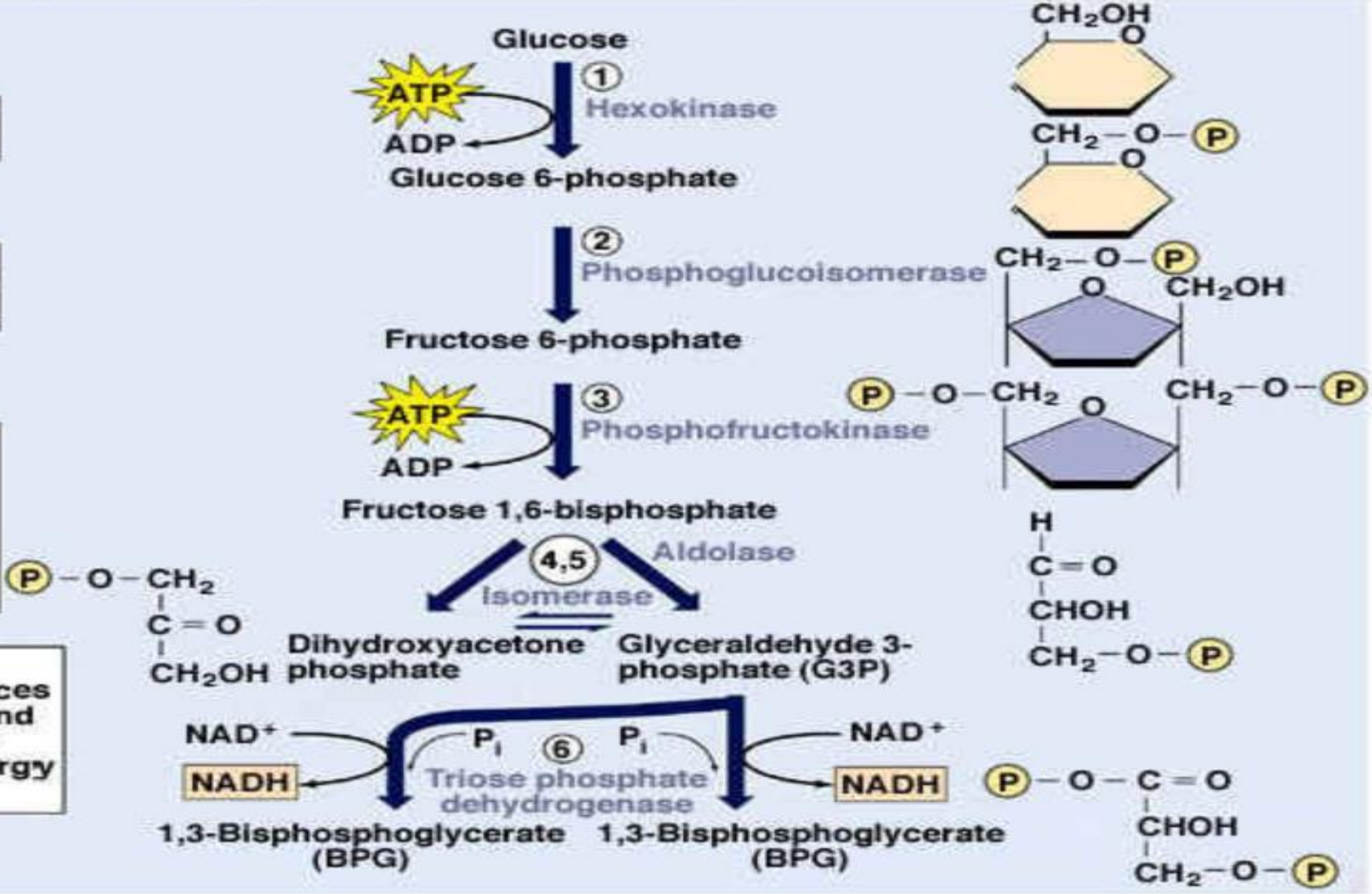
Glycolysis—Steps 1–6

1. Phosphorylation of glucose by ATP

2-3. Rearrangement, followed by a second ATP phosphorylation.

4-5. The six-carbon molecule is split into two three-carbon molecules–one G3P, another that is converted into G3P in another reaction.

6. Oxidation followed by phosphorylation produces two NADH molecules and two molecules of BPG, each with one high-energy phosphate bond.



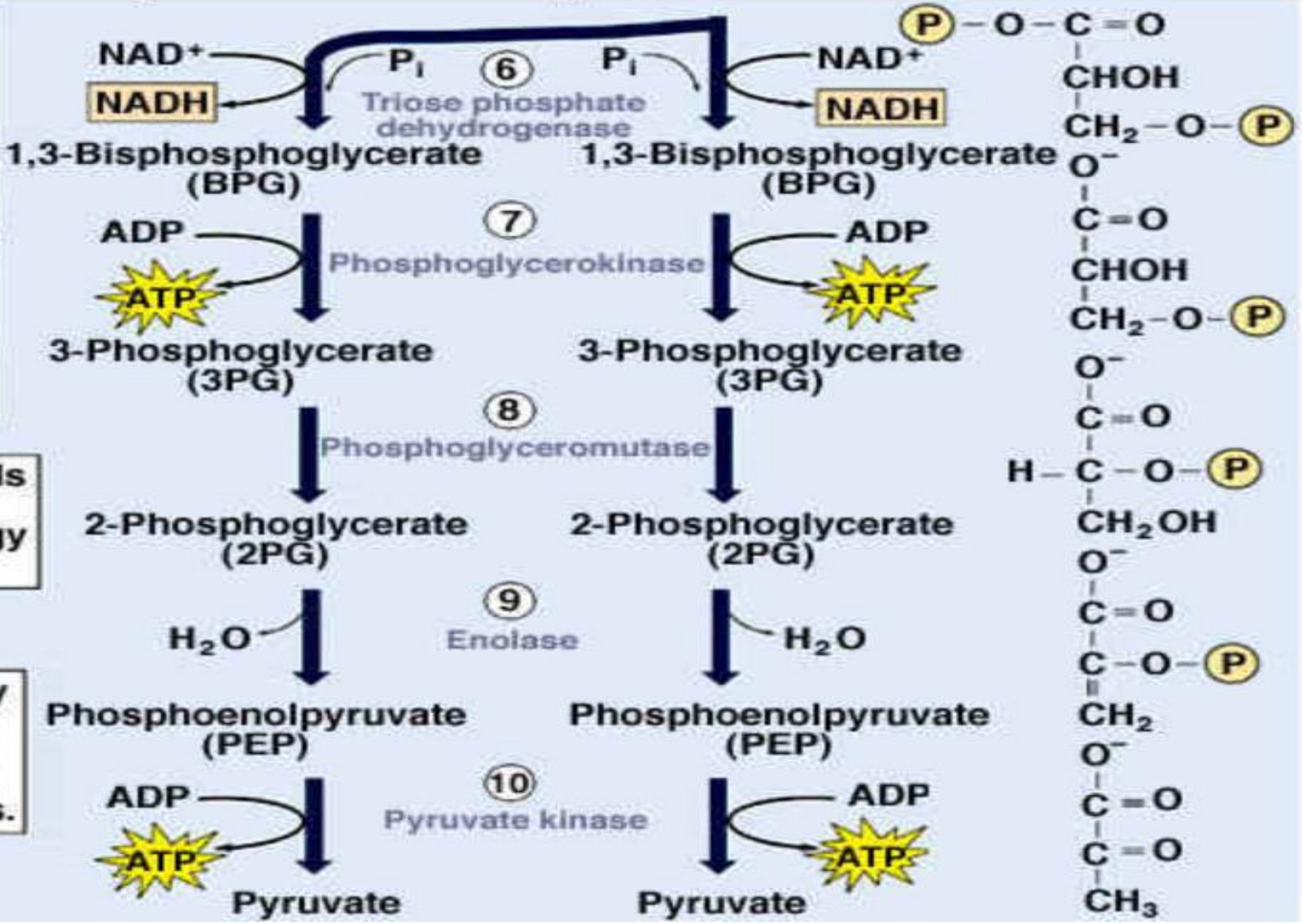
Glycolysis—Steps 6 – 10

6. Oxidation followed by phosphorylation produces two NADH molecules and two molecules of BPG, each with one high-energy phosphate bond.

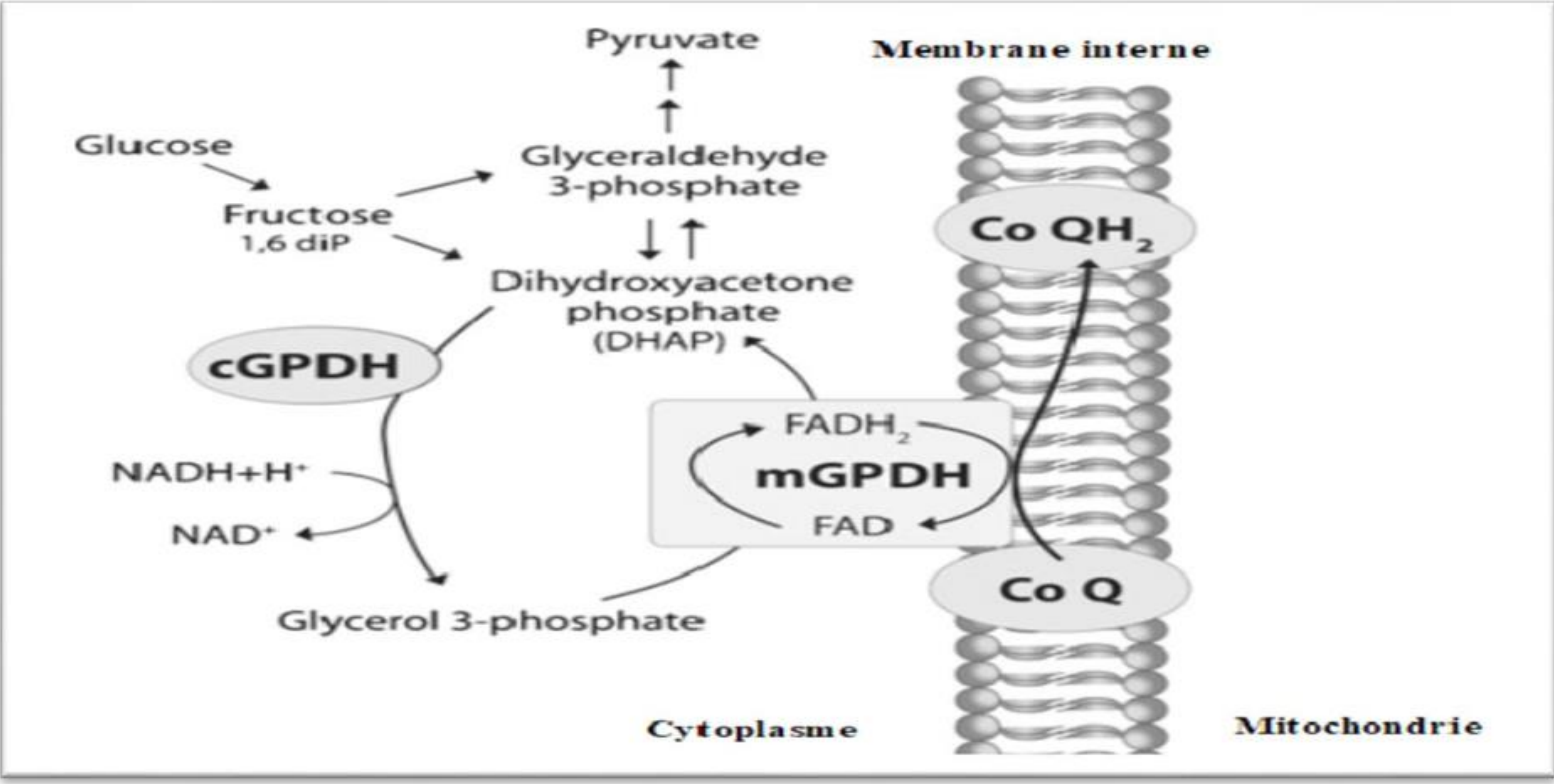
7. Removal of high-energy phosphate by two ADP molecules produces two ATP molecules and leaves two 3PG molecules.

8-9. Removal of water yields two PEP molecules, each with a high-energy phosphate bond.

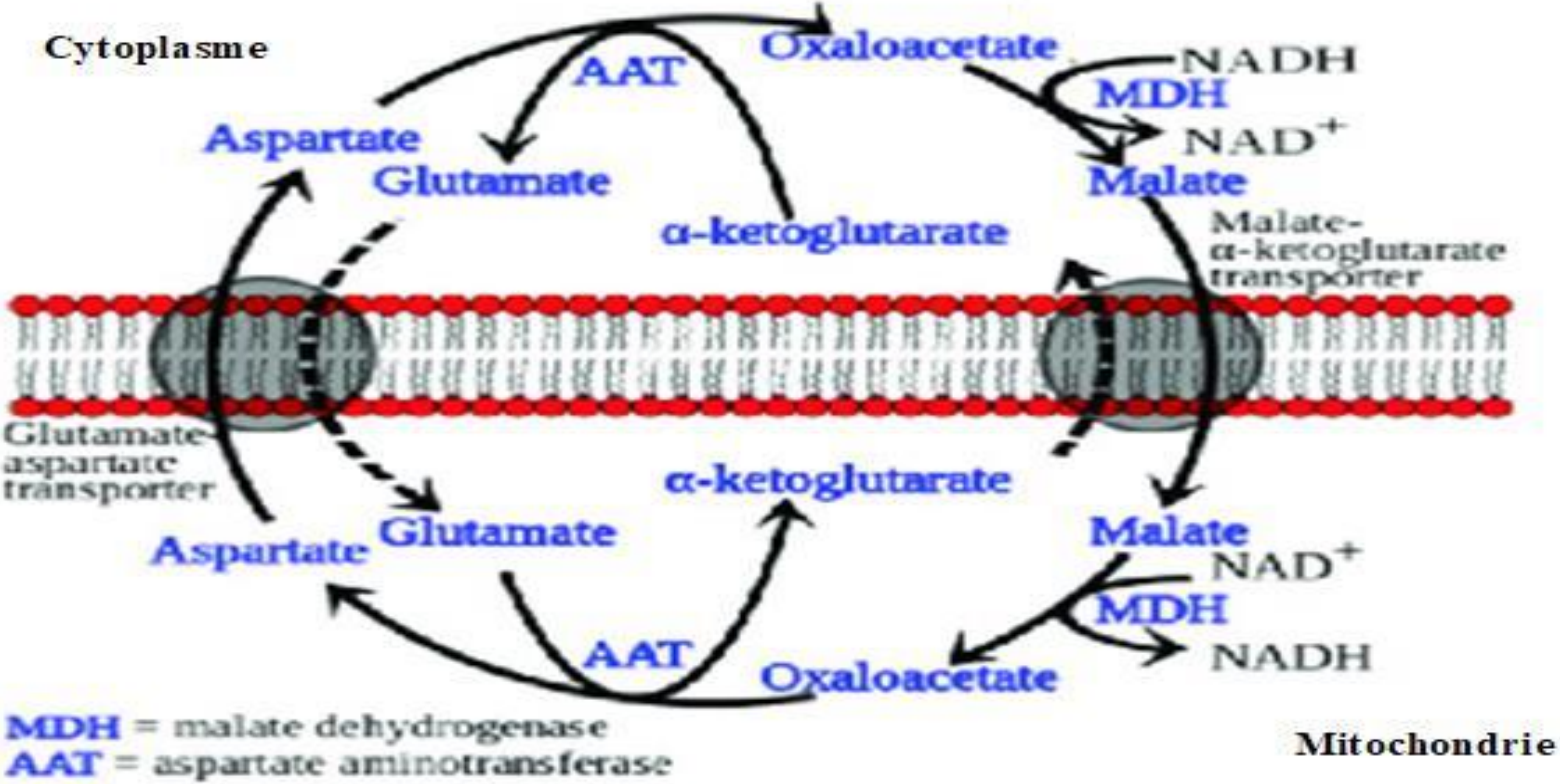
10. Removal of high-energy phosphate by two ADP molecules produces two ATP molecules and two pyruvate molecules.



