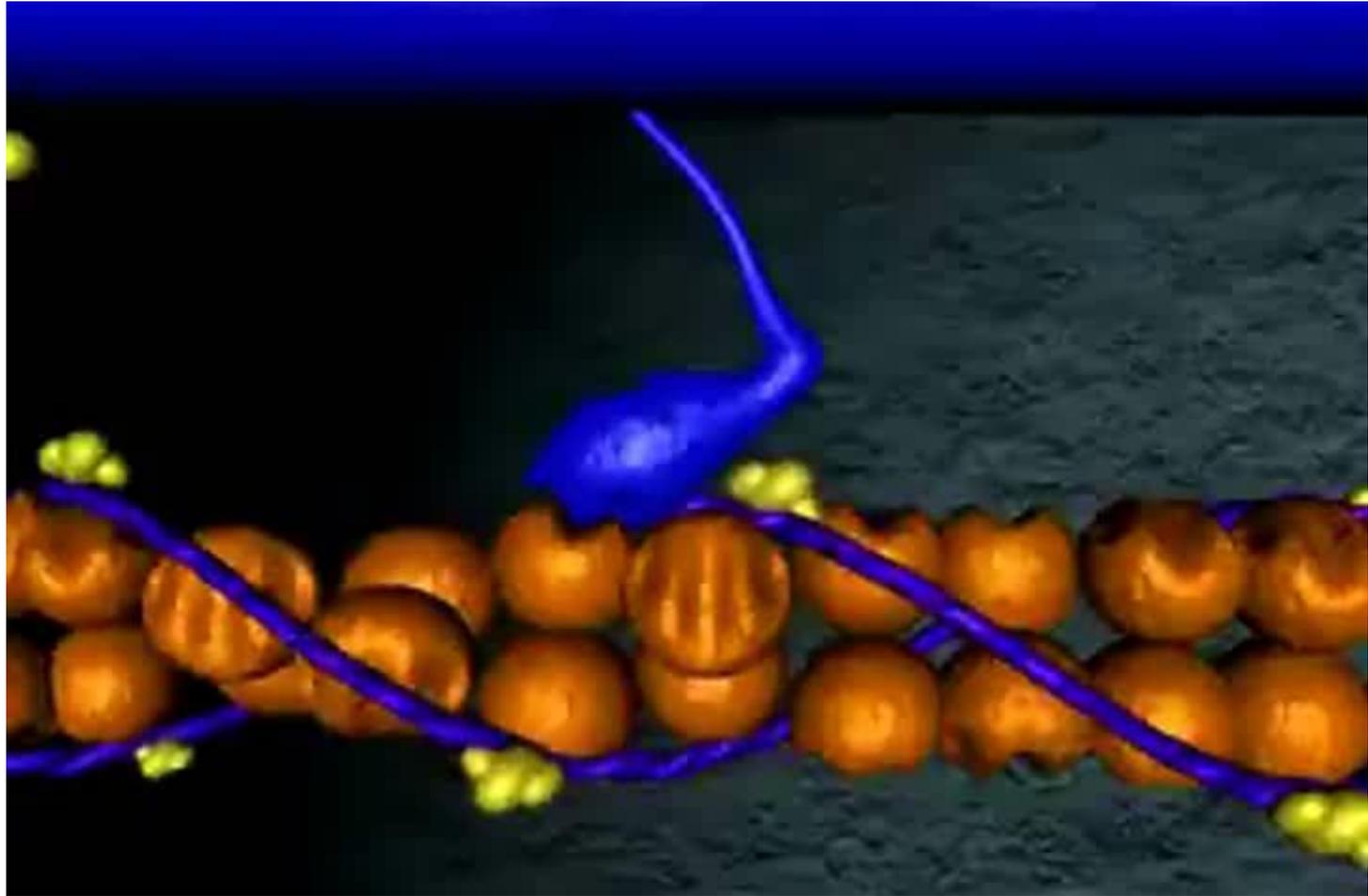
Movement (physical reaction)



H zone, I band ... 알 필요 x



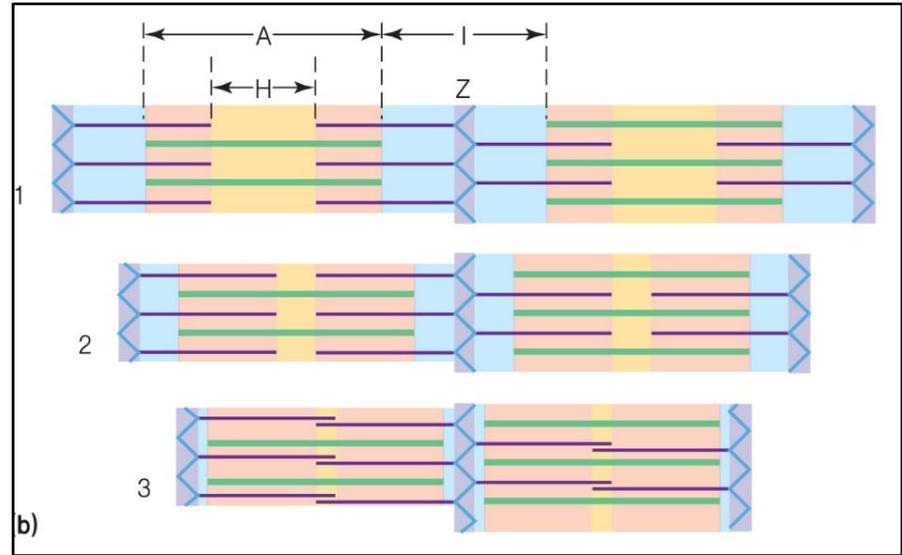
Movement (physical reaction)



Movement (physical reaction)

