BOUT 233 (Sem. 03)
Plant Physiology
Respiration (Credit III)
(M.Sc II)

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❖ RESPIRATION DEFINITION:

- Respiration is a define as an intracellular organic process of oxidation in which complex organic substances are broken down in step wise manner with release of energy which is immediately converted into metabolically usable form of energy that is ATP

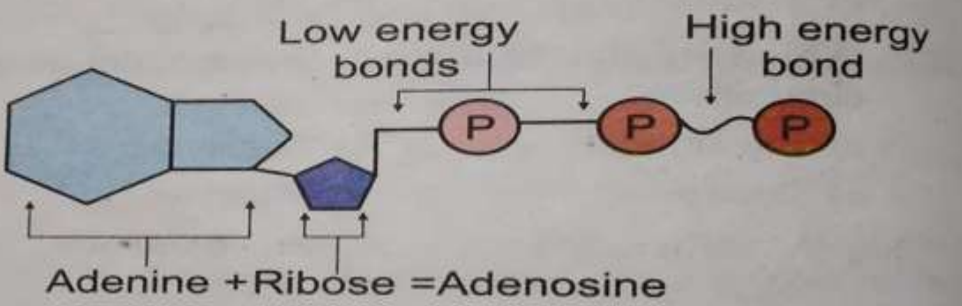
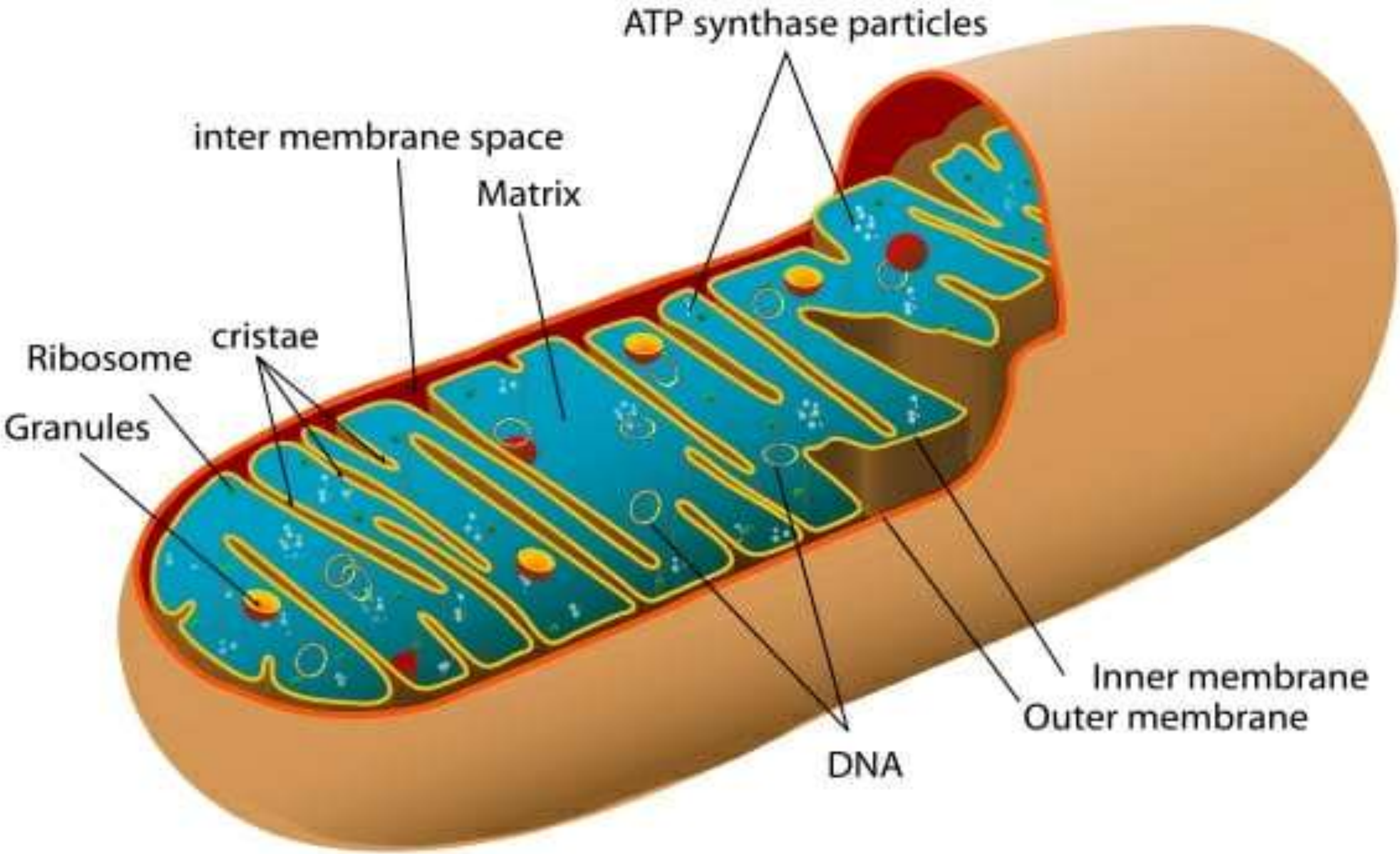