Glycerol 3 phosphate shuttle

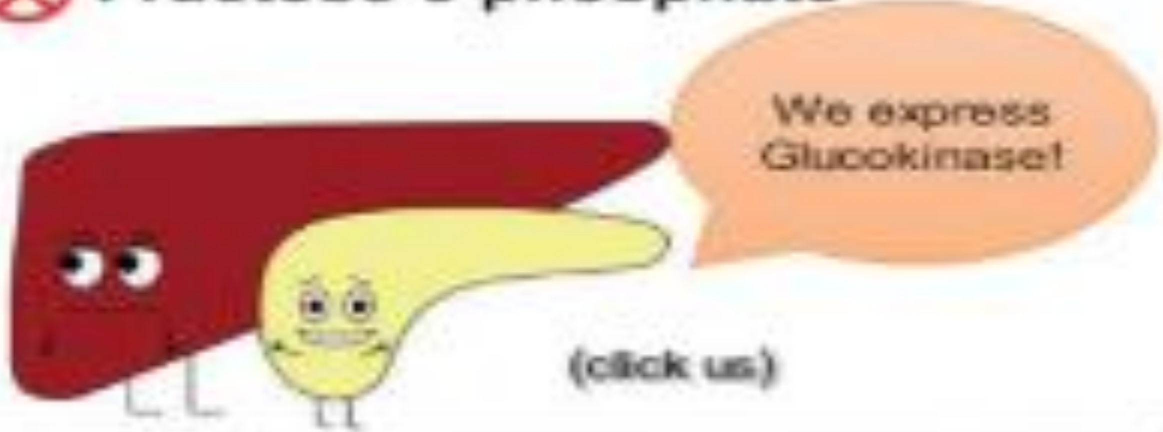


Aspartate-malate shuttle

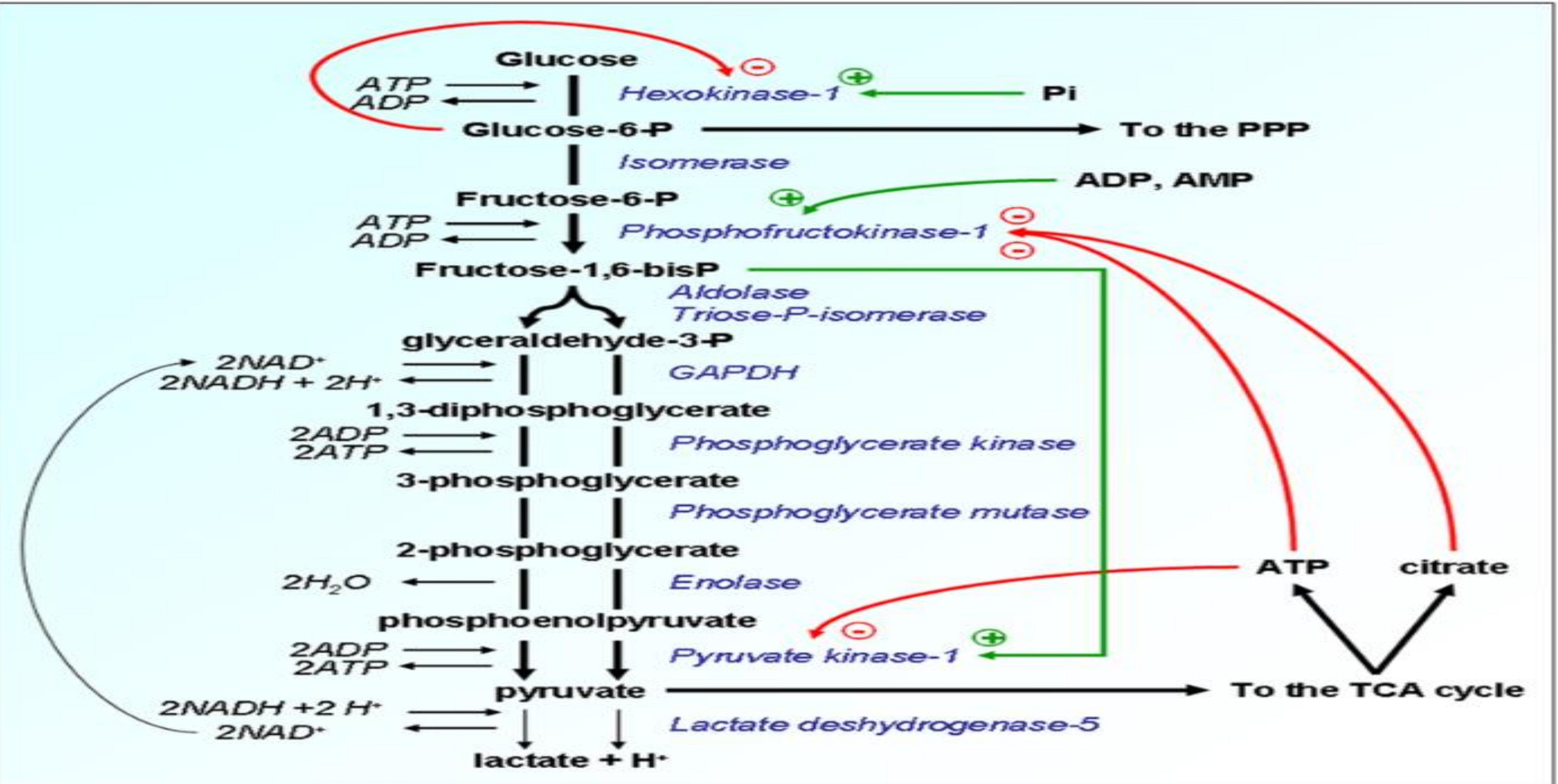


Hexokinase vs. Glucokinase

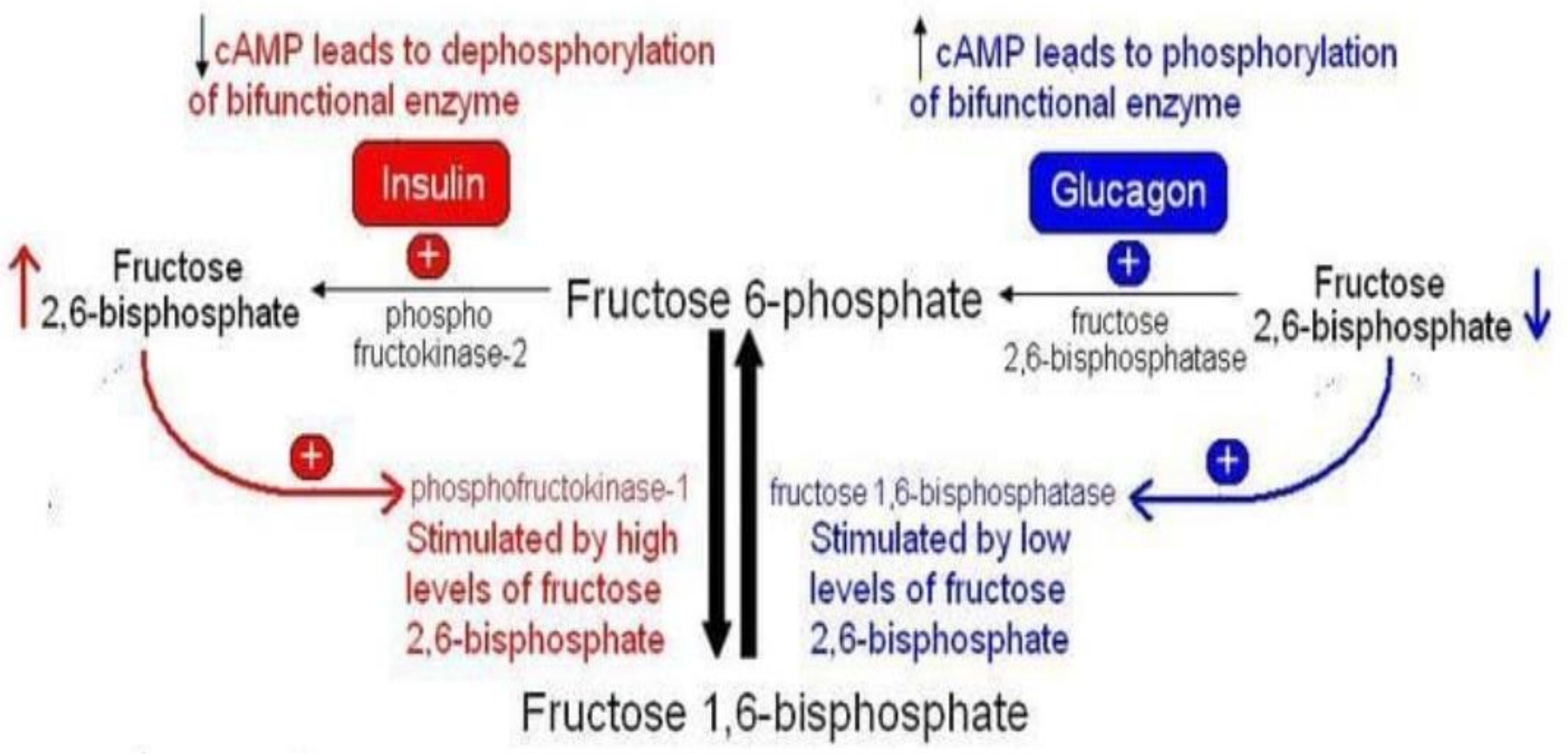
Hexokinase	Glucokinase
Expressed in most tissues	Expressed in Liver and Beta cells of pancreas
High Affinity (Low Km)	Lower affinity (High Km)
Low capacity (Low Vmax)	High Capacity (High Vmax)
NOT induced by insulin	Induced by insulin
Inhibited by ⊗ **Glucose-6-Phosphate**	Inhibited by ⊗ **Fructose 6 phosphate**



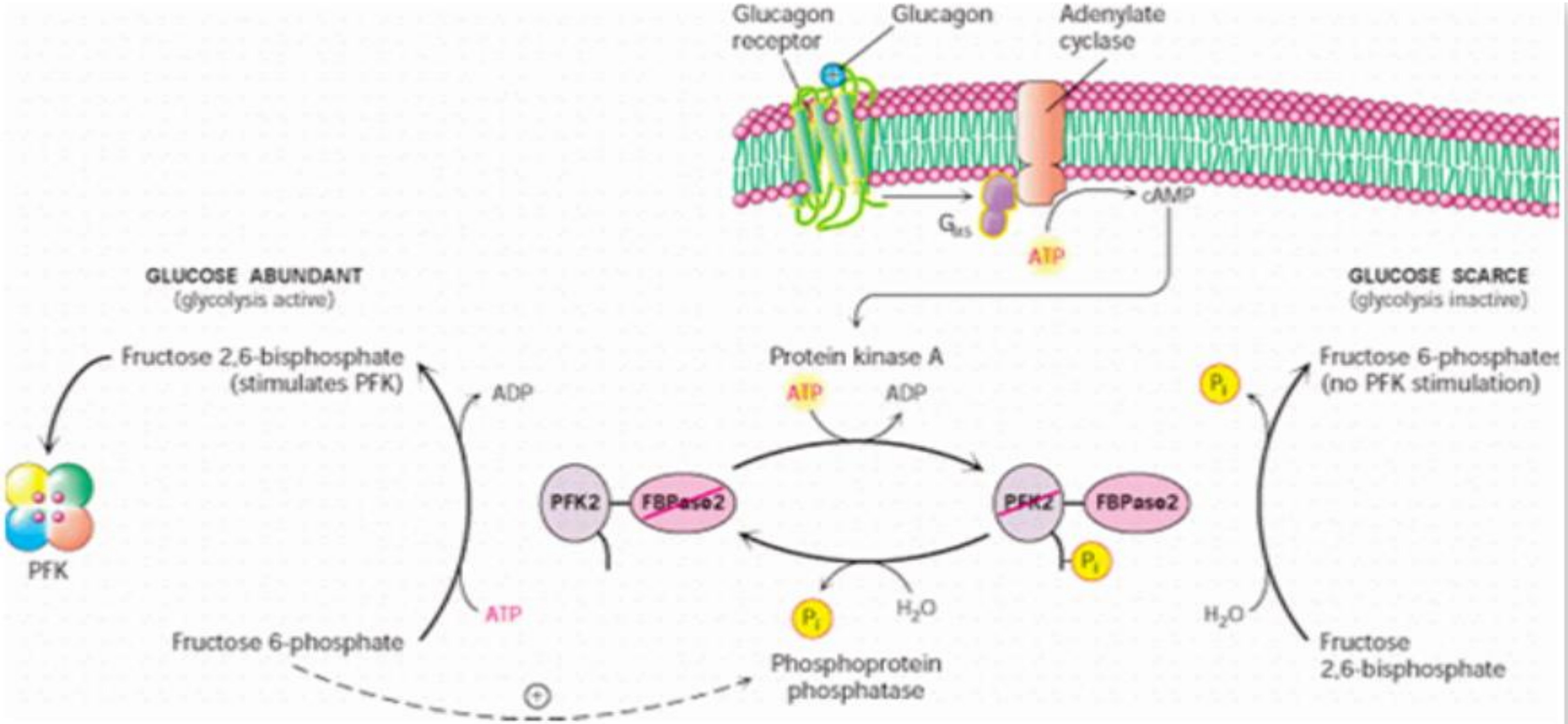
Allosteric regulation of glycolysis enzymes