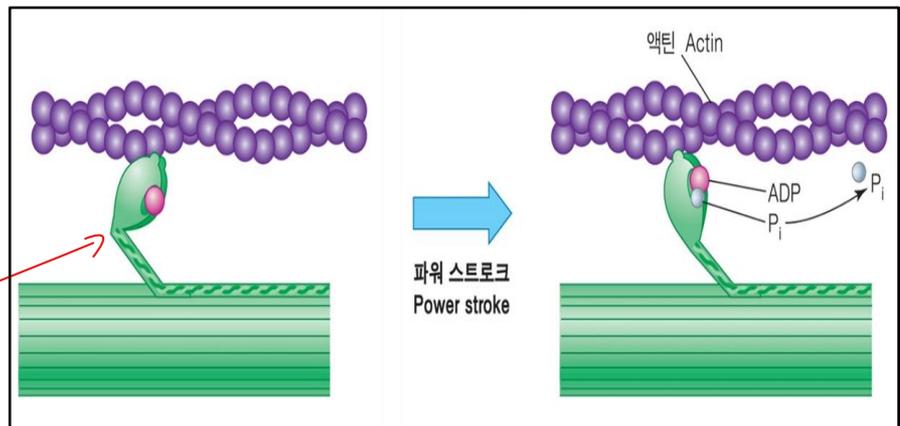
Muscle contraction

Shortening of sarcomere =>
shortening of muscle length

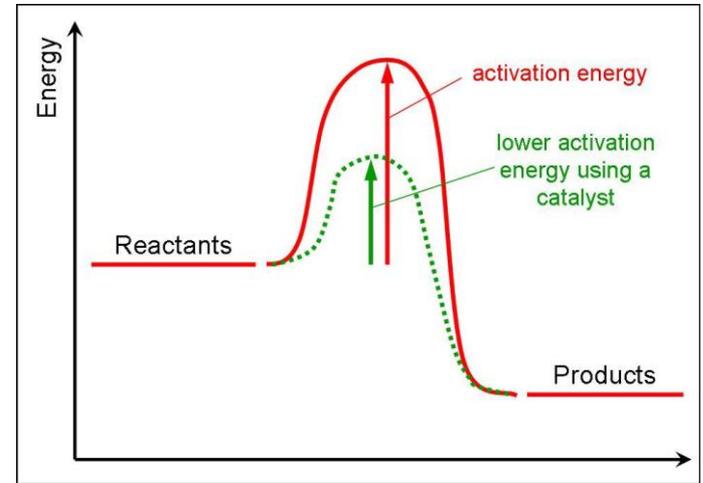
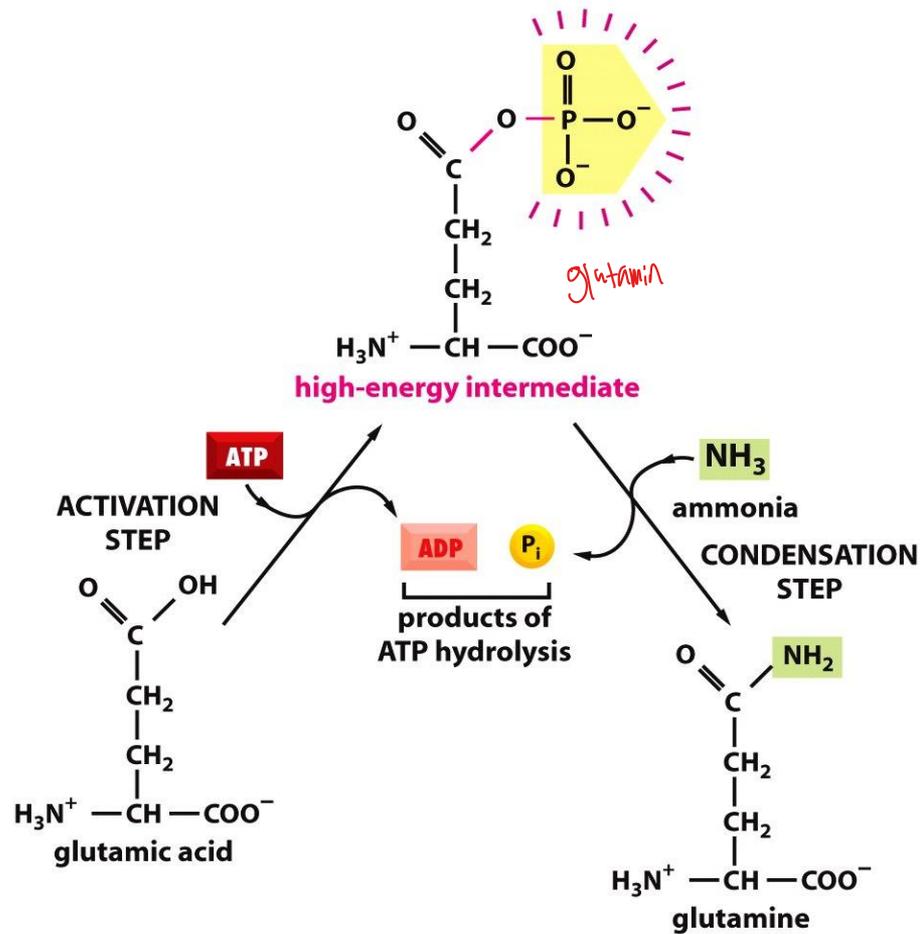


Power stroke

ATP hydrolysis changes structure
of **cross-bridge** (protein)

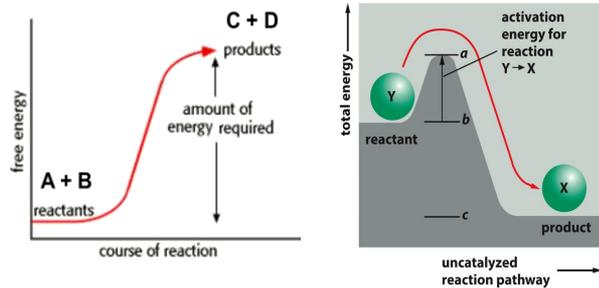
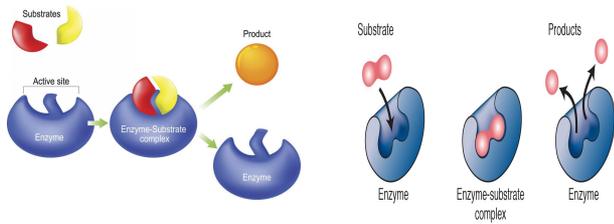