Fig. 7.1 Structure of ATP

❖ TYPES OF RESPIRATION:

1. Aerobic Respiration
2. Anaerobic Respiration

ULTRASTRUCTURE OF MITOCHONDRIA



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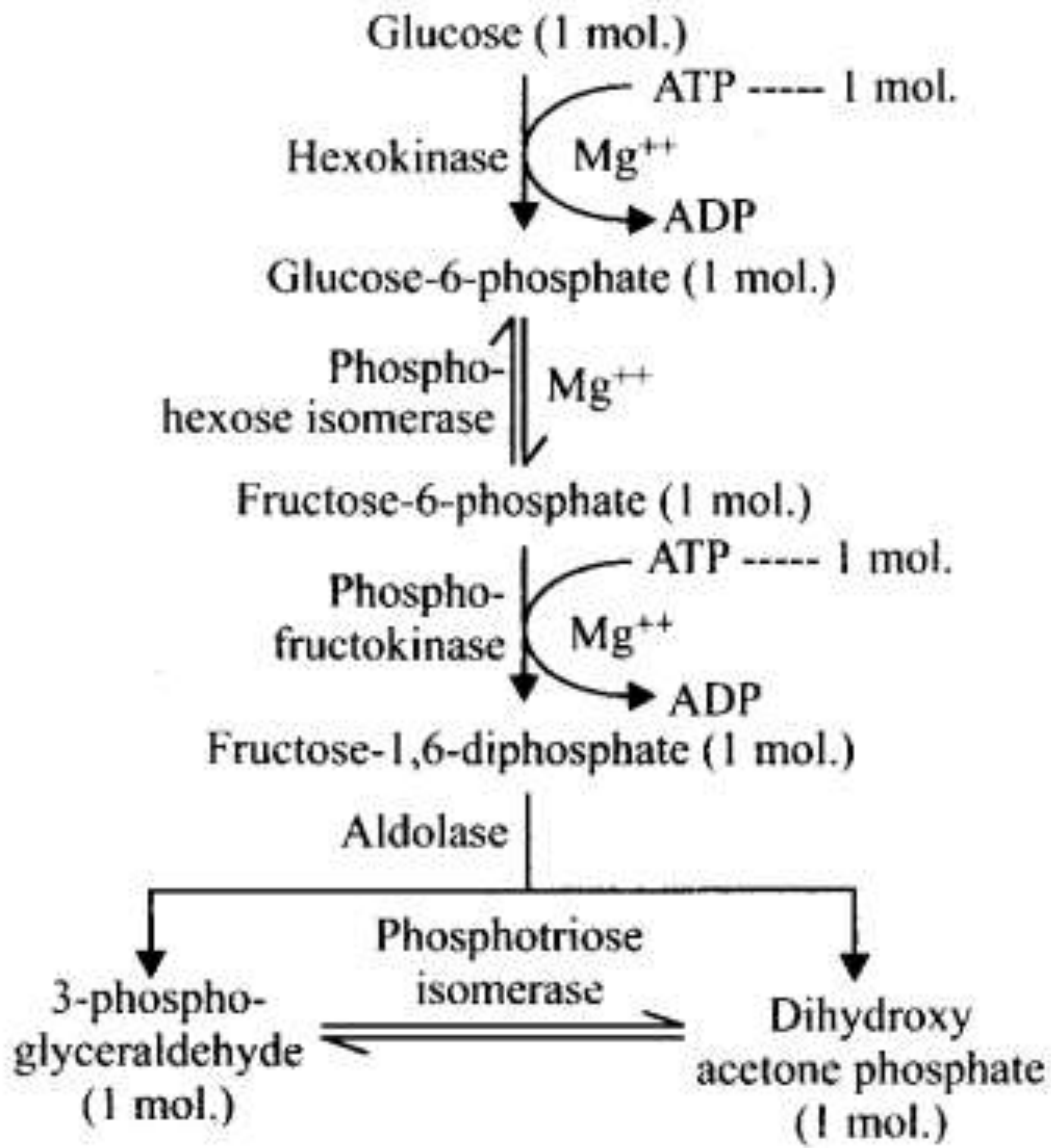
Schematic Representation of Glycolysis or Embden, Meyerhof & Parnas Pathway