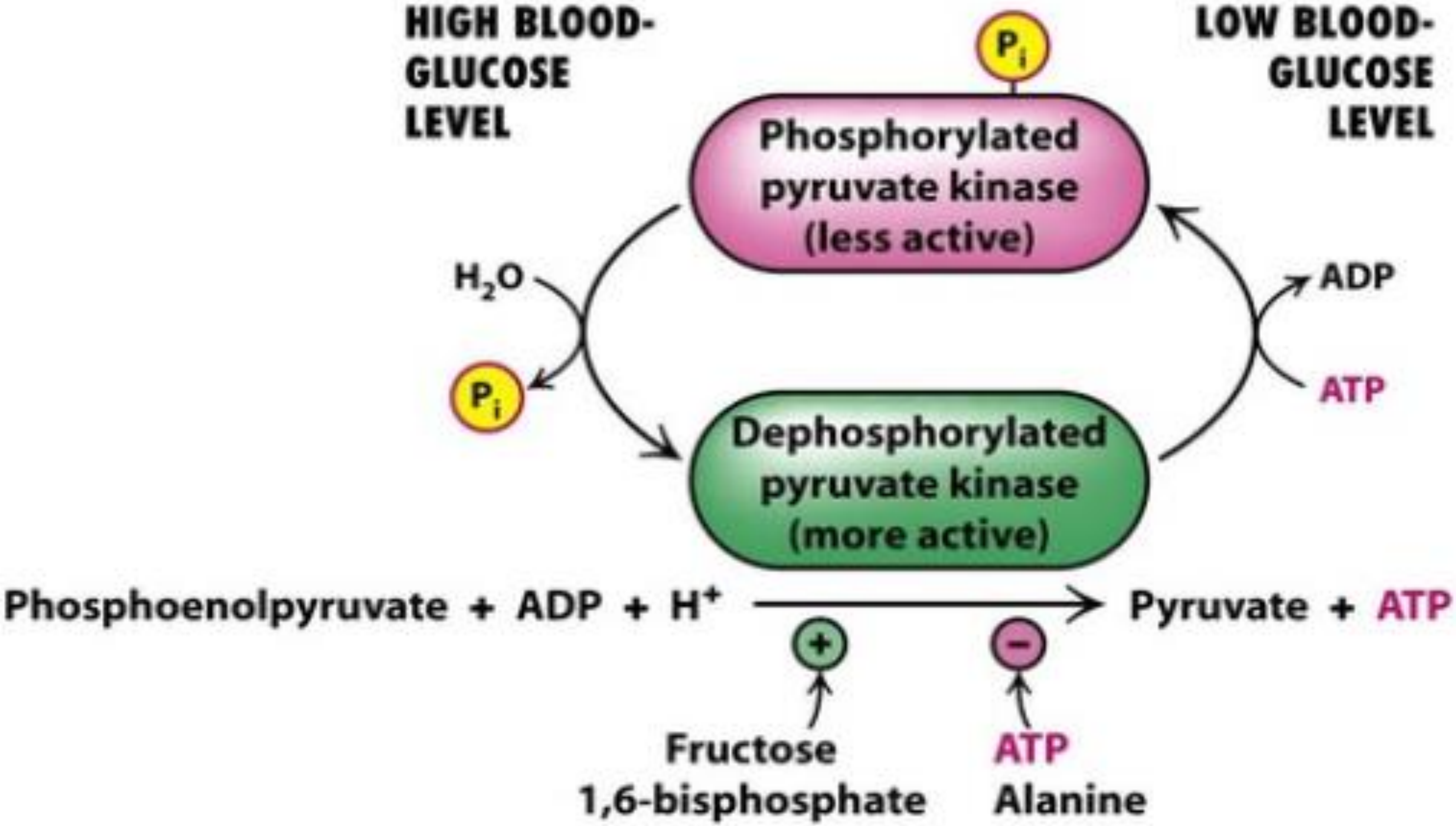
Phosphofructokinase 1 regulation



Phosphofructokinase 1 regulation

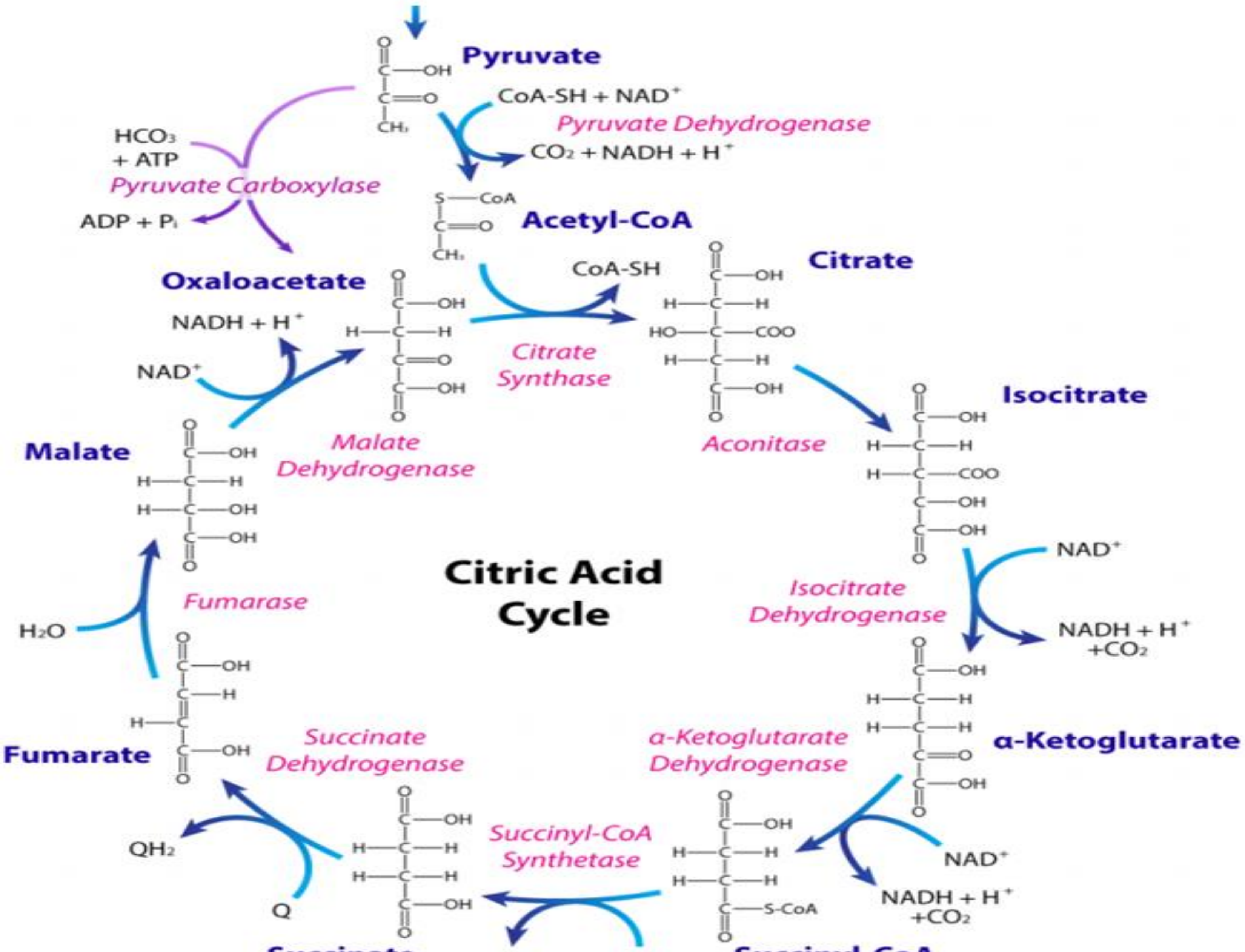


Pyruvate kinase regulation

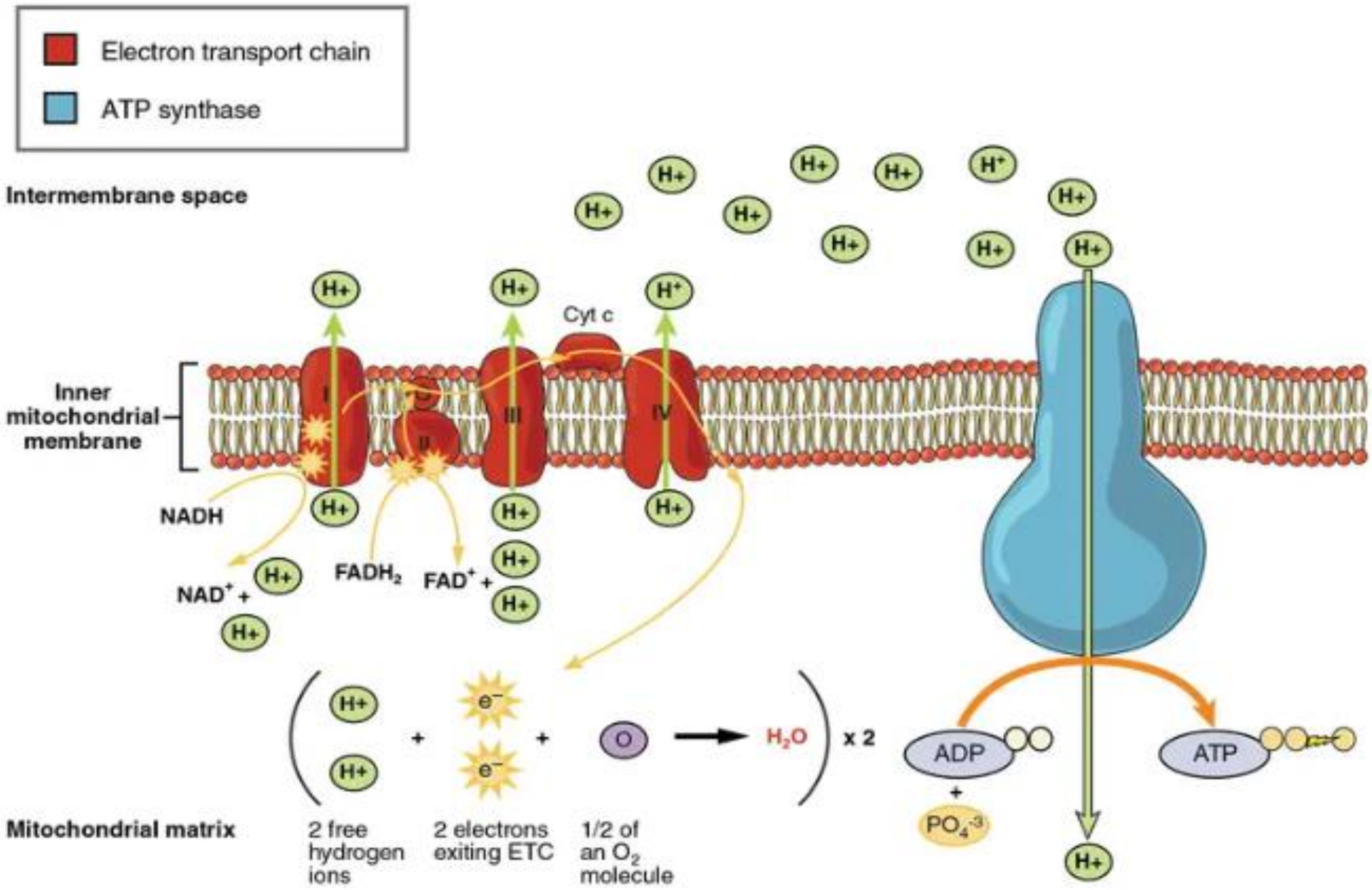


Citric acid cycle

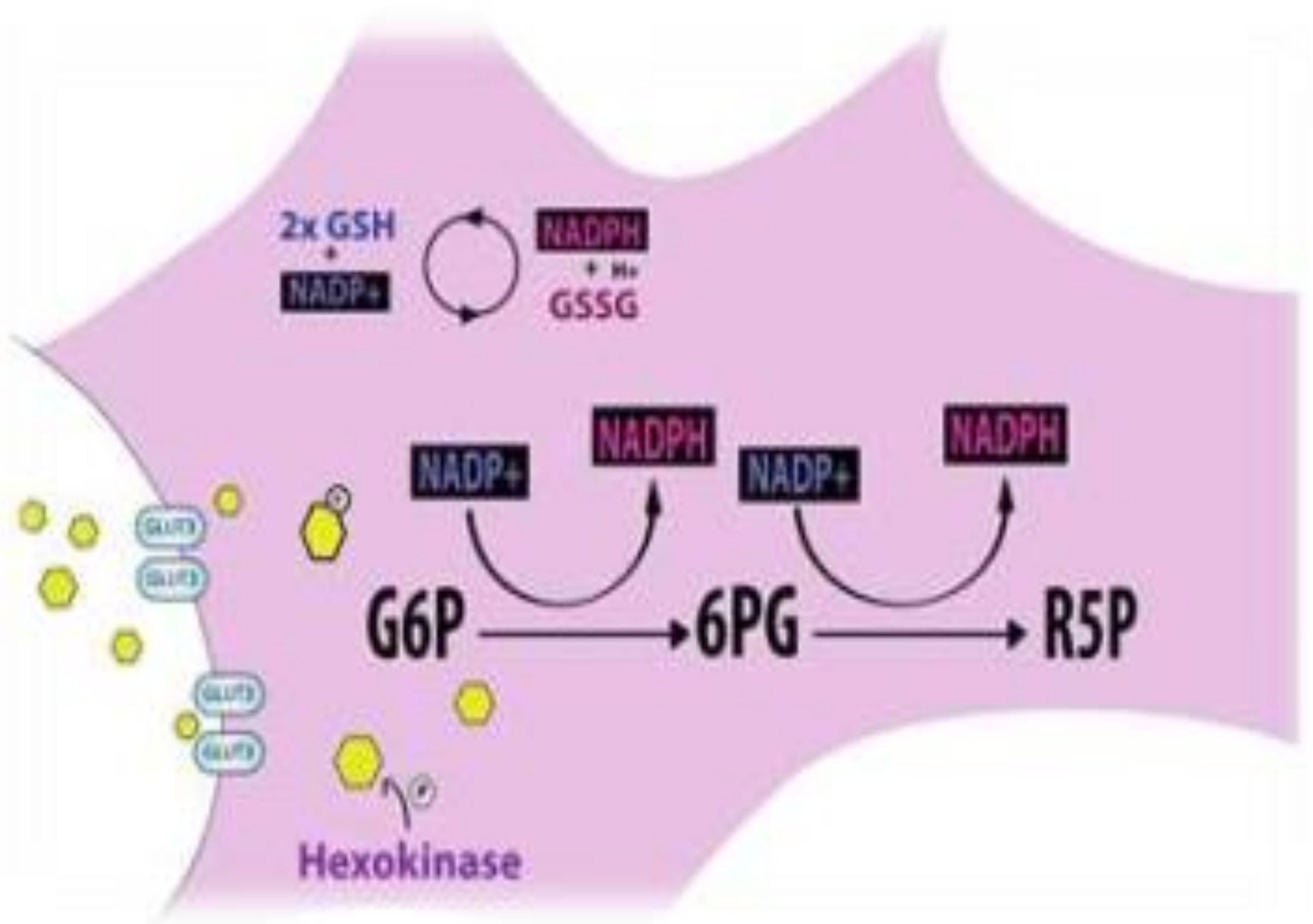
2 acetyl groups + 6 NAD^+ +2 FAD+2 ADP+2 Pi → 4 CO_2 + 6 NADH + 6H^+ +2 $FADH_2$ + 2 ATP