Substrate activation

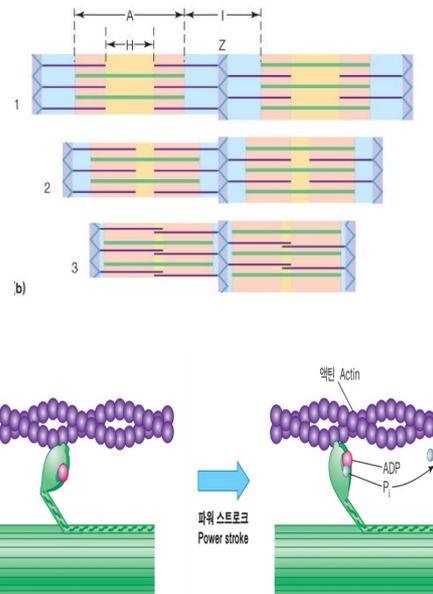


Use of ATP as energy

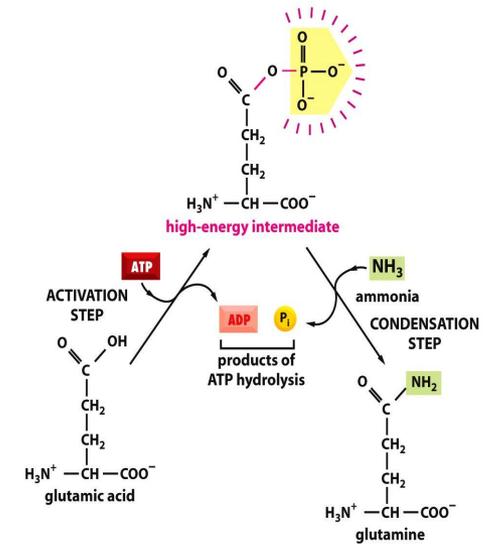
Enzyme



Protein

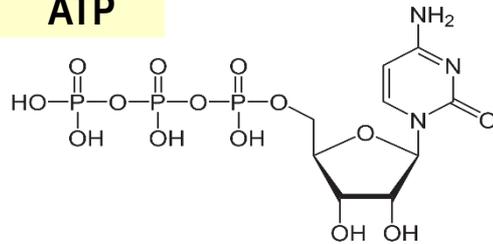


Substrate activation

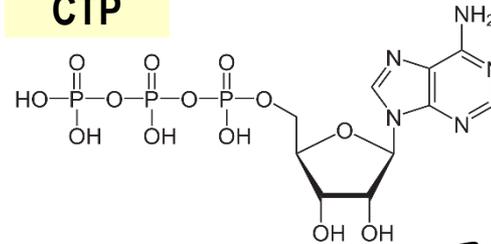


Universal biological energy ATP

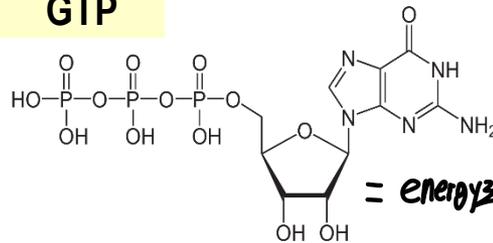
ATP



CTP

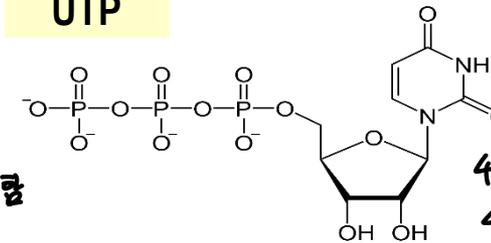


GTP



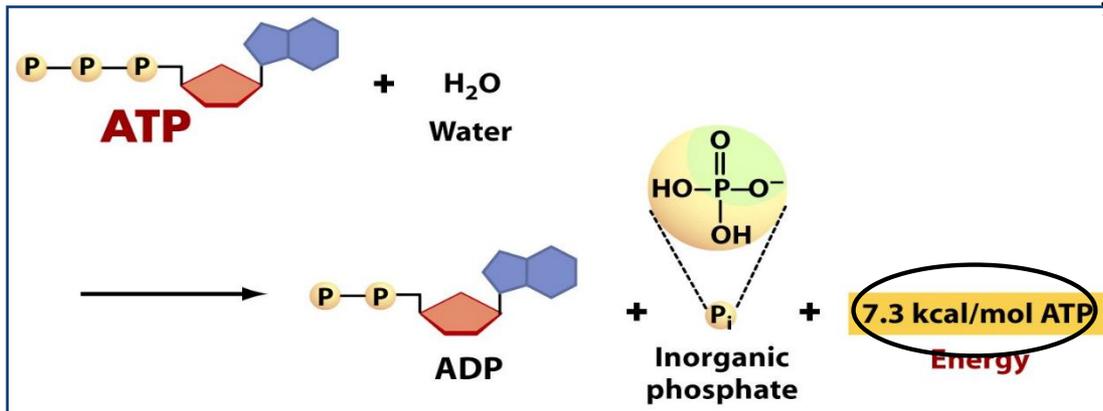
= energy를 생성하기도 함

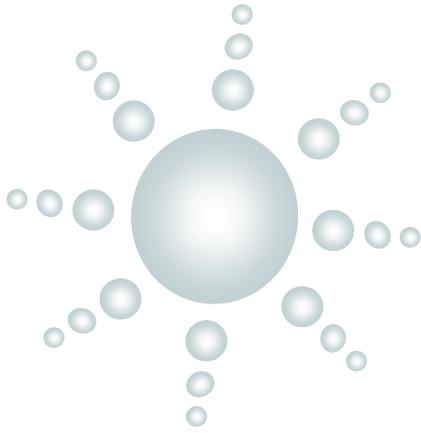
UTP



다른 못 쓴다 = 여건 view

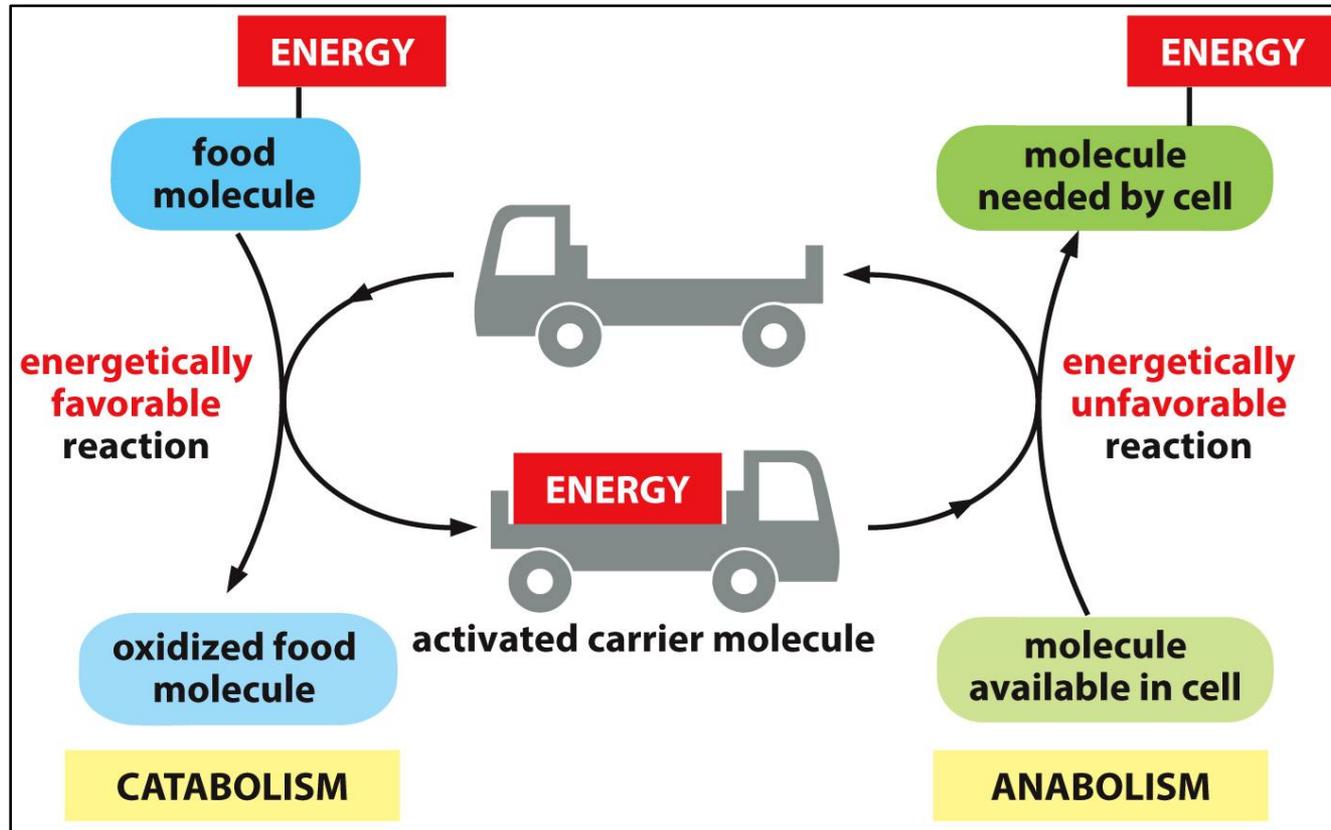
↓
4개를 다 쓰기 위해서는 4개의 enzyme이 필요
=> ATP만 사용
=> bacteria(조식)이 그렇게 함



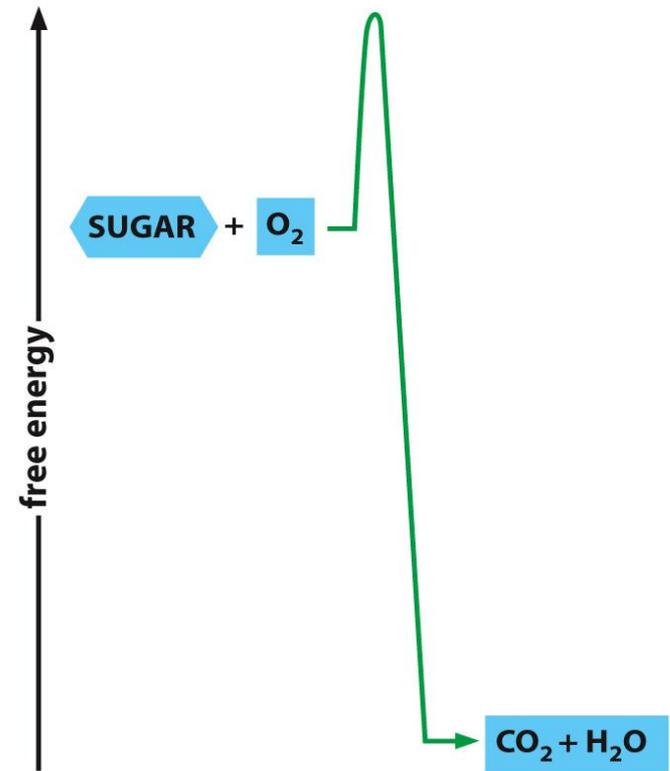
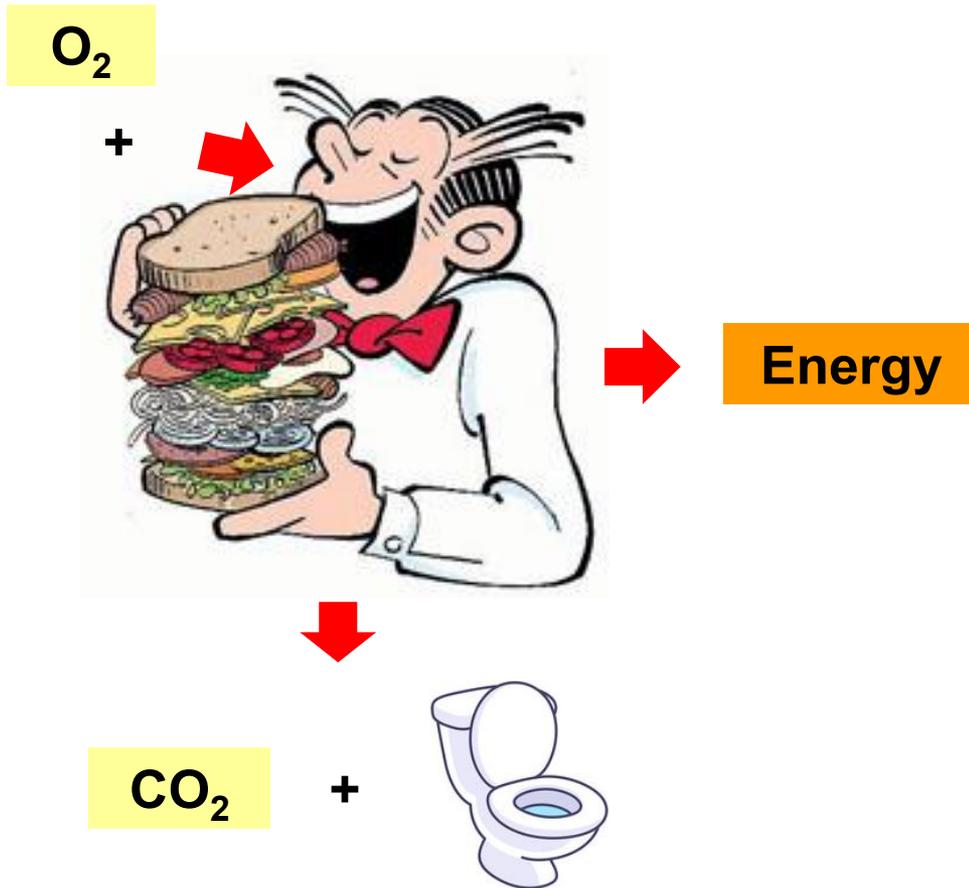


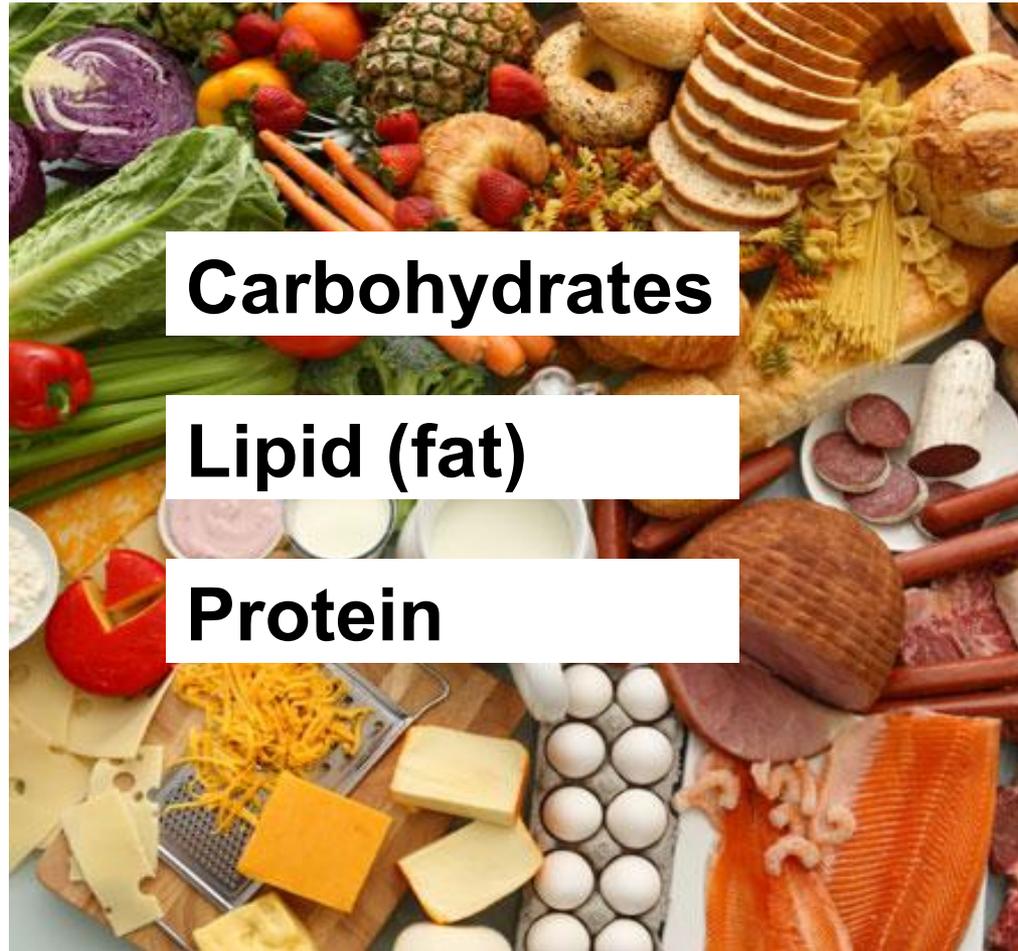
How ATP is generated?