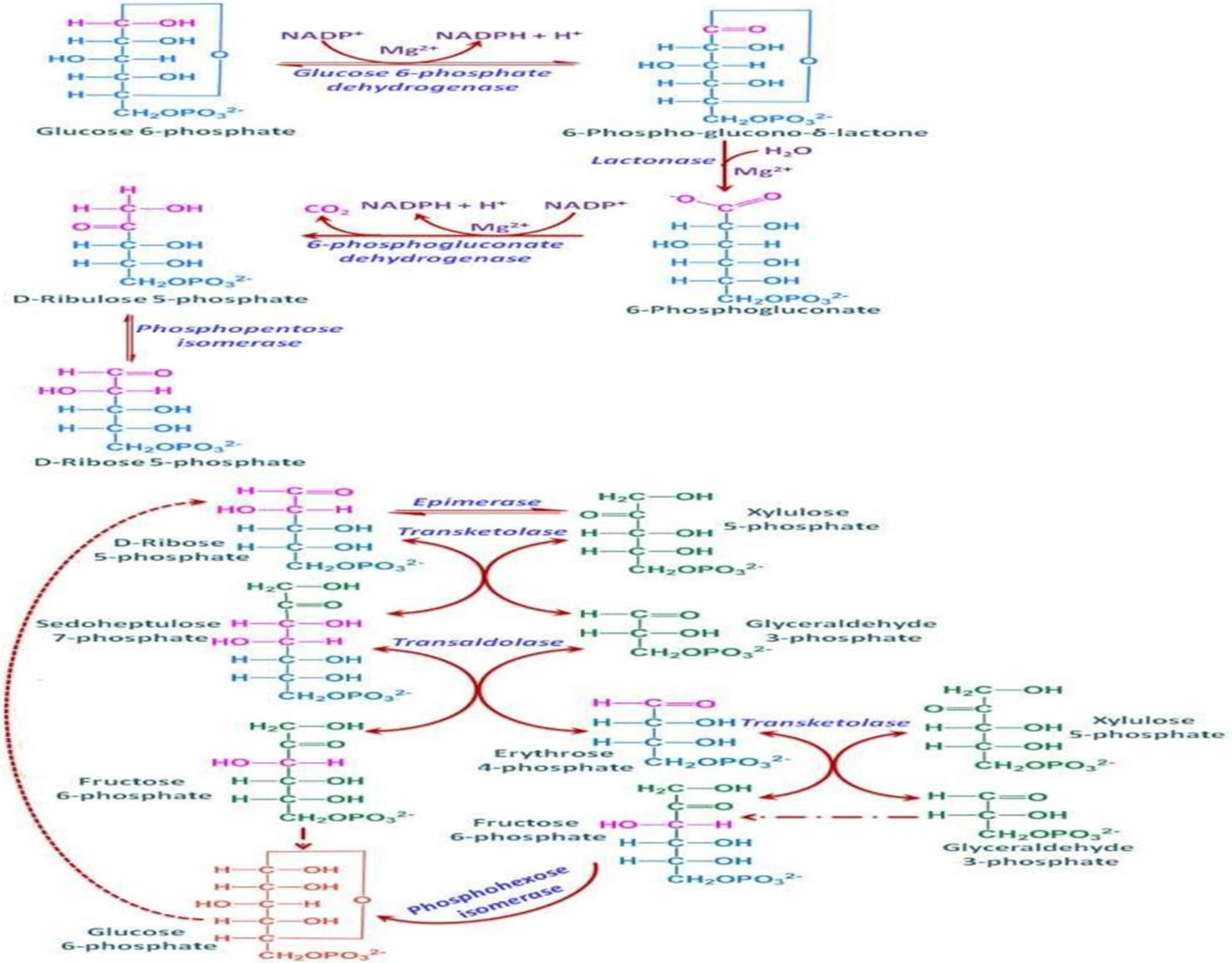
Oxidative phosphorylation mecanism



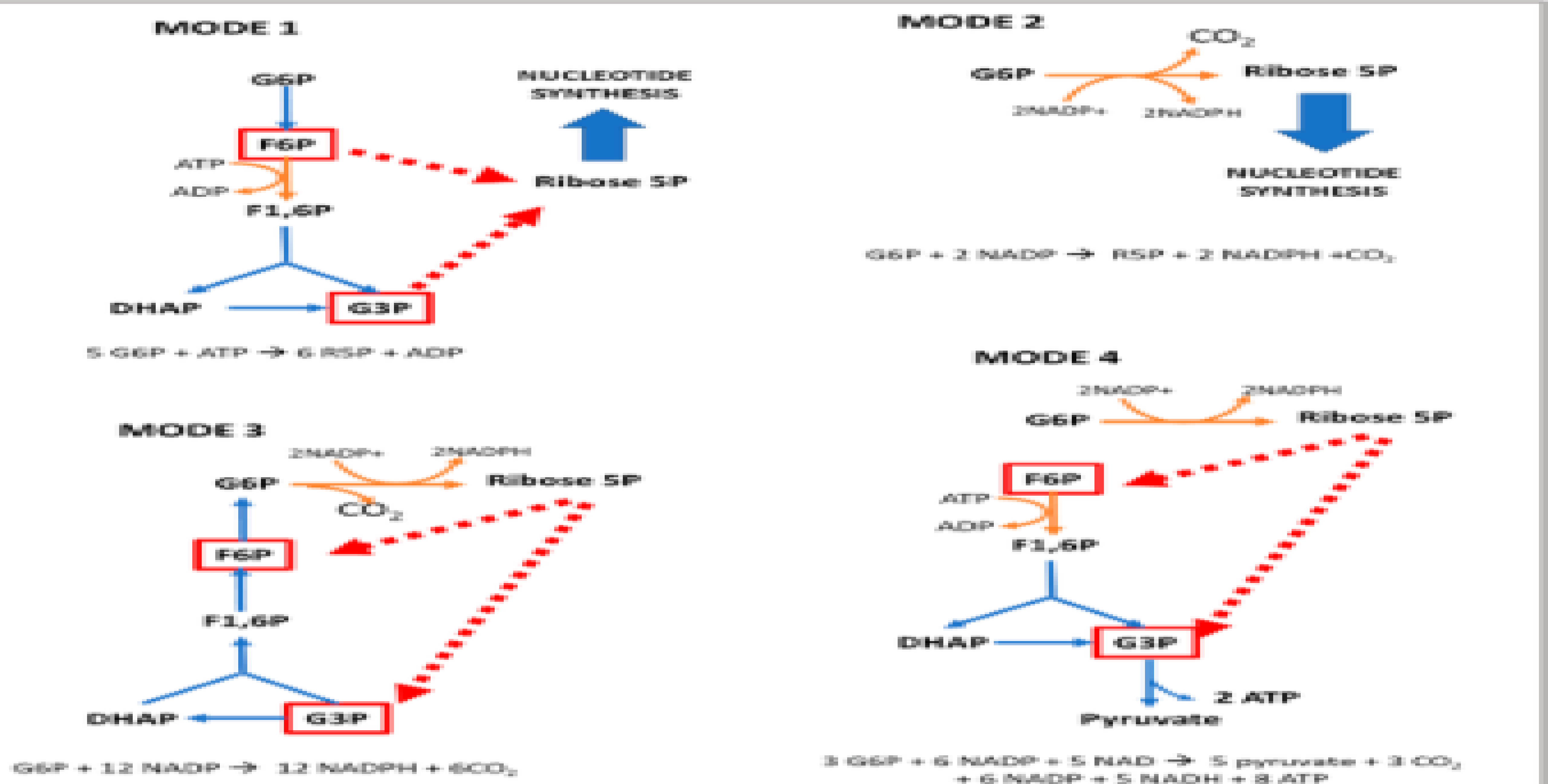
Pentose phosphate pathway



Pentose phosphate pathway

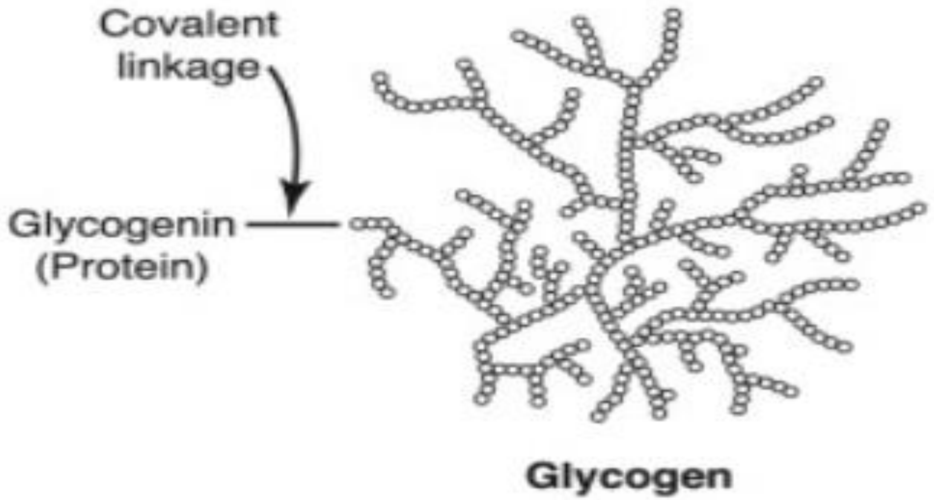


Pentose phosphate pathway

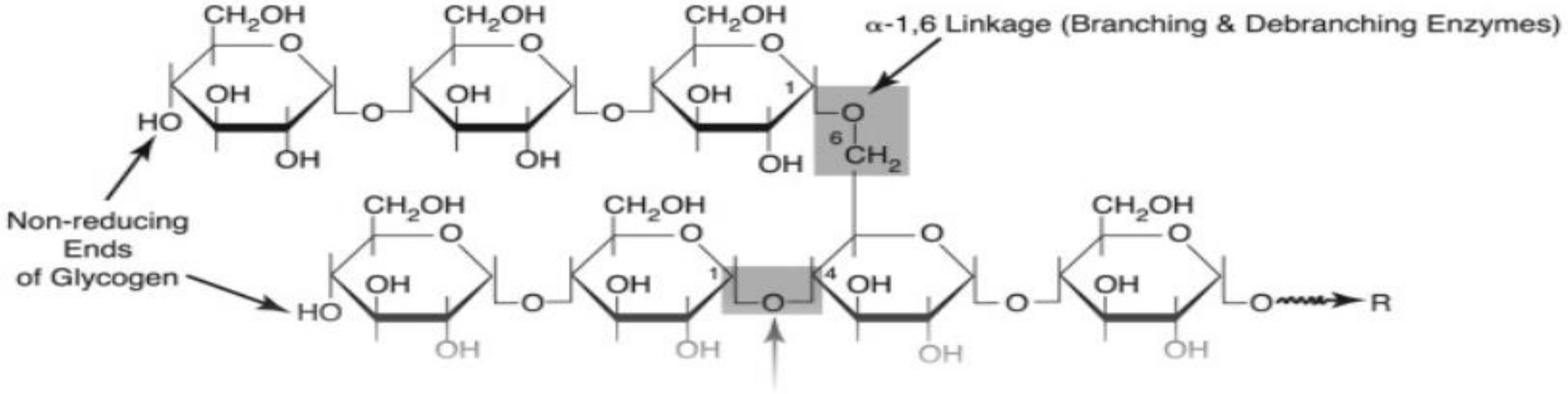


Glycogen structure

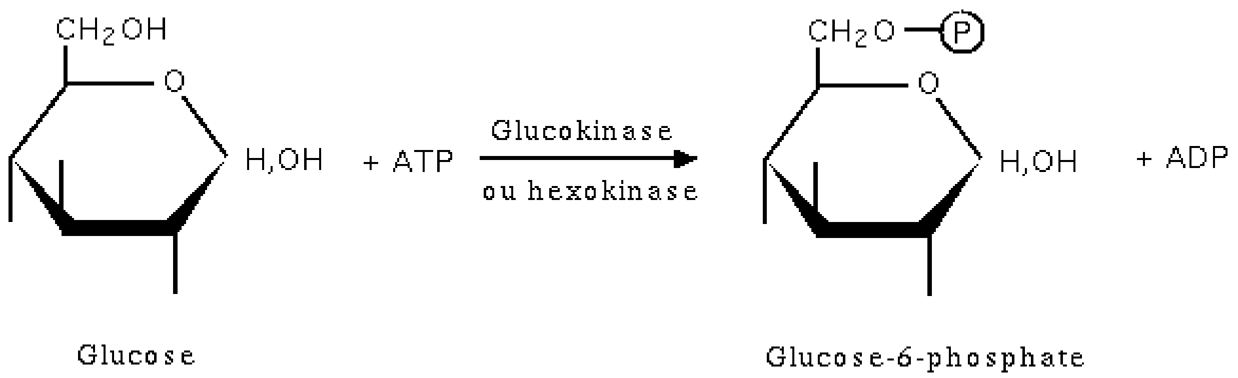
Structure



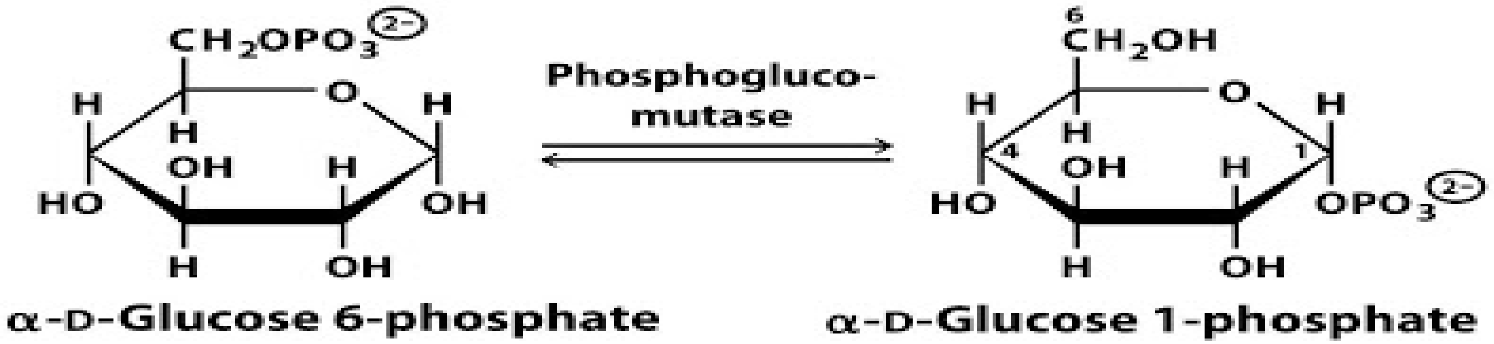
The α-1,6 glycosidic bonds in glycogen are produced by the non-regulatory branching enzyme (and broken by debranching enzyme), while α-1,4 glycosidic bonds in glycogen are produced by the regulatory glycogen synthase (and broken by glycogen phosphorylase).



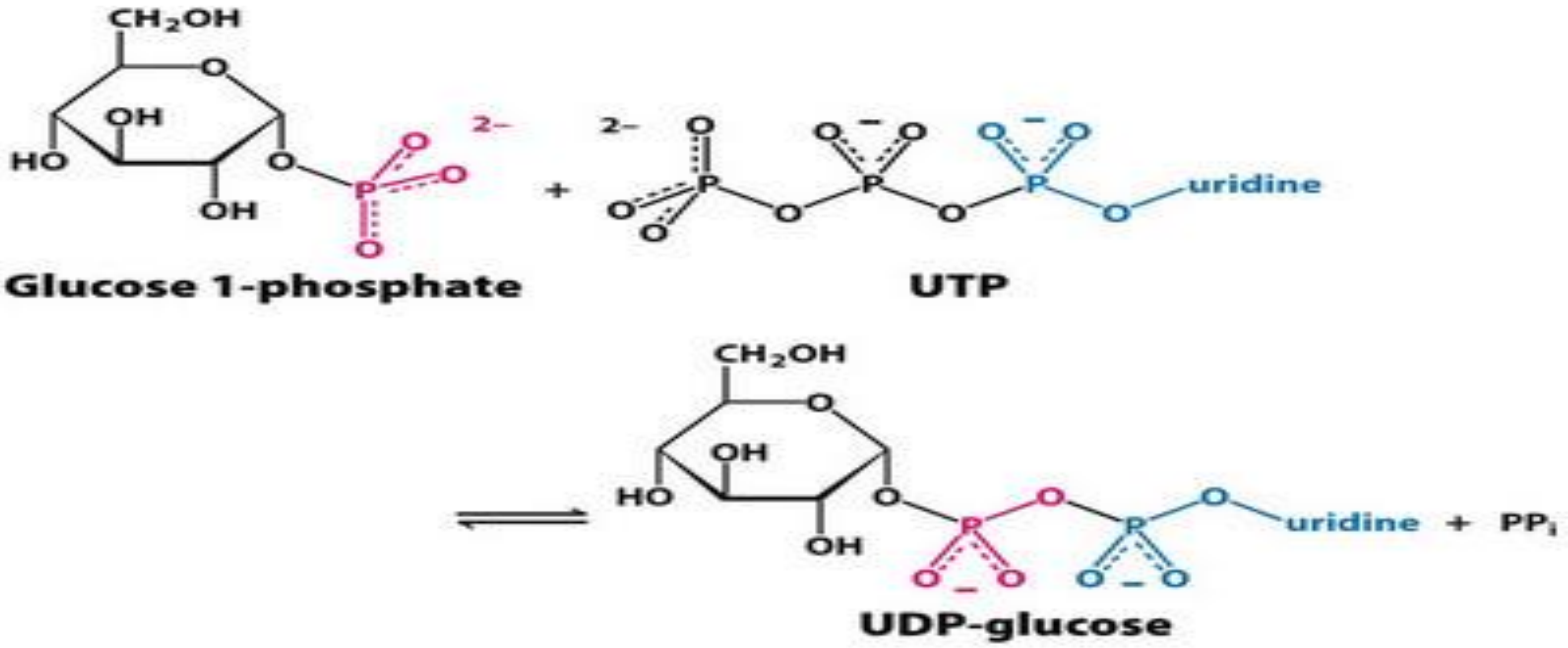
Reaction 1: Phosphorylation of glucose



Reaction 2: Conversion of glucose 6Ⓟ into glucose 1-Ⓟ



Reaction3: formation of l'UDP glucose by UDP glucose pyrophosphorylase

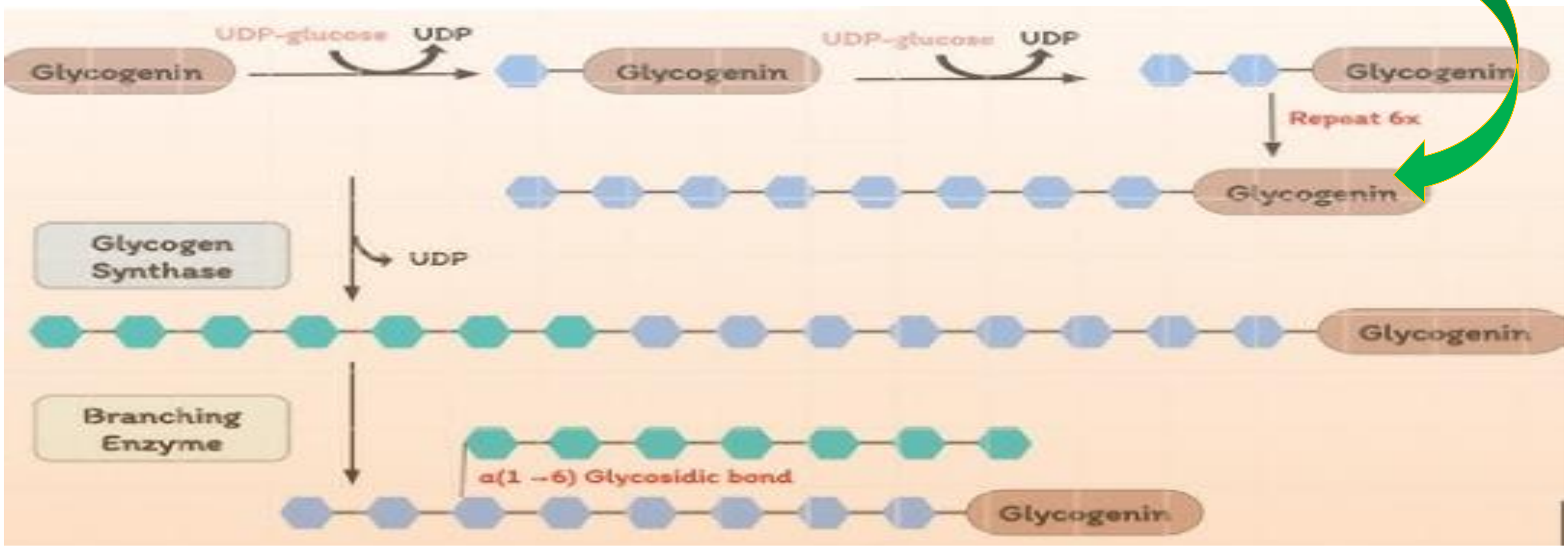


Glycogenesis

Reaction 4: Synthesis of a primer to initiate the glycogen formation

TWO TYPES OF PRIMERS

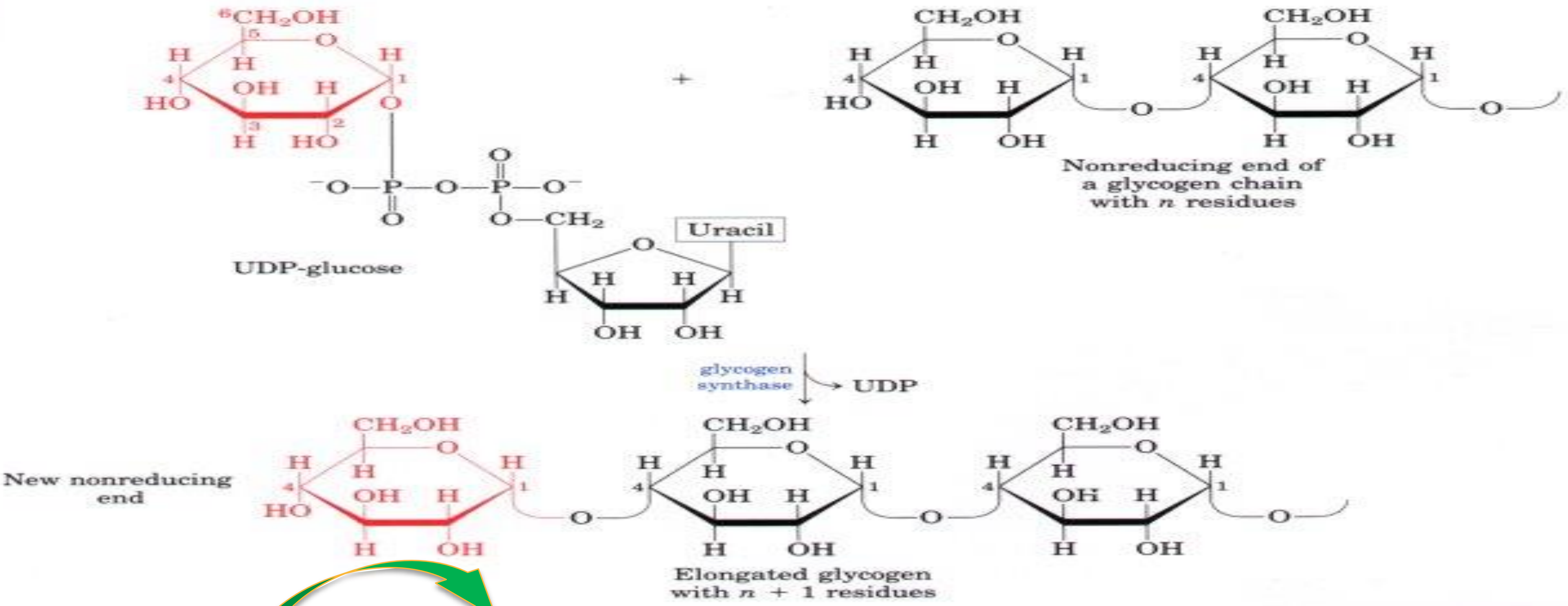
- a fragment of glycogen in the form of dextrin
- intervention of glycogenin to form a short chain approximately 8 units of glucose



Glycogenesis

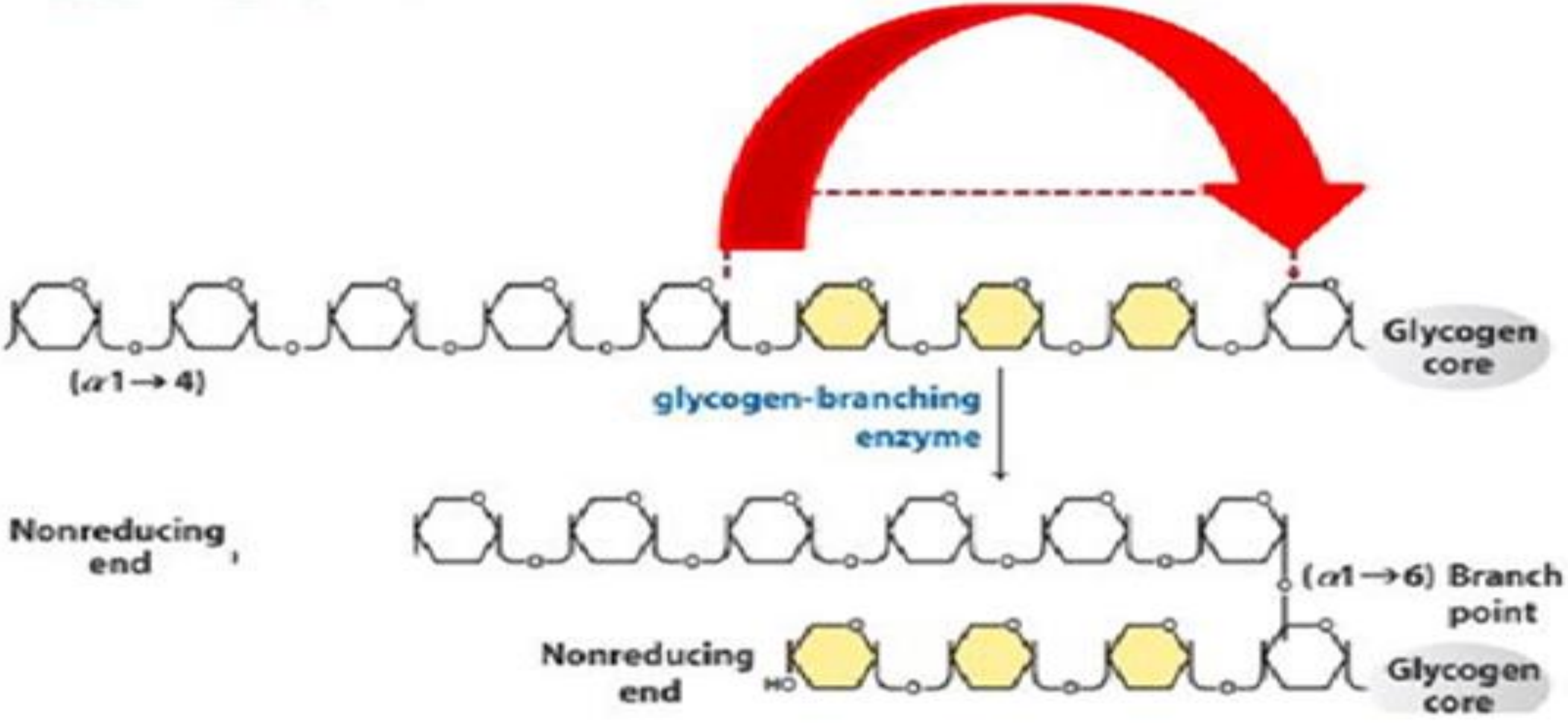
Reaction 5: **Elongation of the chain catalyzed by glycogen synthetase**