Energy conversion

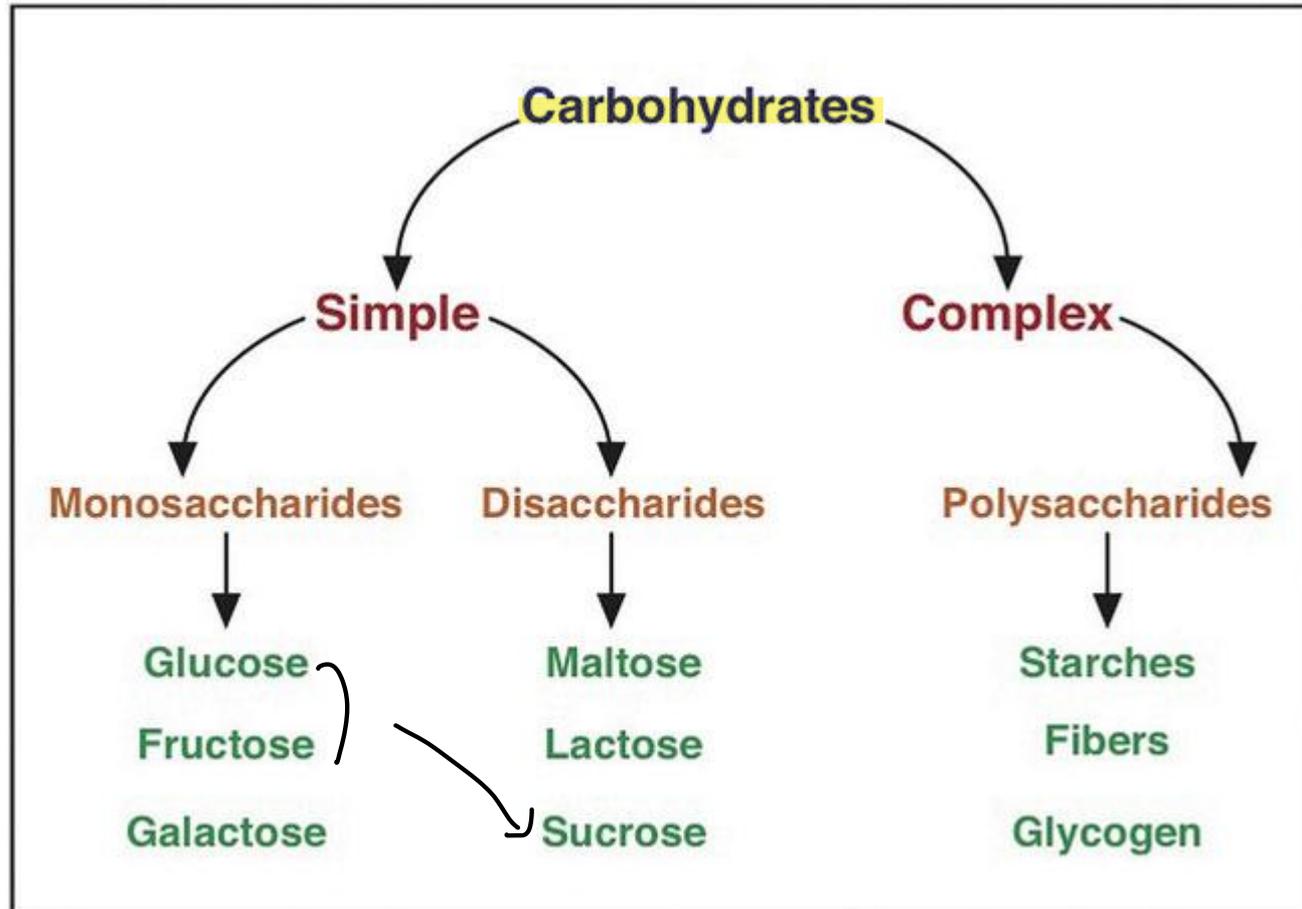


Energy conversion

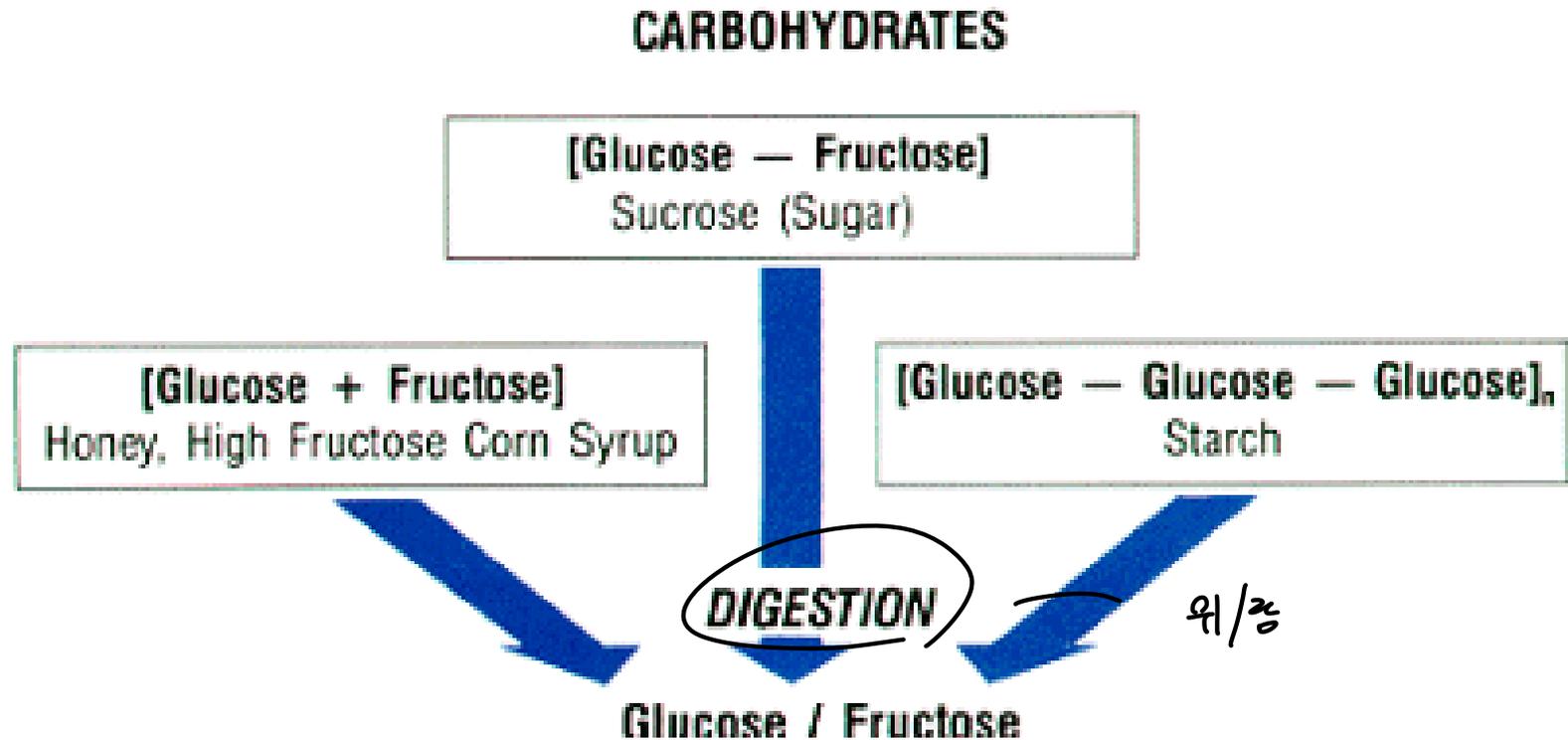




Carbohydrates



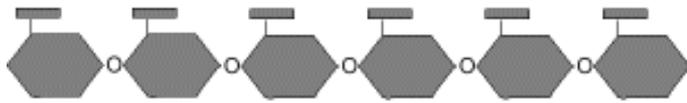
Carbohydrates in food



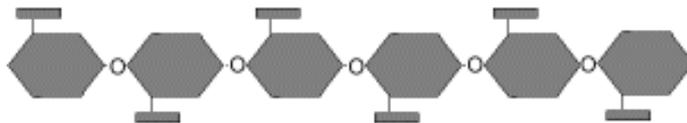
Carbohydrates



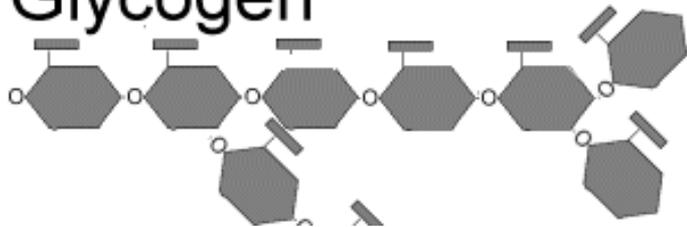
Starch



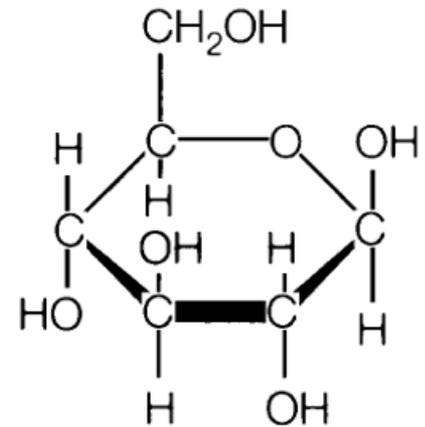
Cellulose



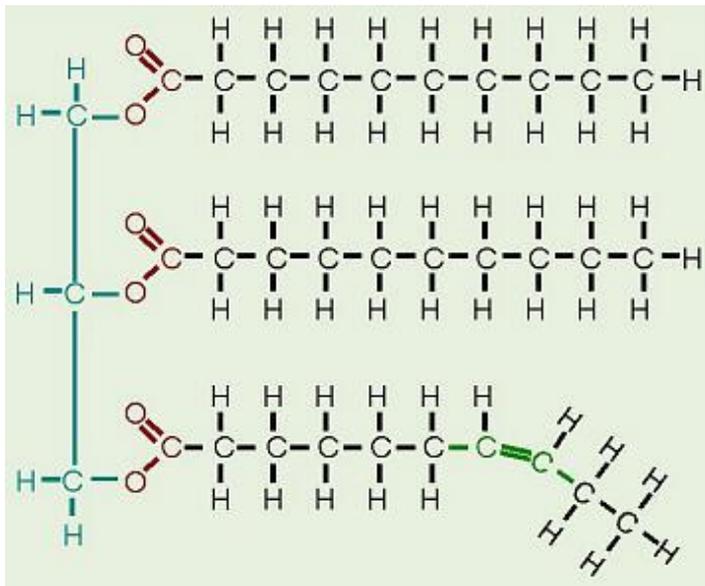
Glycogen



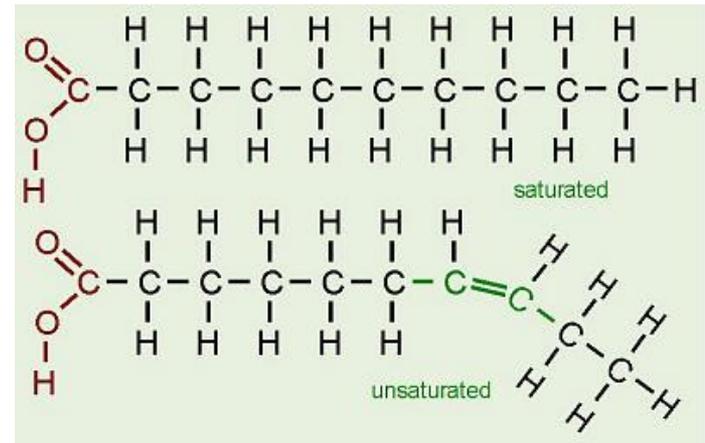
Glucose



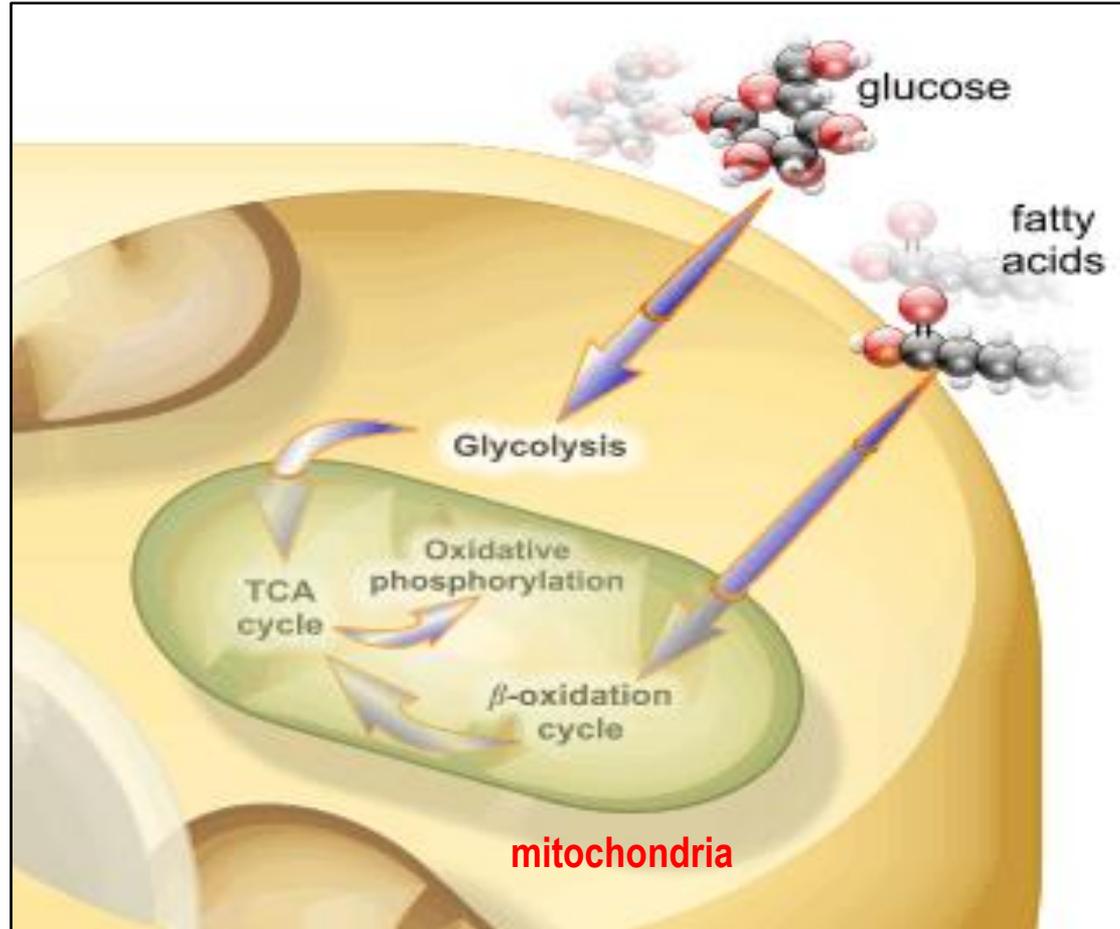
Lipid (Fat)