New glucosyl units added to nonreducing end terminal residues of glycogen and the formation of α(1,4) linkage

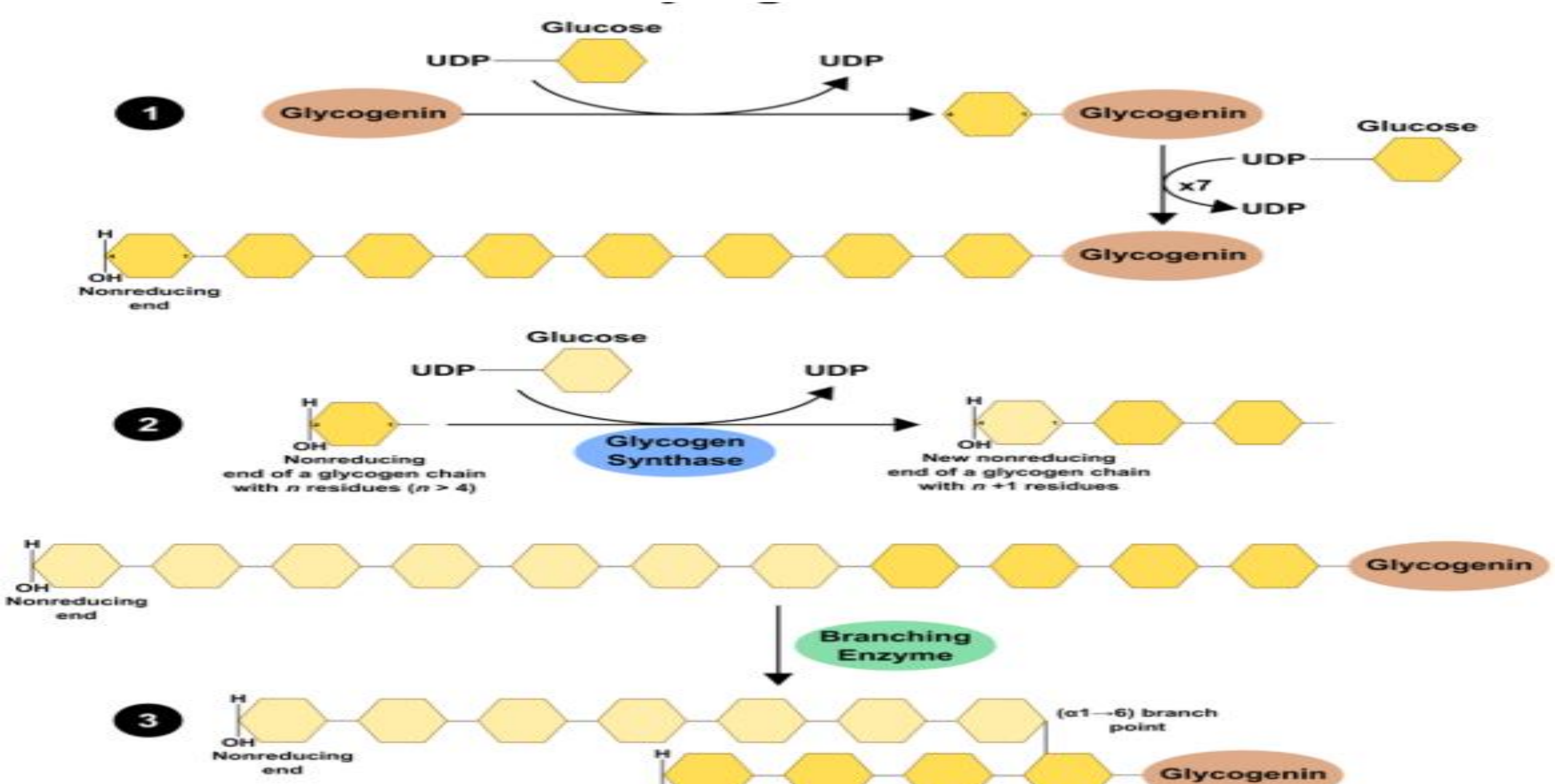


$$UDP + ATP \leftrightarrow UTP + ADP$$

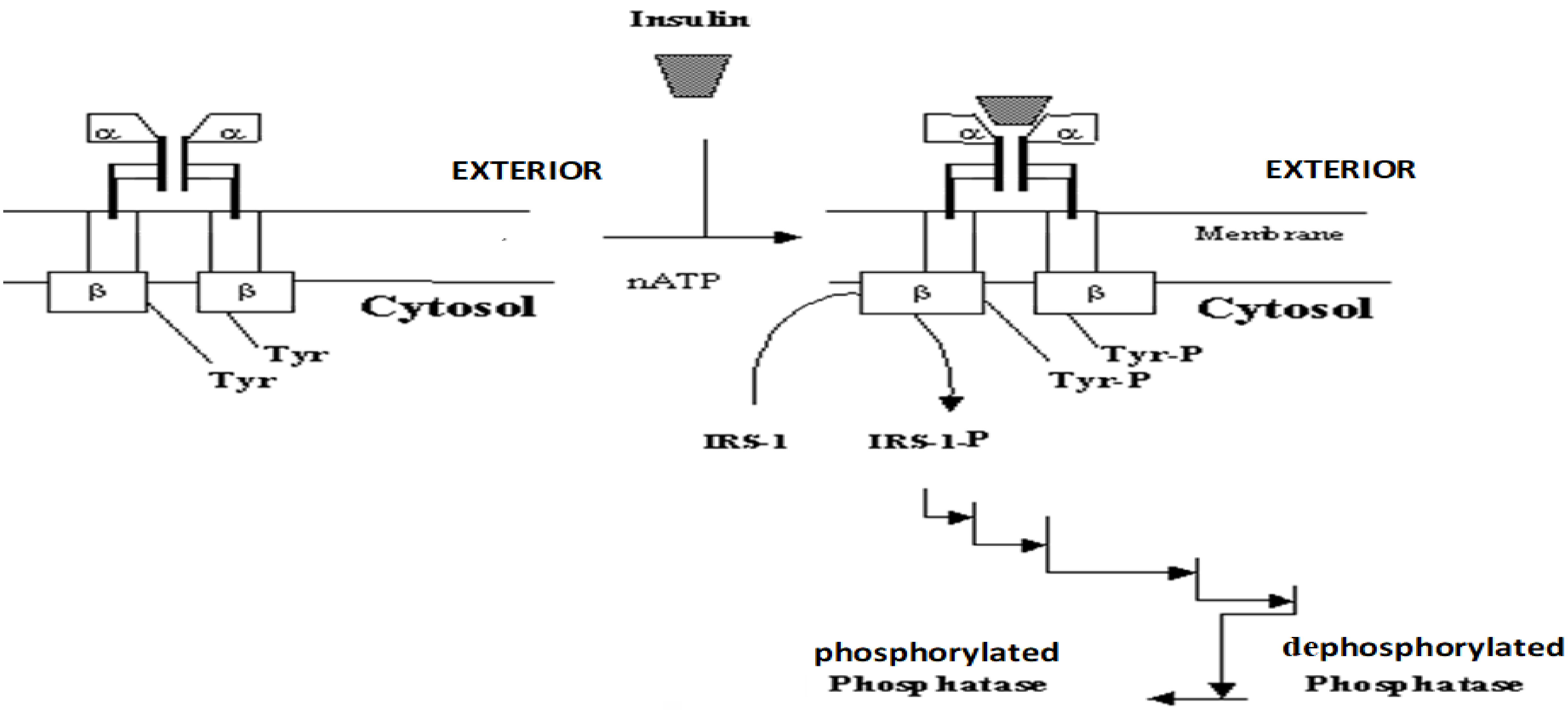
Reaction6: Glycogen branching



Glycogenesis



Hormonal regulation of glycogenesis

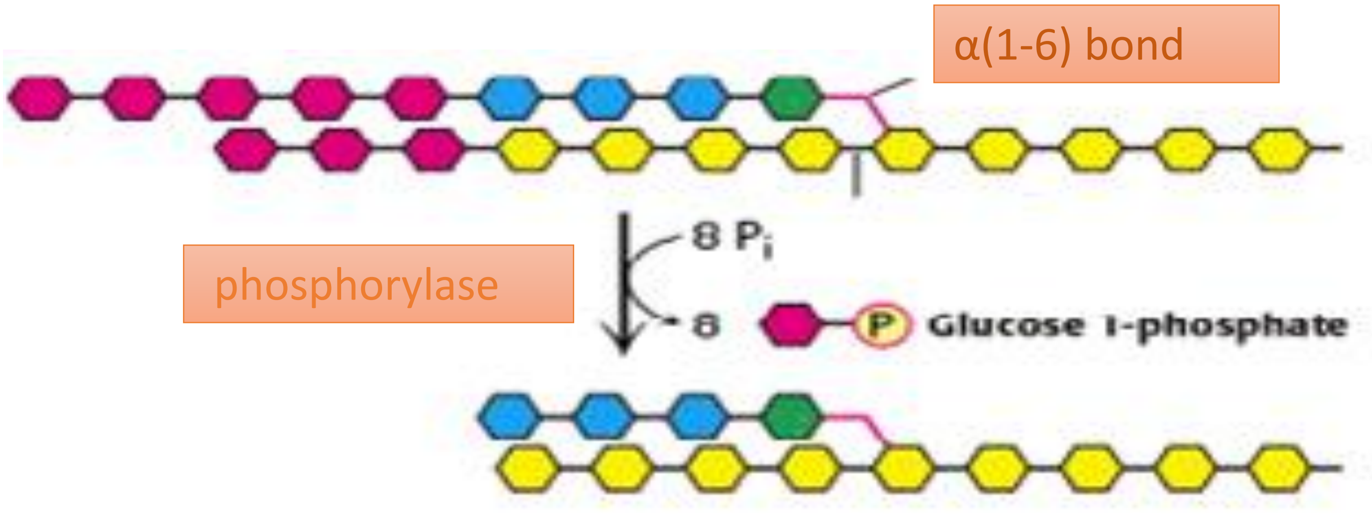


Activation mecanism of protein phosphatase by insulin

Glycogenolysis reactions

Reaction 1: Glycogen phosphorolyse

- Cleavage of the α (1-4) bond from the non-reducing end
- Attachment of a phosphate group provided by ATP to carbon 1 of the released glucose
- Phosphorolysis is repeated sequentially on glycogen until 4 glycosyl residues are encountered on each chain before the α (1-6) bond



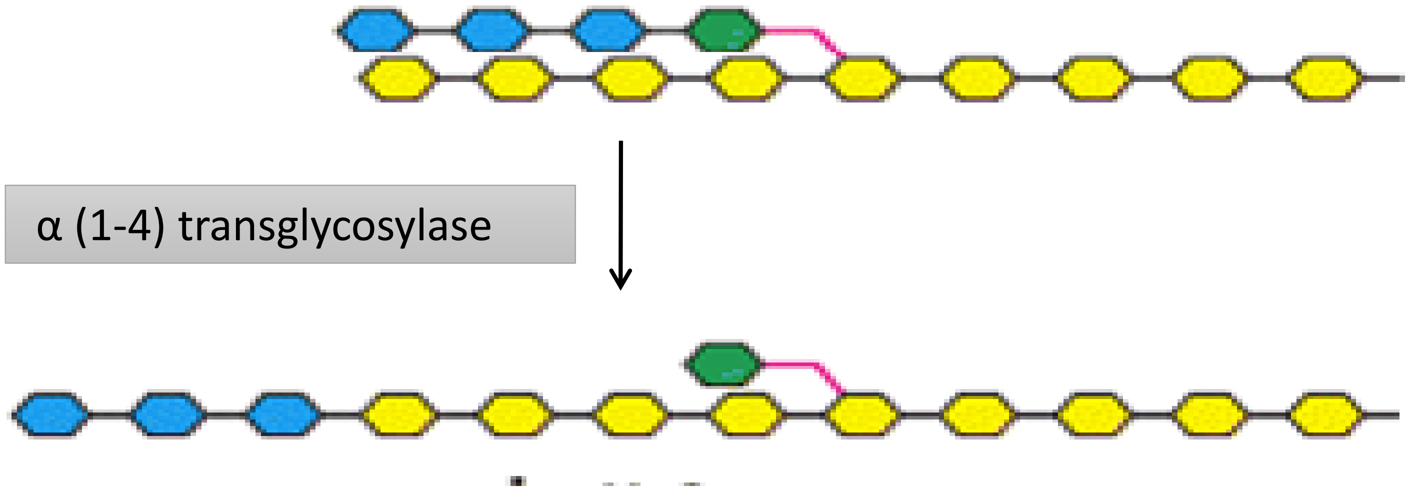
Glycogenolysis

Reaction2: **glycosyl transferase effect by α (1-4) transglycosylase**

- Glycosyltransferase acts on limiting dextrin by removing an oligoside made up of 3 glucose residues from each chain

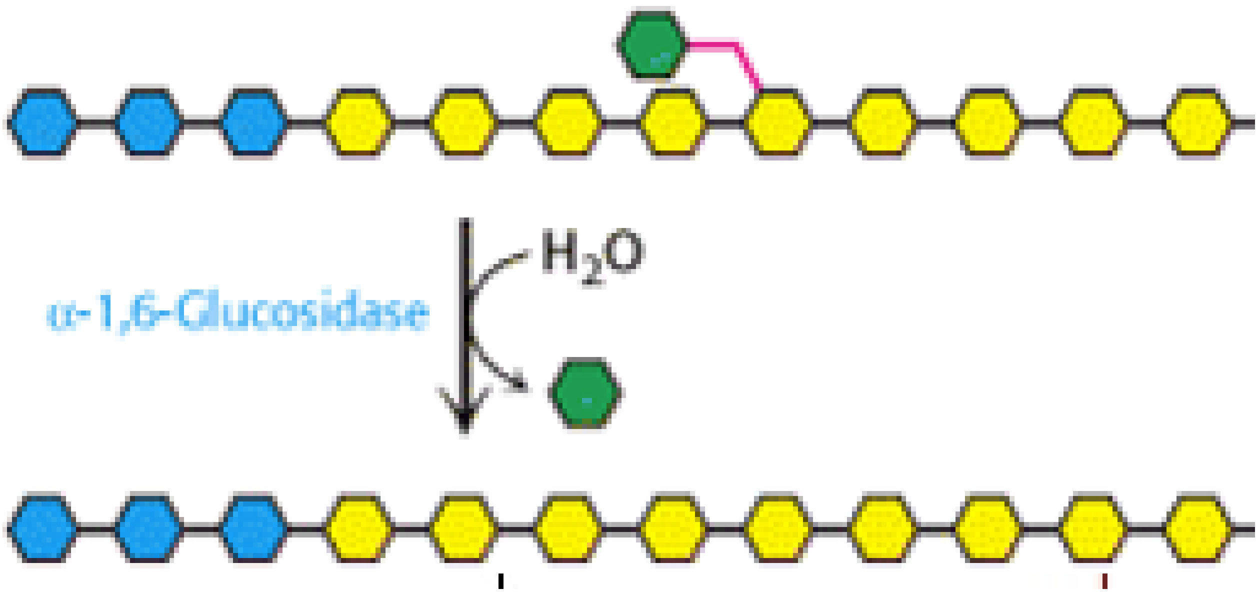
- The three glucose residues are attached to another limit dextrin chain, thus allowing phosphorolysis to resume on this chain.

- After the action of this enzyme, a glucose molecule linked by the α (1-6) bond remains in place of the side chain.



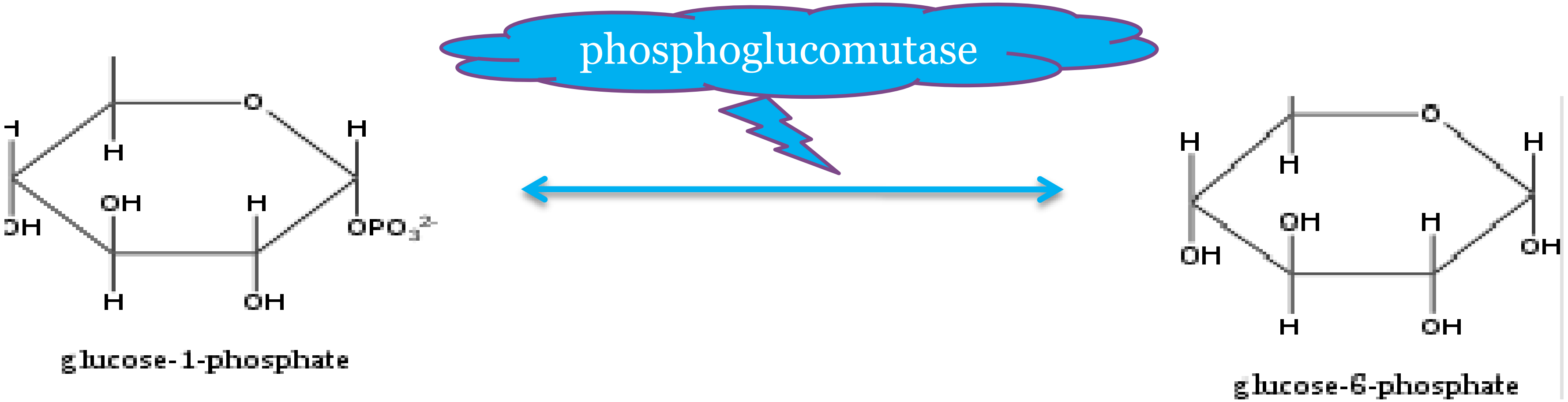
Reaction3: Debranching (ou α (1-6) glucosidase) effect

- A debranching enzyme hydrolyzes glucose residues linked by the α (1-6) bond and releases glucose molecules

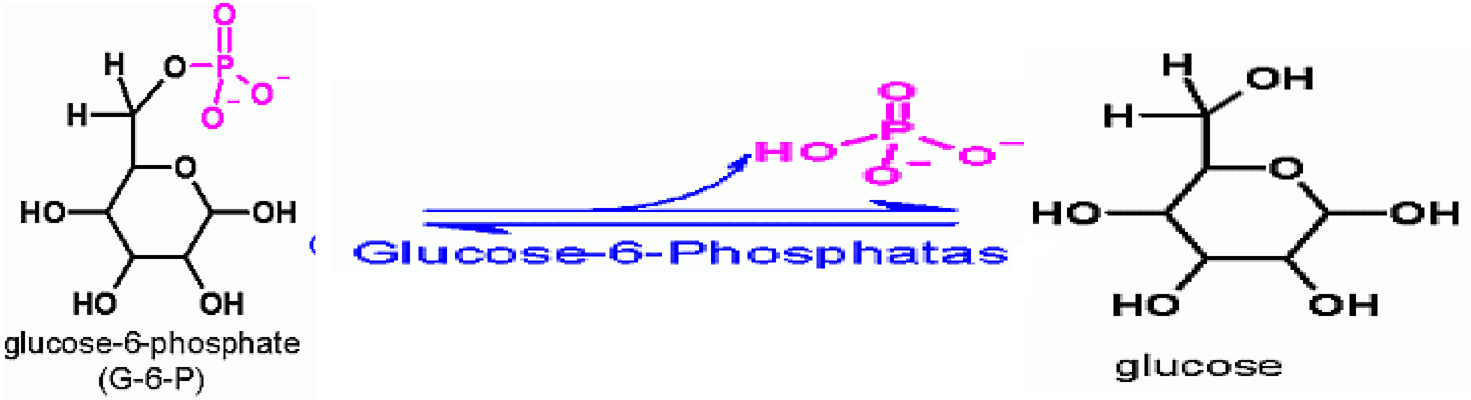


Glycogenolysis

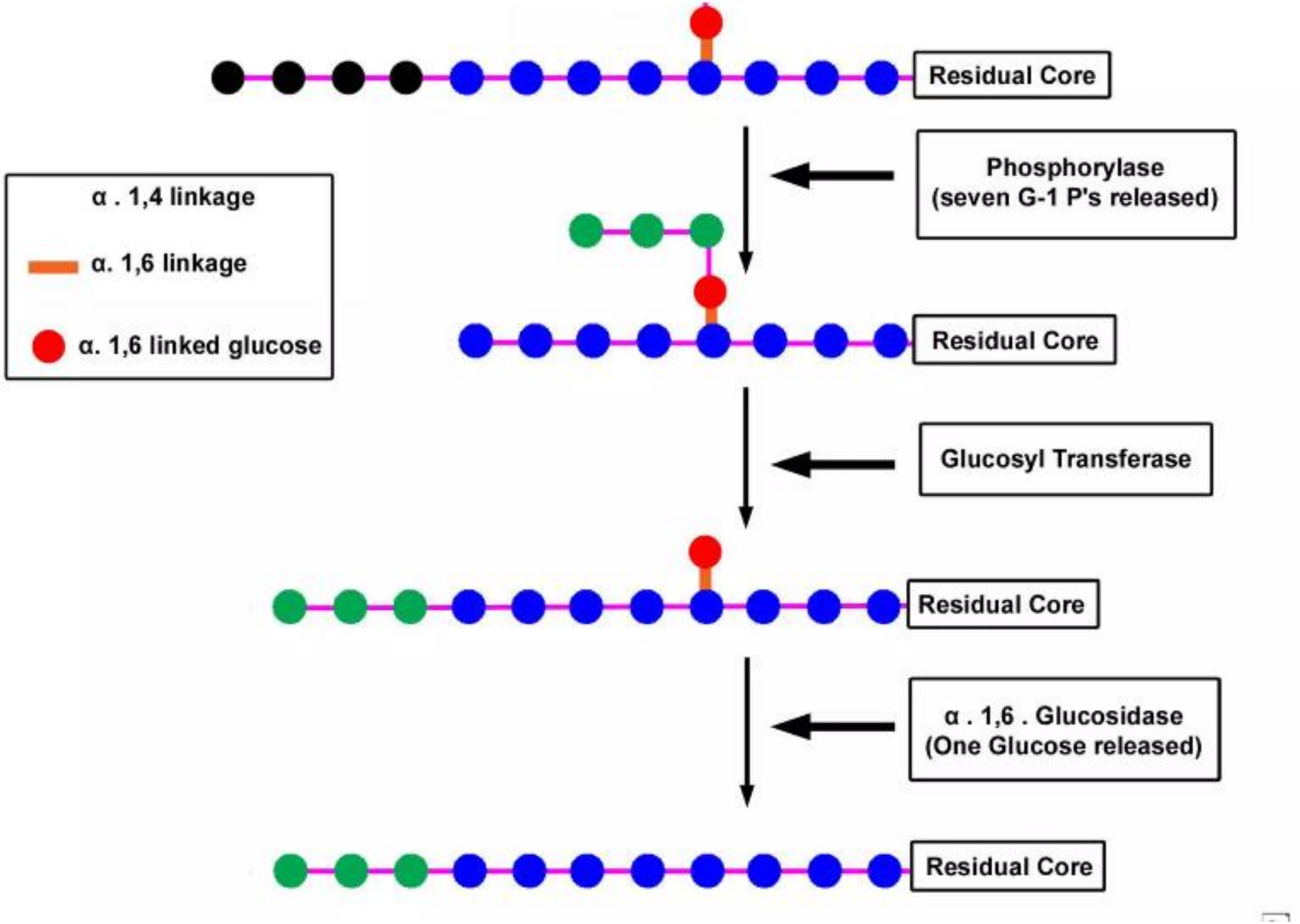
- G1P is converted to G6P by phosphoglucomutase. G6P can enter glycolysis in the liver and muscle



- Glucose 6-phosphatase allows the hydrolysis of G6P into glucose and the release of the latter into the blood



Glycogenolysis



Hormonal regulation of glycogenolysis

The binding of each
of the hor
its sp
membrane
leads t
activati
memb
adenylat
(adenylate

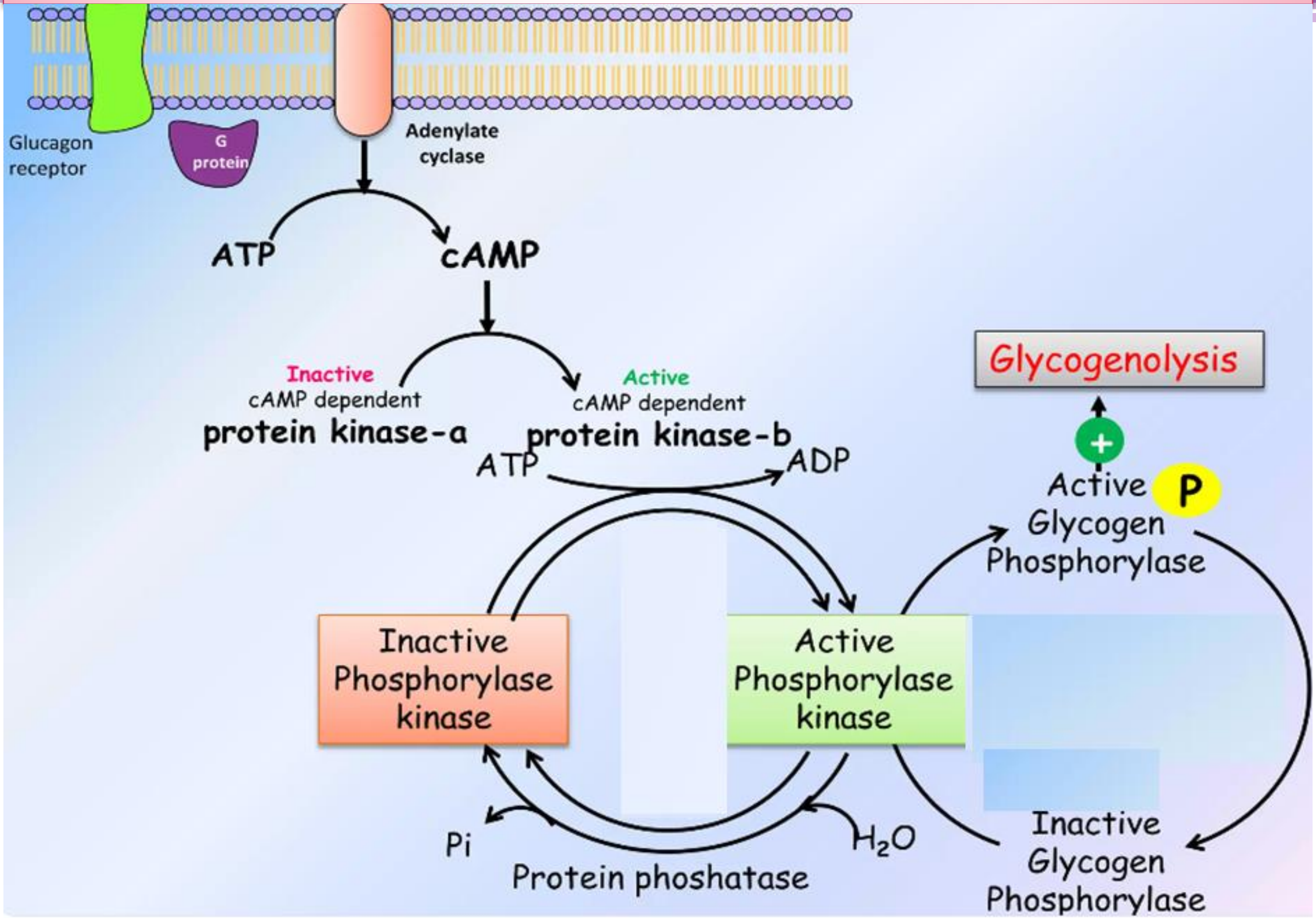
Activated adenylate
cyclase catalyzes,
thro
hyd
forr
AM
con
mes

cAMP
kinase
depen
combi
regula
releas
subun
Kinase

Protein kinase A
(active)
phosph
presen
glycoge
phosph
which l
in phos
form.

Finally, this last one phosphorylates glycogen phosphorylase, changing it from the b form to the a form, which catalyzes the phosphorolysis of glycogen.

Hormonal regulation of degradation of glycogen



Gluconeogenesis

Gluconeogenesis is the formation of glucose from non-carbohydrate carbon sources.

Fasting, Low Carb Diet, Intense Exercise, Starvation

↓

The body uses carbon from fats and proteins to make sugar.

Amino Acids, Lactate, Glycerol

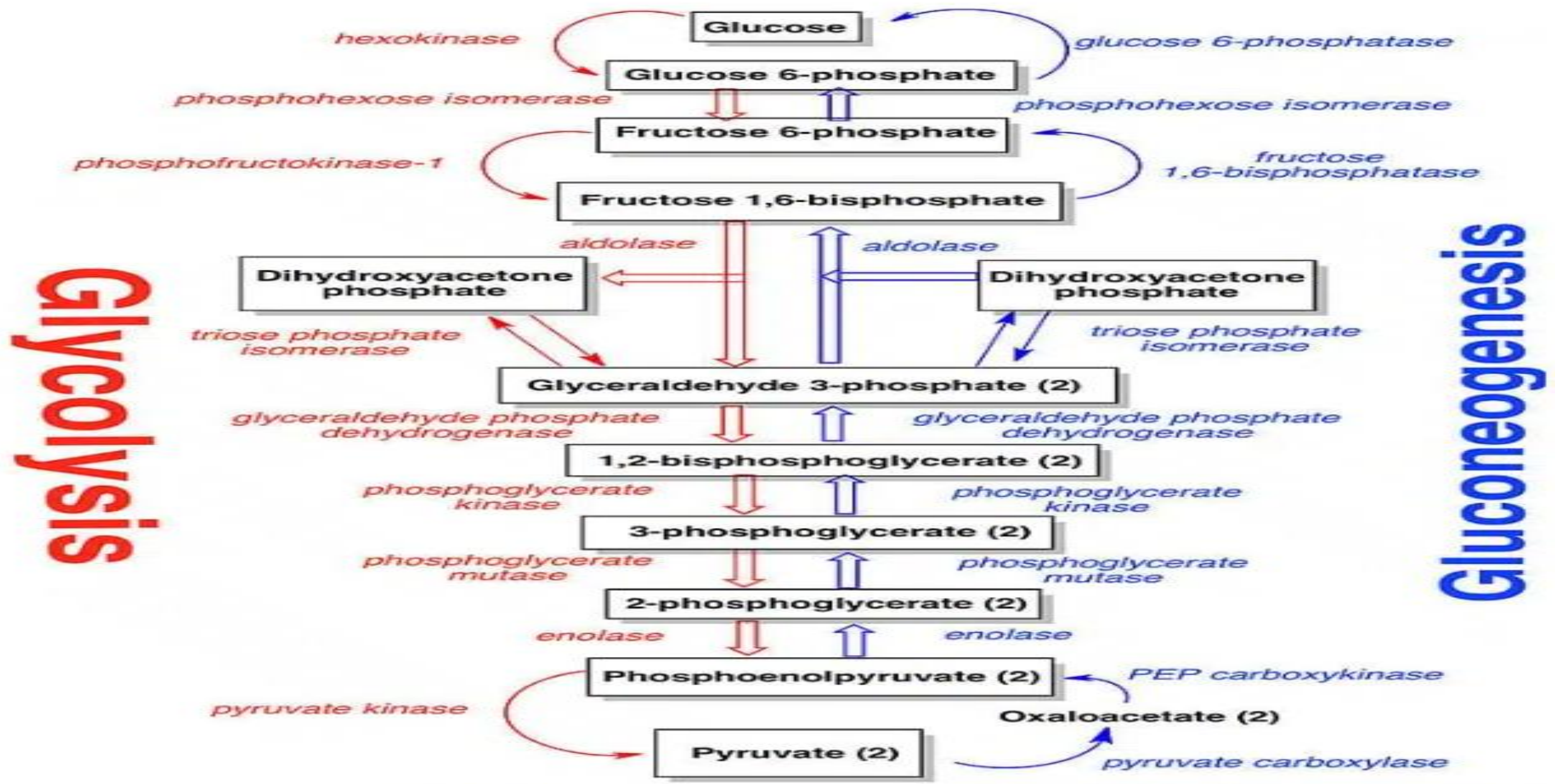
↓

↓

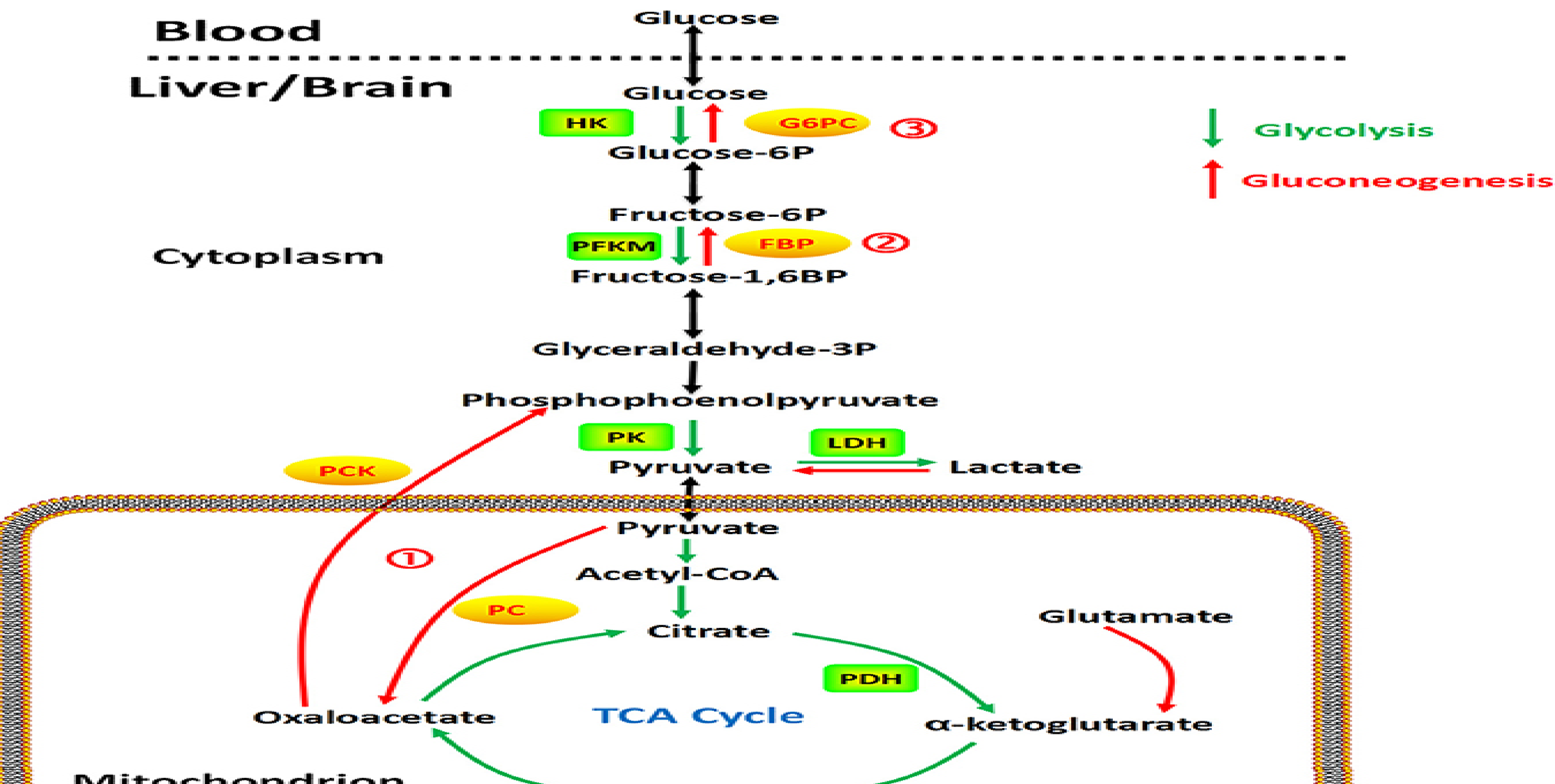
In humans, the process mainly occurs in the liver, but also in the kidney, intestine, muscle and brain.