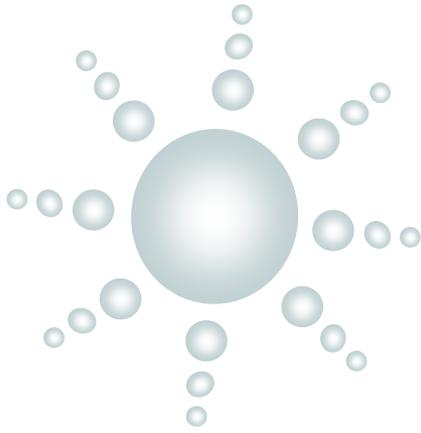


Fatty acids



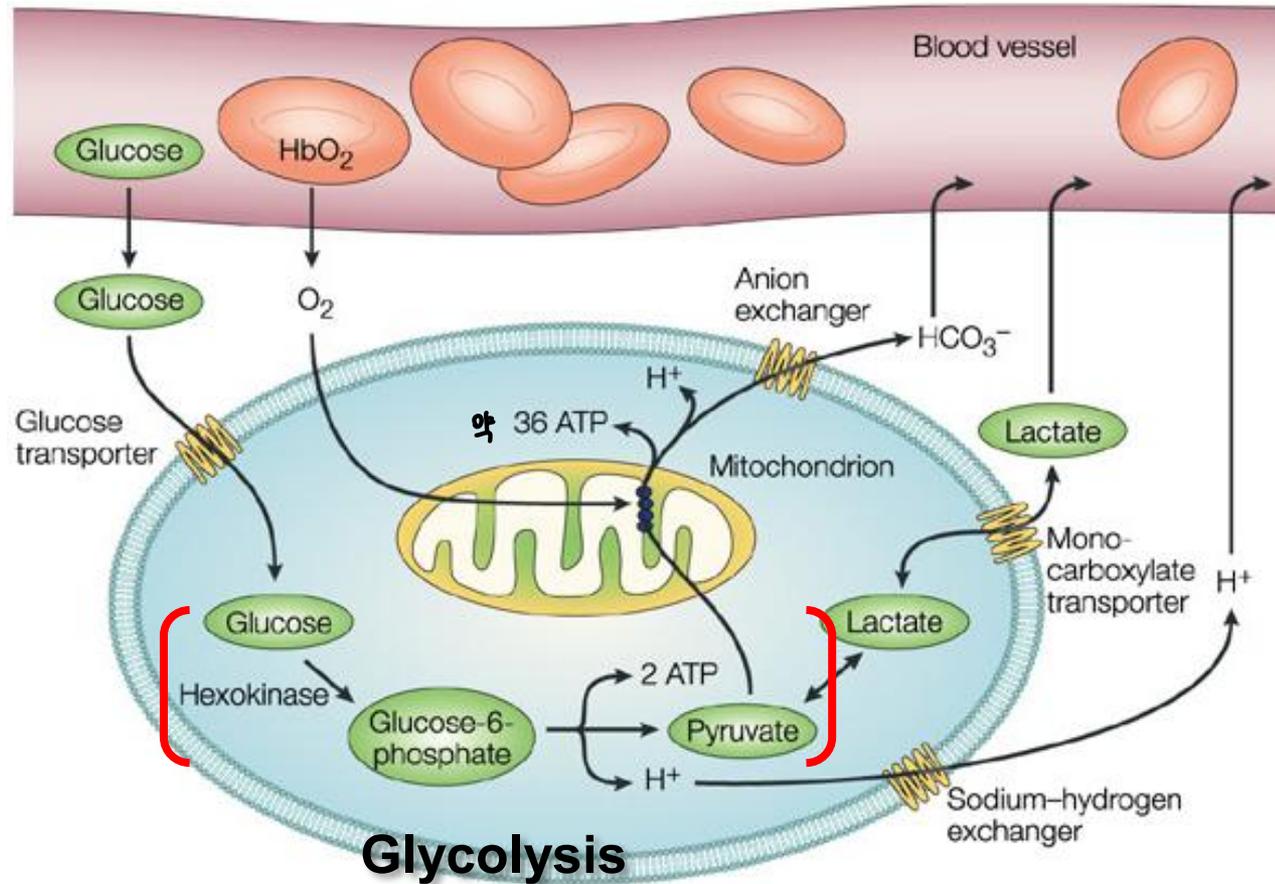
Energy metabolism





ATP Production from Glucose

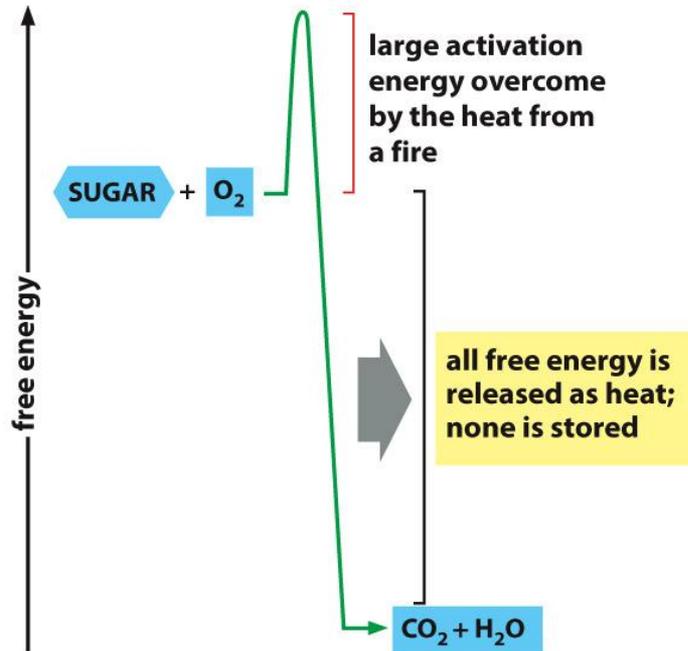
Glucose metabolism for ATP generation



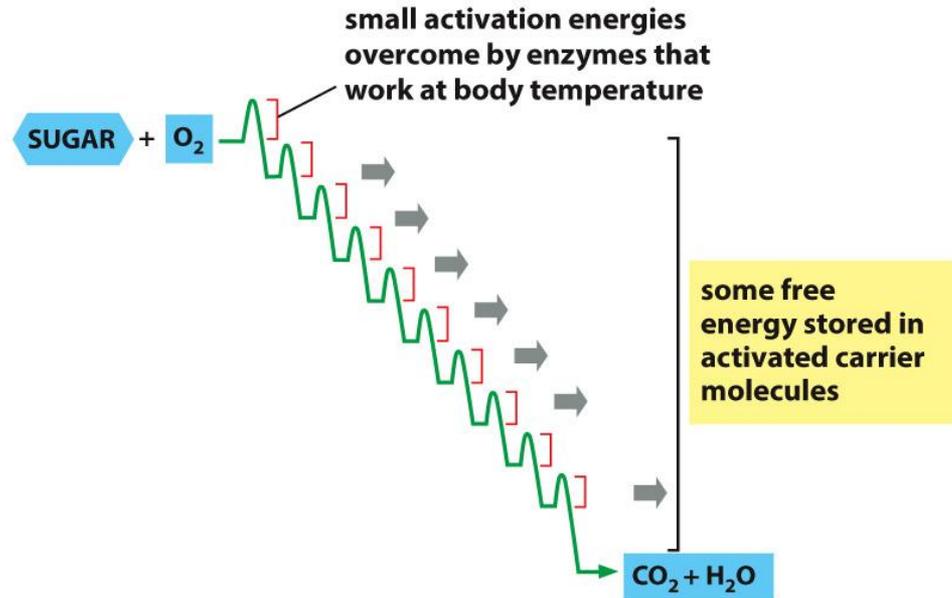
Energy conversion



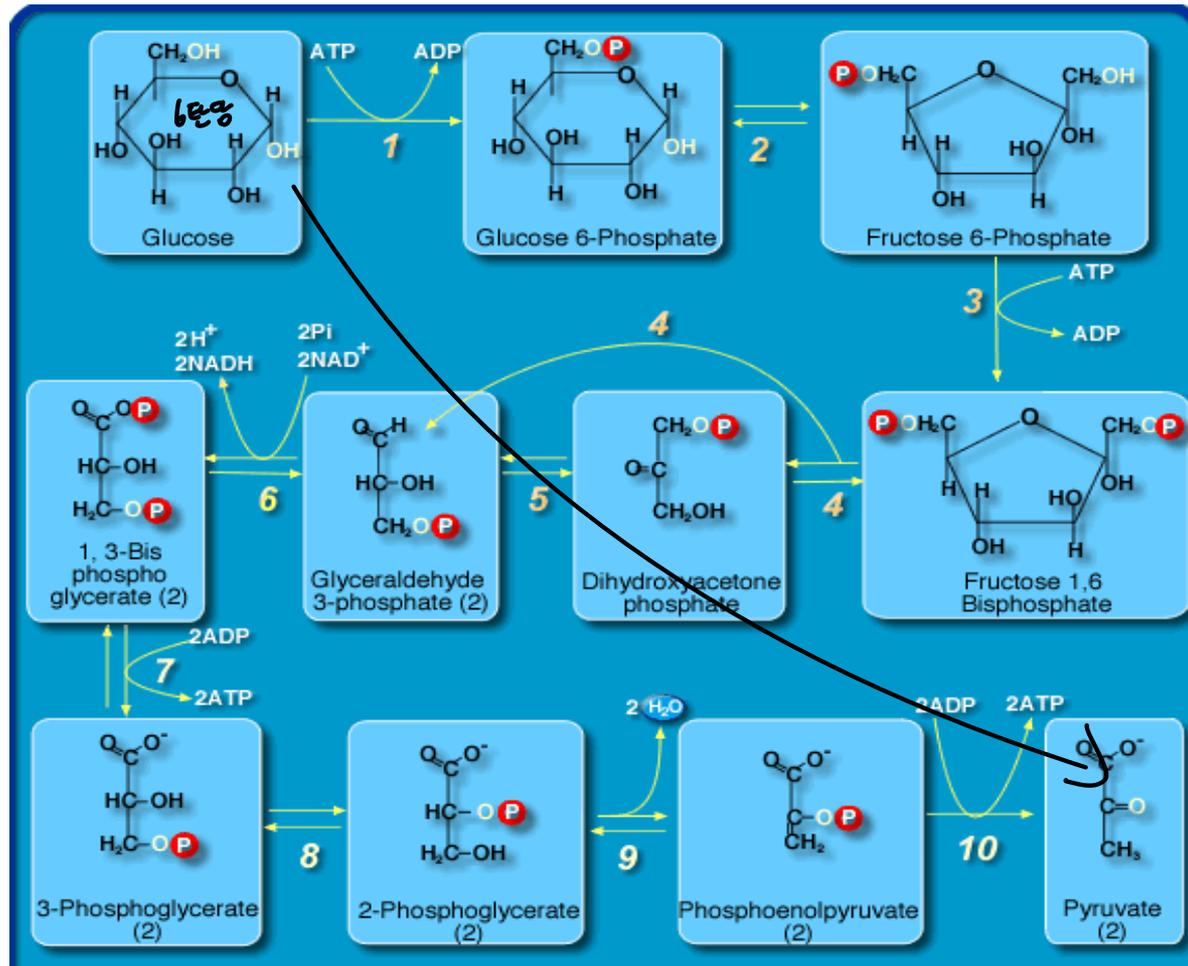
(A) DIRECT BURNING OF SUGAR IN NONLIVING SYSTEM



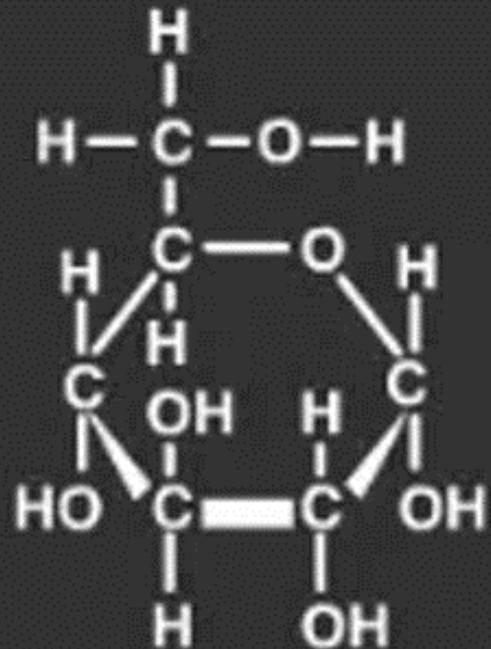
(B) STEPWISE OXIDATION OF SUGAR IN CELLS