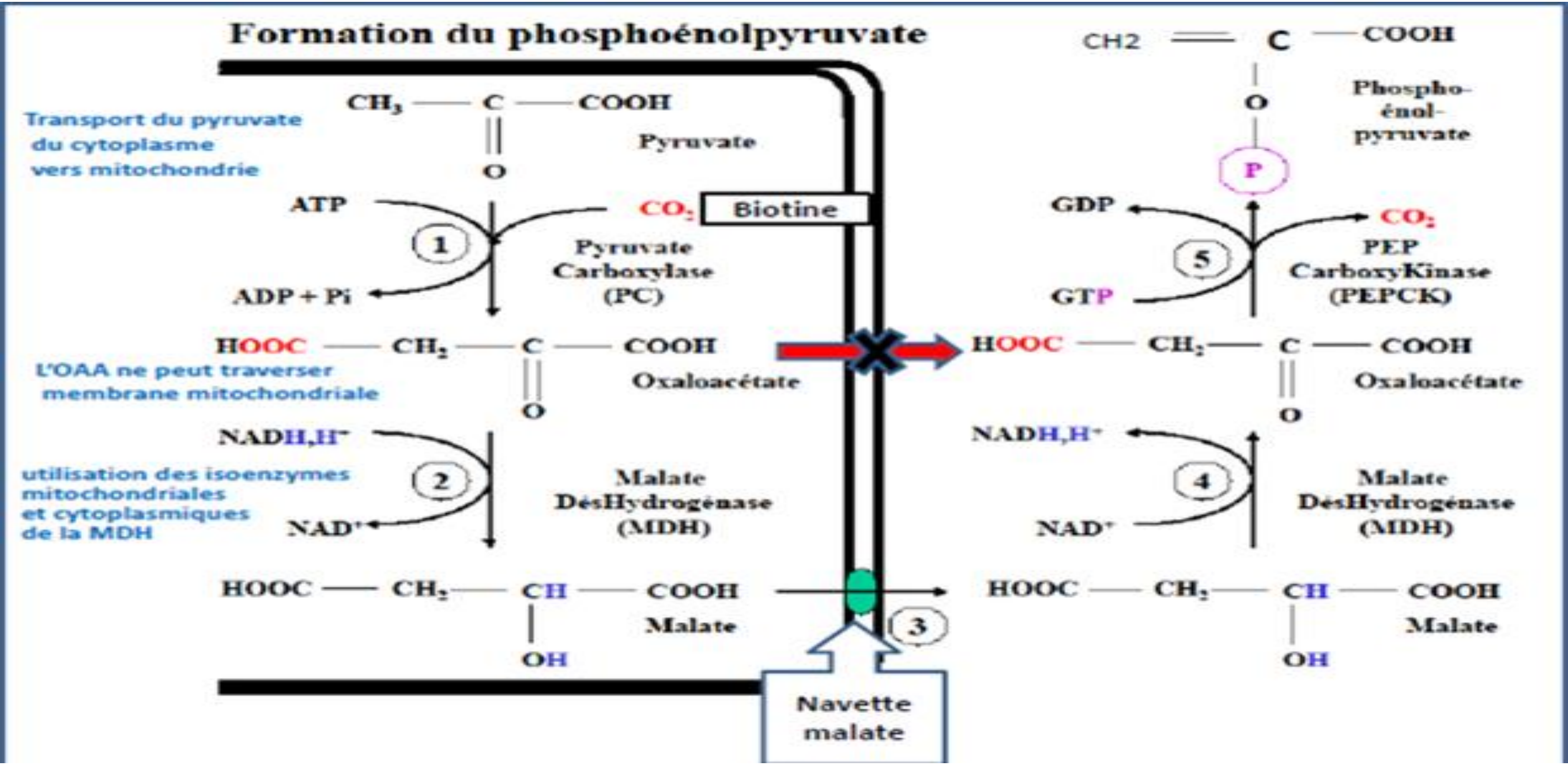
Glucose

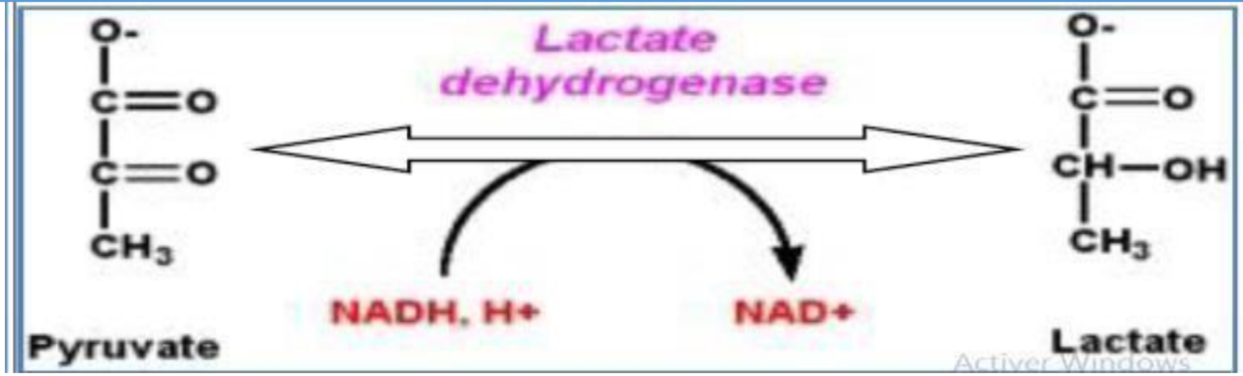
Gluconeogenesis



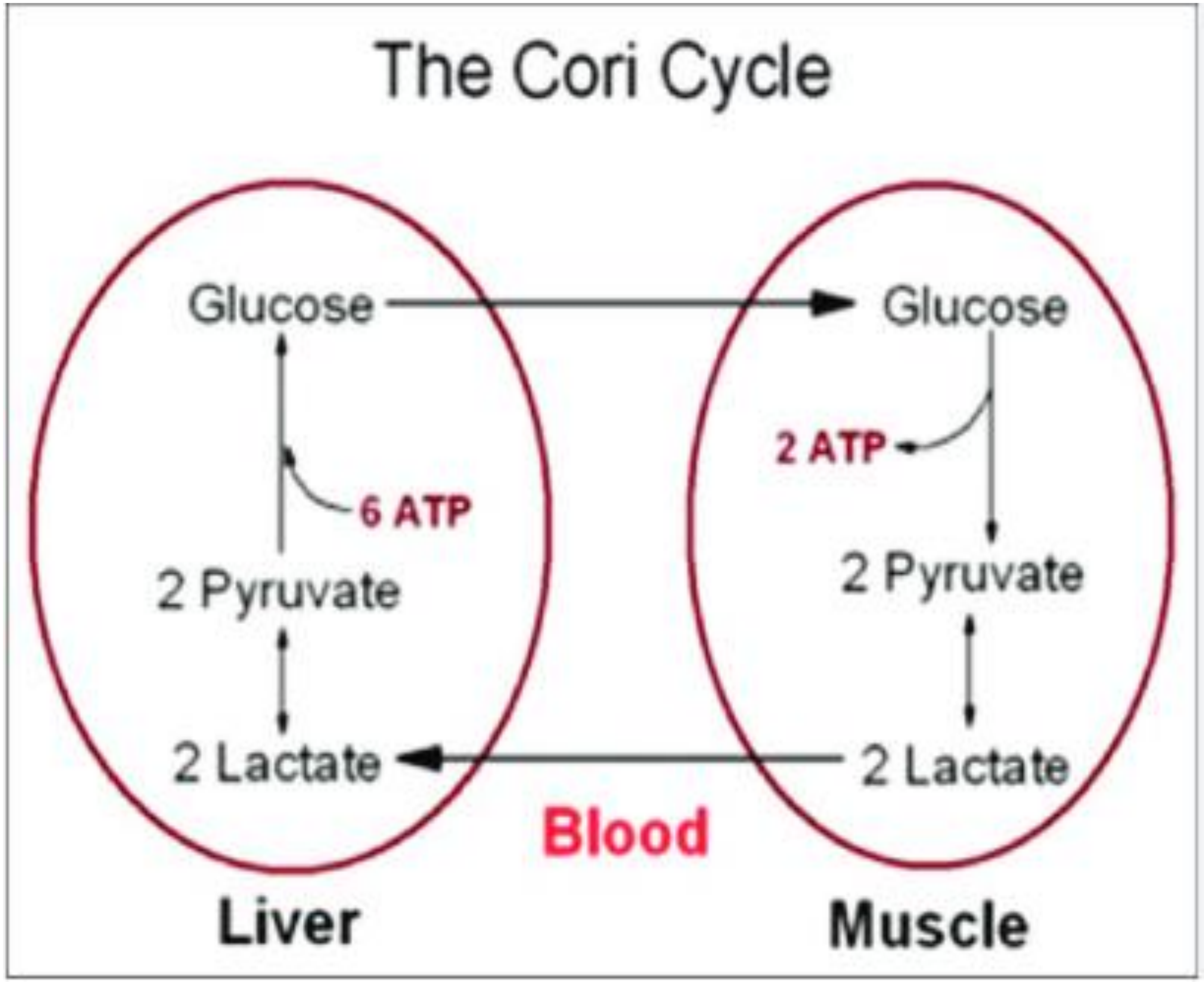
Gluconeogenesis



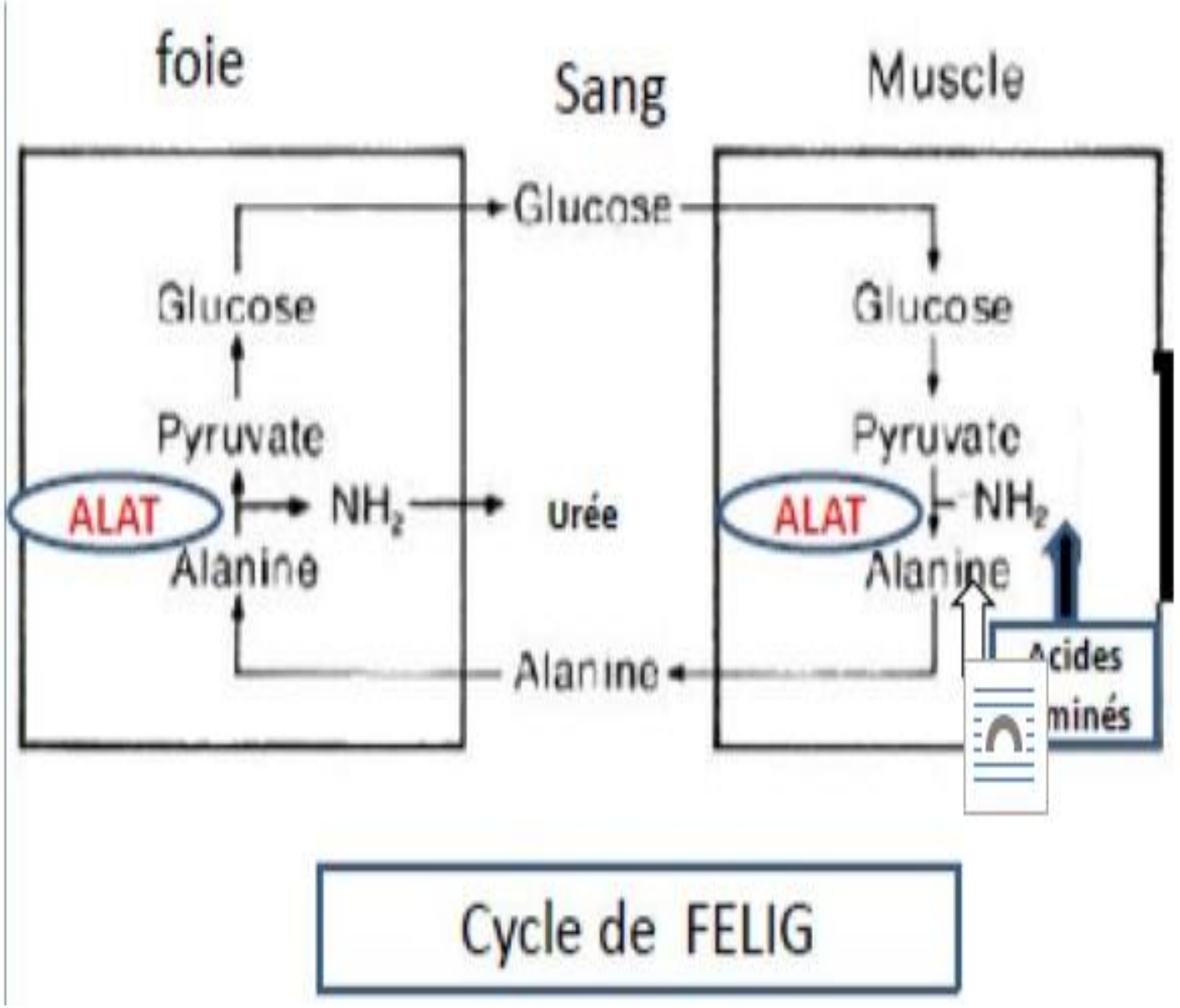

Formation du phosphoénolpyruvate
CH3 — C — COOH
O
Pyruvate
Transport du pyruvate du cytoplasme vers mitochondrie
ATP
CO2
Biotine
1
Pyruvate Carboxylase (PC)
ADP + Pi
HOOC — CH2 — C — COOH
O
Oxaloacétate
L'OAA ne peut traverser membrane mitochondriale
NADH,H+
2
Malate DésHydrogénase (MDH)
utilisation des isoenzymes mitochondriales et cytoplasmiques de la MDH
NAD+
HOOC — CH2 — CH — COOH
OH
Malate
3
Navette malate
CH2 = C — COOH
O
P
Phospho-énol-pyruvate
GDP
CO2
5
PEP CarboxyKinase (PEPCK)
GTP
HOOC — CH2 — C — COOH
O
Oxaloacétate
NADH,H+
4
Malate DésHydrogénase (MDH)
NAD+
HOOC — CH2 — CH — COOH
OH
Malate

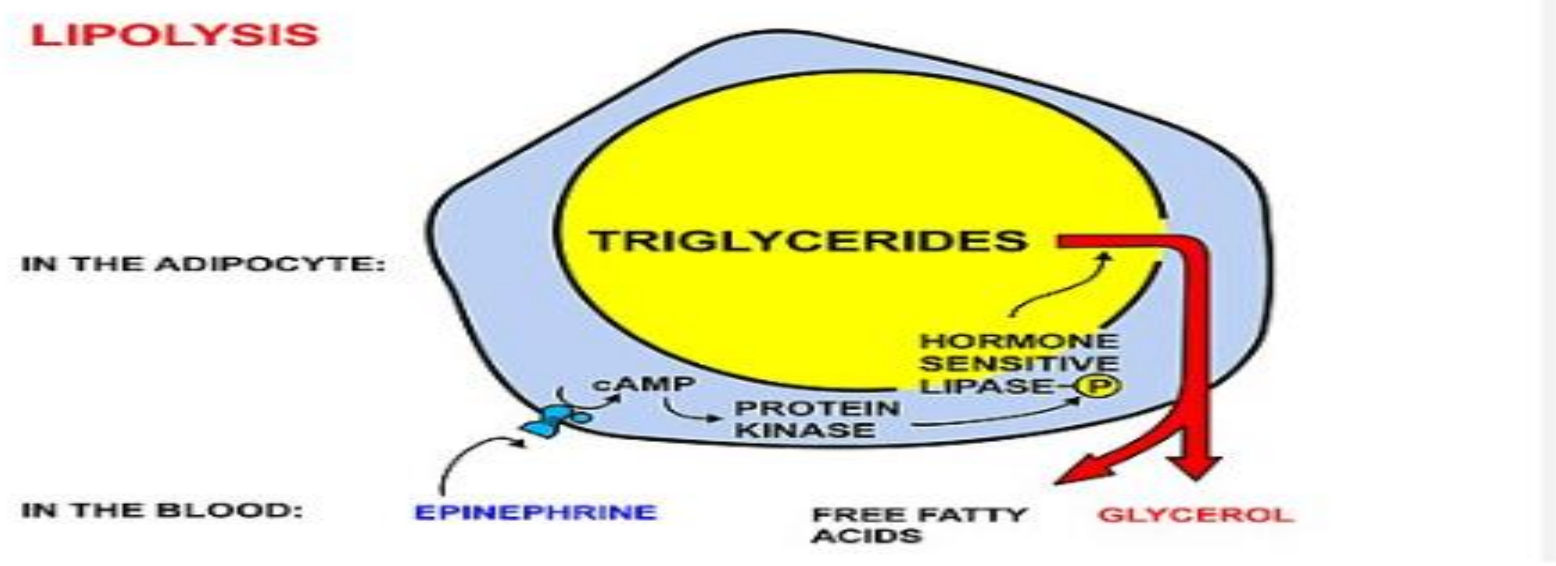


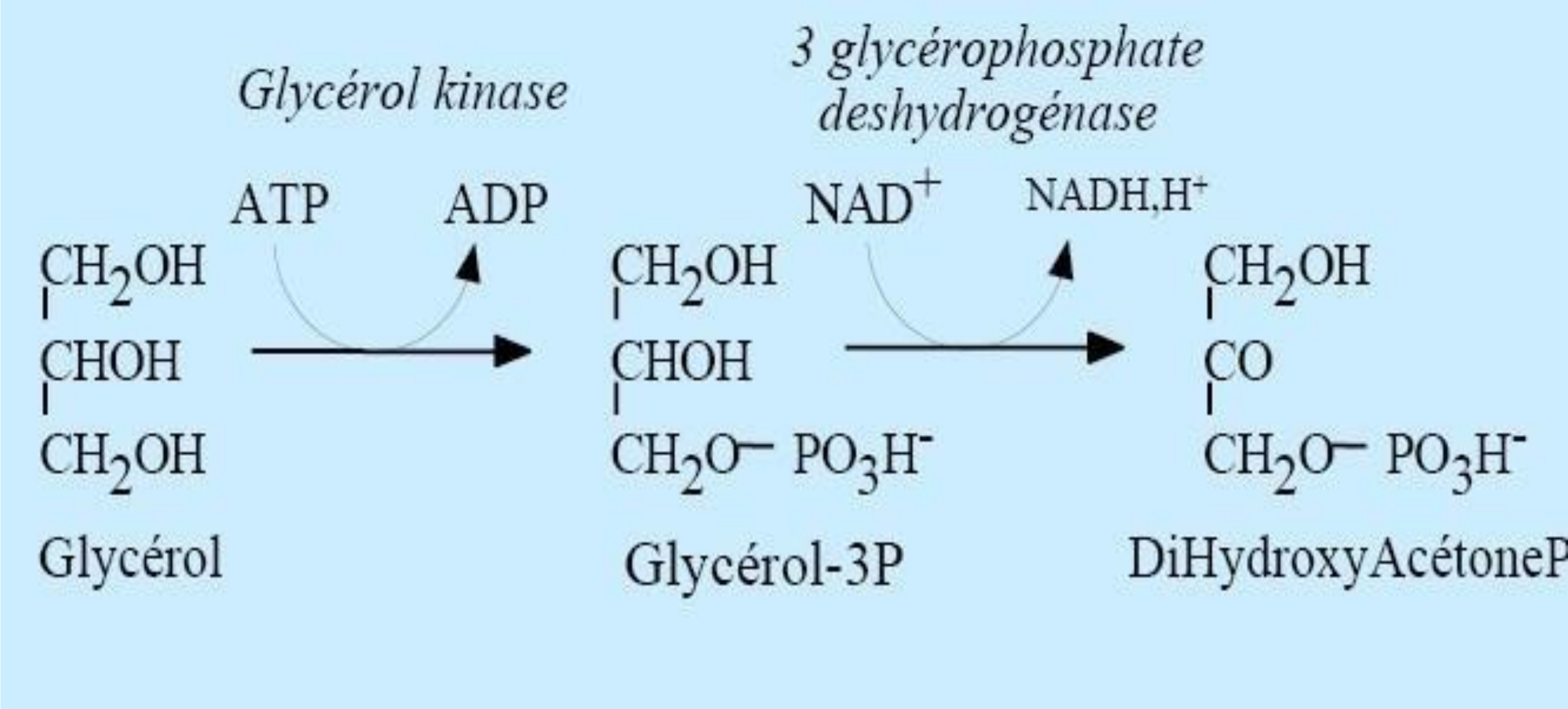
The Cori cycle is a crucial metabolic pathway that allows for the recycling of lactate produced in muscles and red blood cells, converting it back into glucose in the liver.
This process is particularly important during intense exercise or when the oxygen supply is insufficient (anaerobic metabolism).



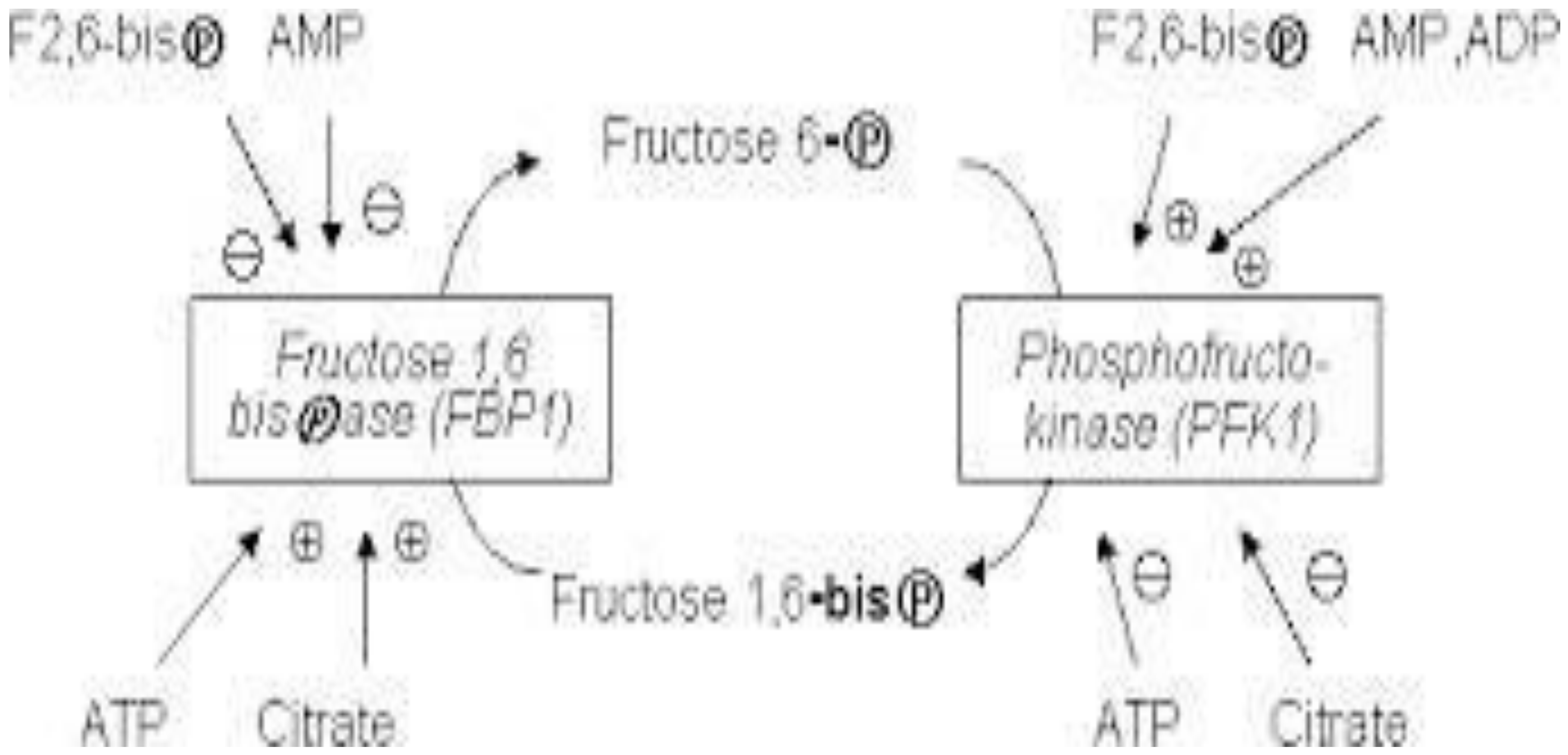
The Felig cycle, also known as the glucose-alanine cycle, is a metabolic pathway that ensures the transfer of nitrogen and carbon between skeletal muscles (and other peripheral tissues) and the liver, primarily during fasting or prolonged exercise.



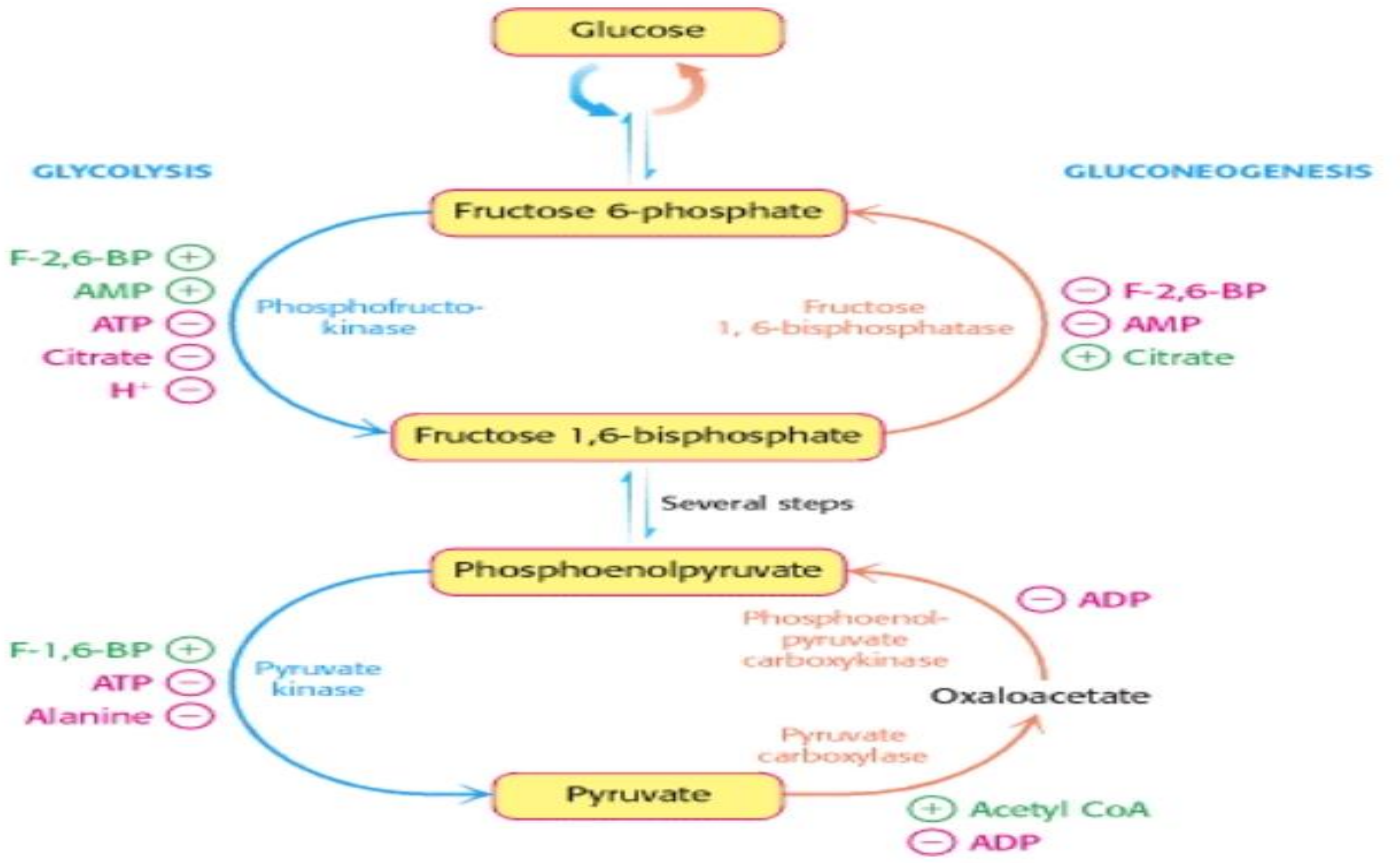

LIPOLYSIS
IN THE ADIPOCYTE:
TRIGLYCERIDES
HORMONE SENSITIVE LIPASE-P
cAMP
PROTEIN KINASE
IN THE BLOOD:
EPINEPHRINE
FREE FATTY ACIDS
GLYCEROL

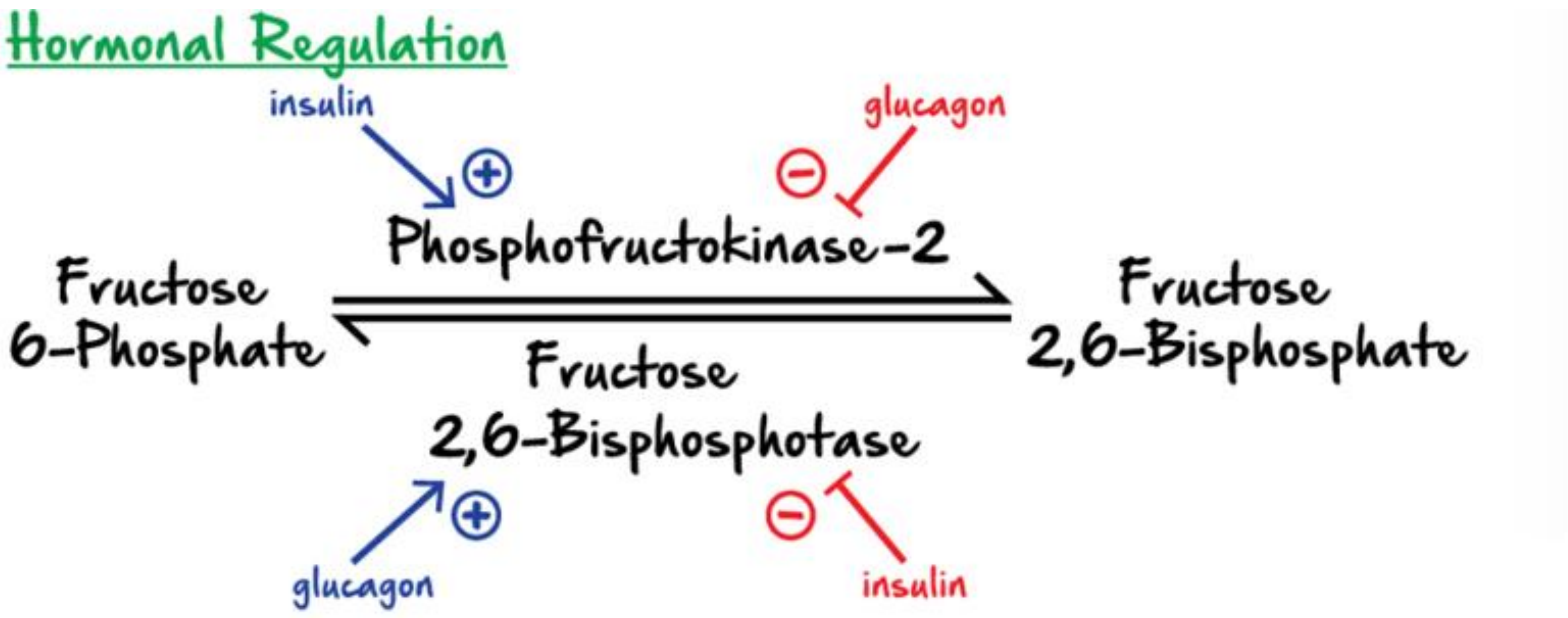

Glycérol kinase
3 glycérophosphate deshydrogénase
ATP
ADP
NAD+
NADH,H+
CH2OH
CHOH
CH2OH
Glycérol
CH2OH
CHOH
CH2O– PO3H-
Glycérol-3P
CH2OH
CO
CH2O– PO3H-
DiHydroxyAcétoneP

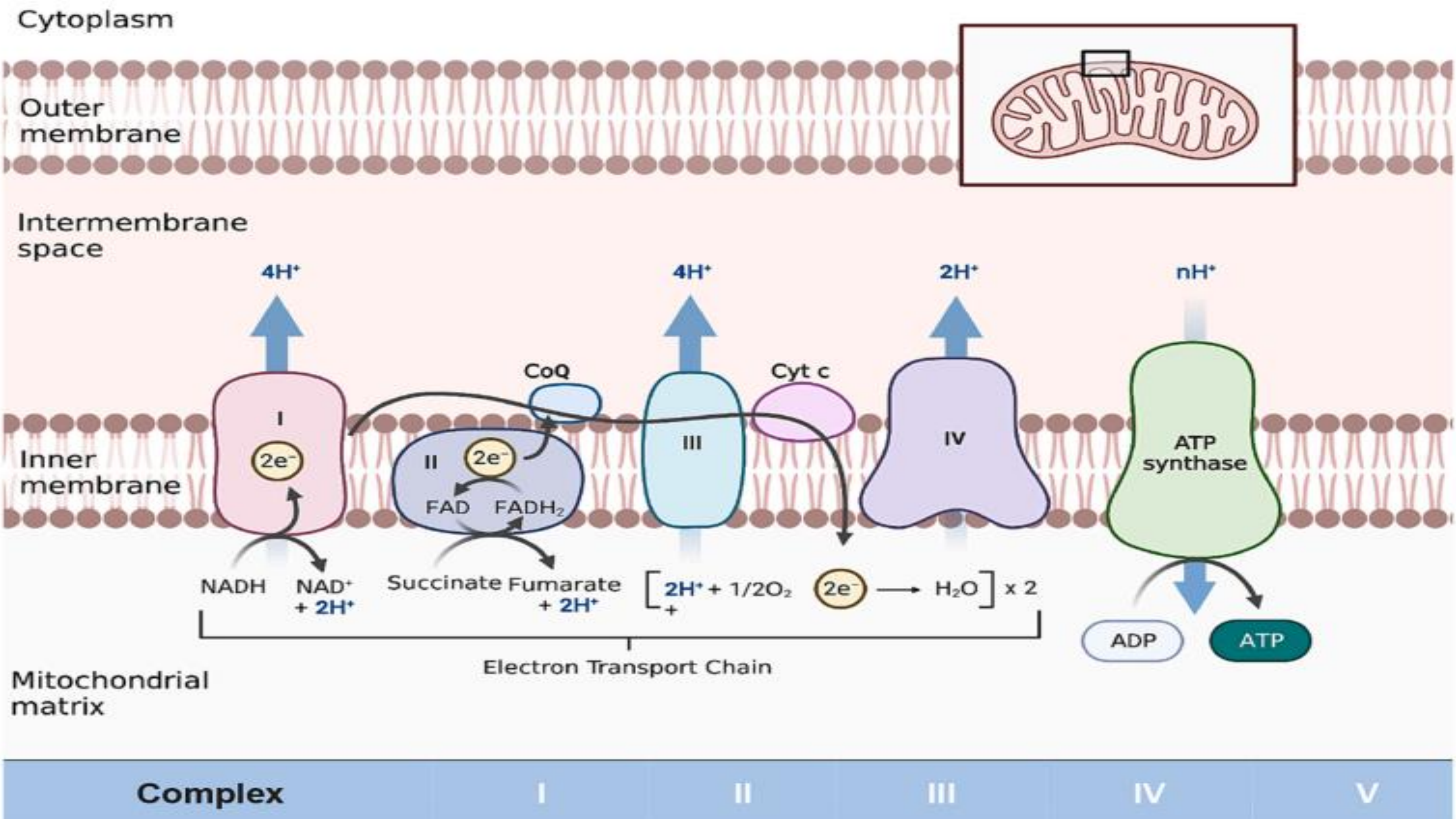
Allosteric regulation of Gluconeogenesis



Allosteric regulation of gluconeogenesis




Hormonal Regulation
insulin
glucagon
Phosphofructokinase-2
Fructose 6-Phosphate
Fructose 2,6-Bisphosphate
Fructose 2,6-Bisphosphotase
glucagon
insulin


Cytoplasm
Outer membrane
Intermembrane space
$4H^+$
$4H^+$
$2H^+$
nH^+
CoQ
Cyt c
I
$2e^-$
II
$2e^-$
FAD
$FADH_2$
III
IV
ATP synthase
Inner membrane
NADH
NAD^+ + $2H^+$
Succinate
Fumarate + $2H^+$
[$2H^+$ + $1/2O_2$ + $2e^-$ → H_2O] x 2
ADP
ATP
Electron Transport Chain
Mitochondrial matrix
Complex
I
II
III
IV
V