Glycolysis

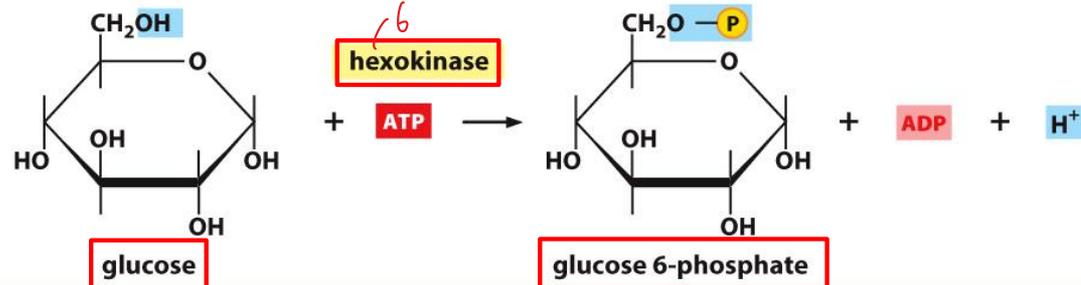


Glycolysis

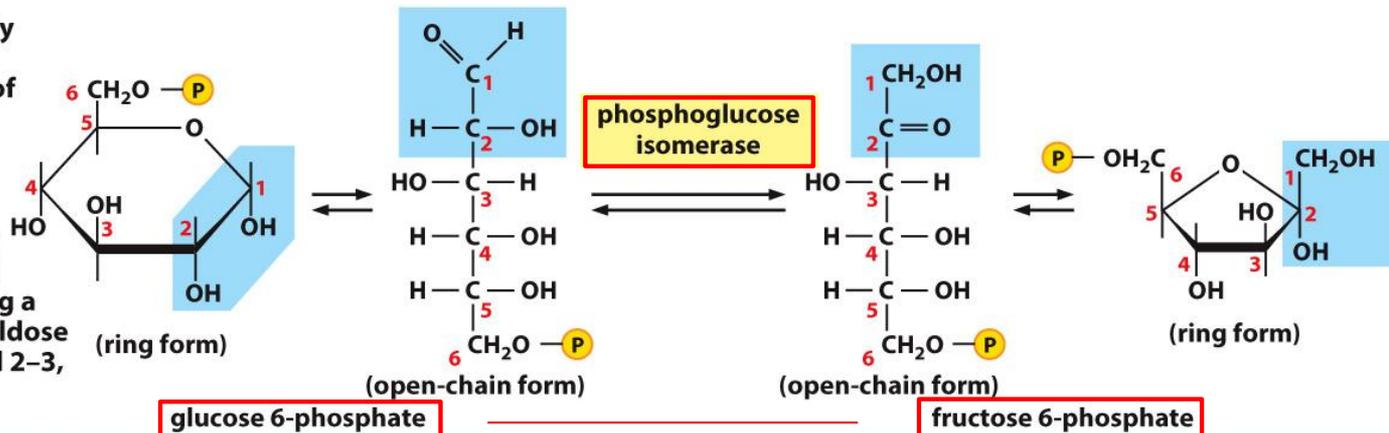


Glycolysis (10 step)

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.

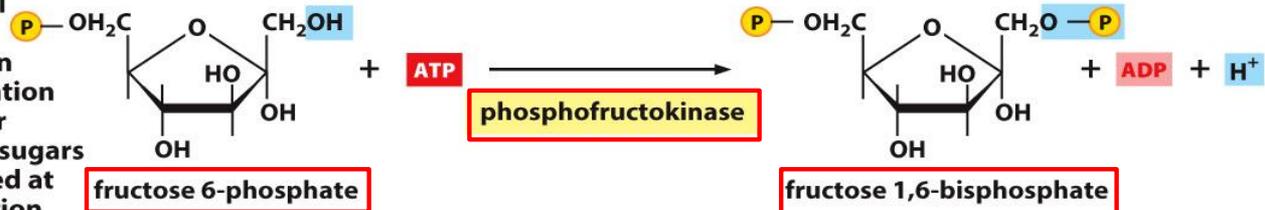


Step 2 A readily reversible rearrangement of the chemical structure (isomerization) moves the carbonyl oxygen from carbon 1 to carbon 2, forming a ketose from an aldose sugar. (See Panel 2-3, pp. 70-71.)

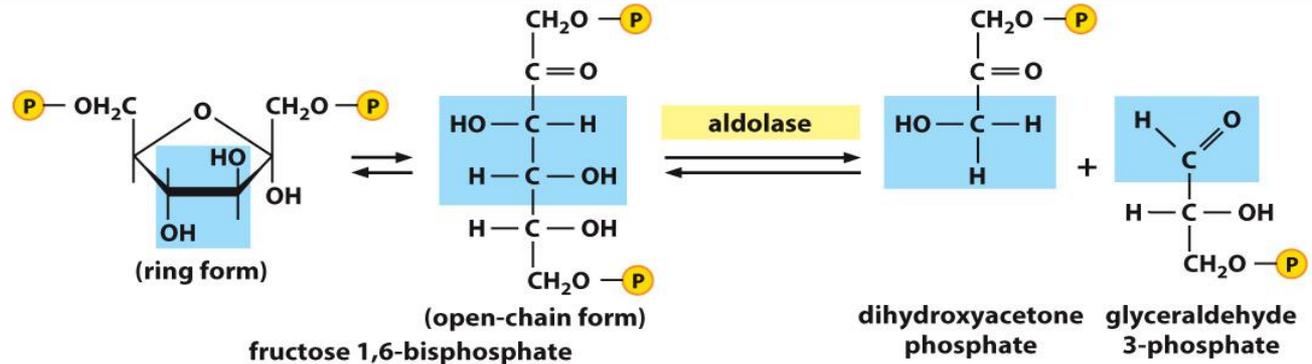


Glycolysis

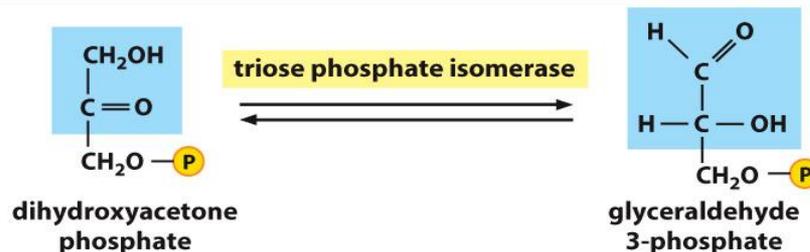
Step 3 The new hydroxyl group on carbon 1 is phosphorylated by ATP, in preparation for the formation of two three-carbon sugar phosphates. The entry of sugars into glycolysis is controlled at this step, through regulation of the enzyme *phosphofructokinase*.



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



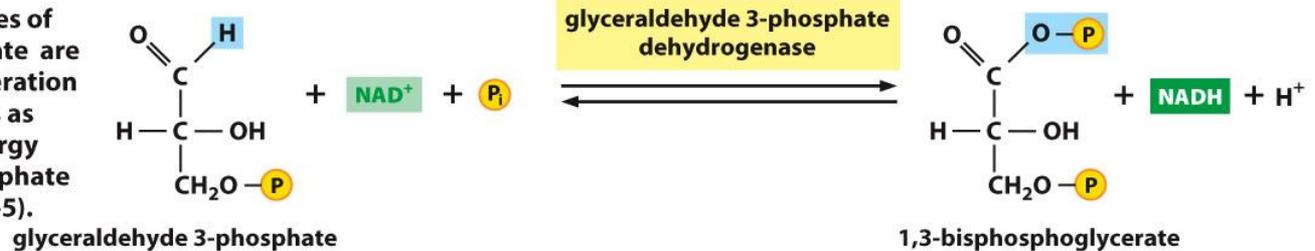
Step 5 The other product of step 4, dihydroxyacetone phosphate, is isomerized to form glyceraldehyde 3-phosphate.



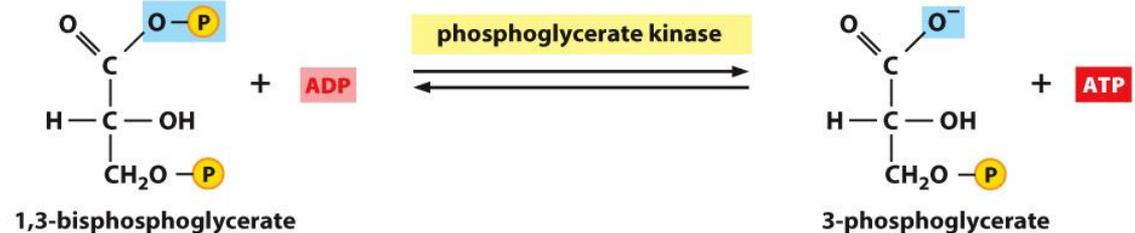
Glycolysis

ORGANIC - 탄소 화합물
inorganic

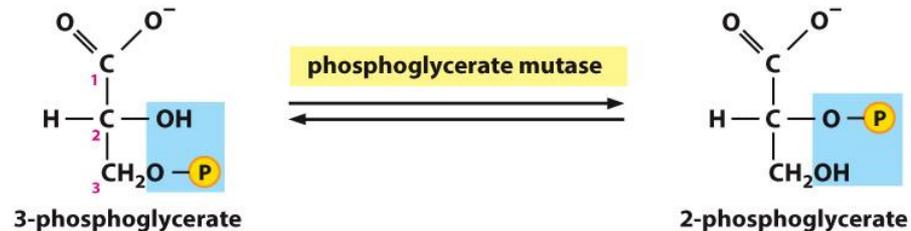
Step 6 The two molecules of glyceraldehyde 3-phosphate are oxidized. The energy-generation phase of glycolysis begins, as NADH and a new high-energy anhydride linkage to phosphate are formed (see Figure 13-5).



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



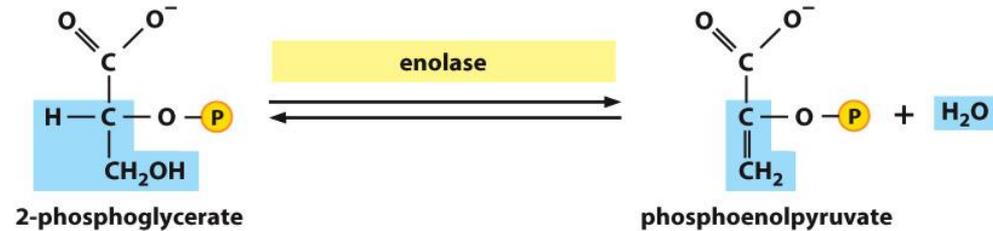
Step 8 The remaining phosphate ester linkage in 3-phosphoglycerate, which has a relatively low free energy of hydrolysis, is moved from carbon 3 to carbon 2 to form 2-phosphoglycerate.



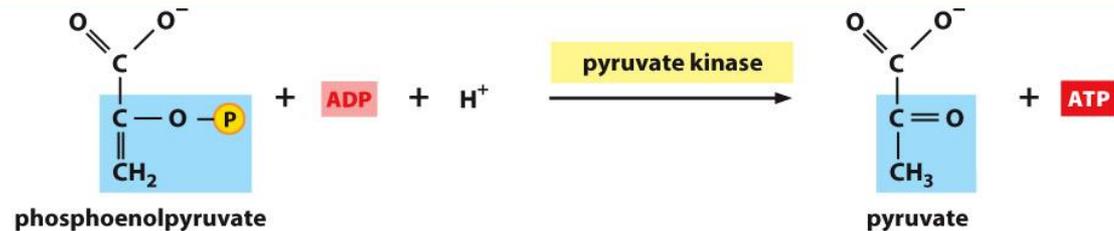
Glycolysis



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



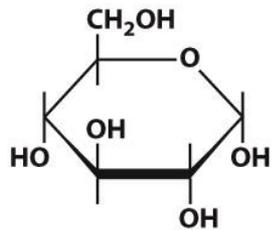
Step 10 The transfer to ADP of the high-energy phosphate group that was generated in step 9 forms ATP, completing glycolysis.



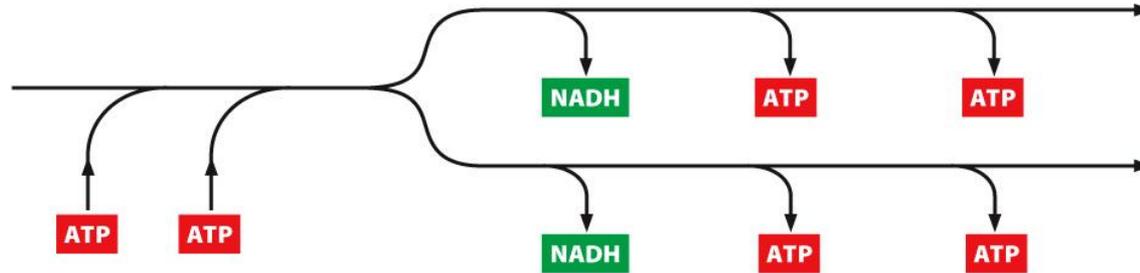
Glycolysis



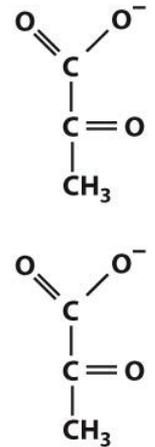
NET RESULT OF GLYCOLYSIS



glucose



In addition to the pyruvate, the net products are two molecules of ATP and two molecules of NADH.



two molecules of pyruvate



Glycolysis