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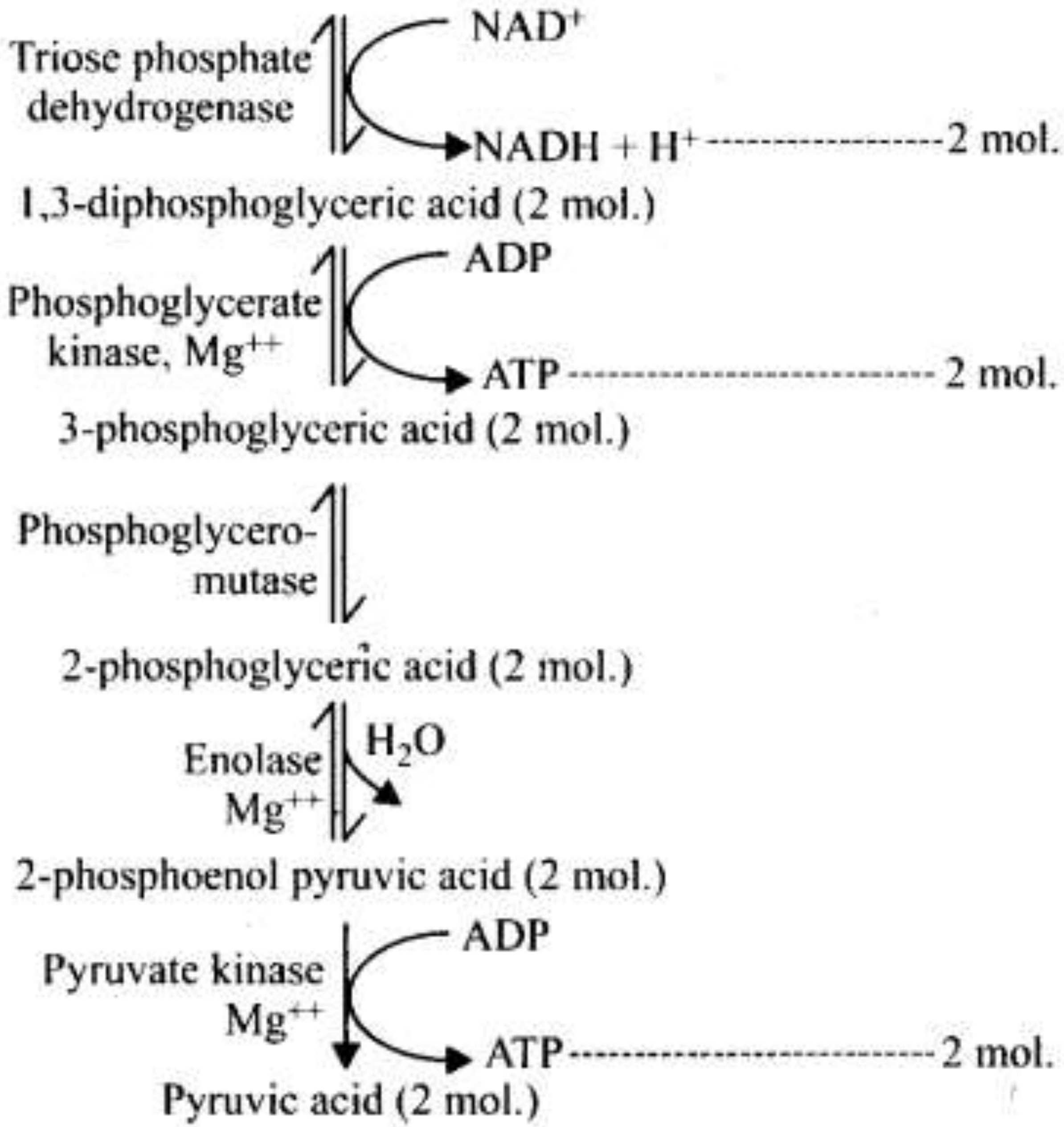
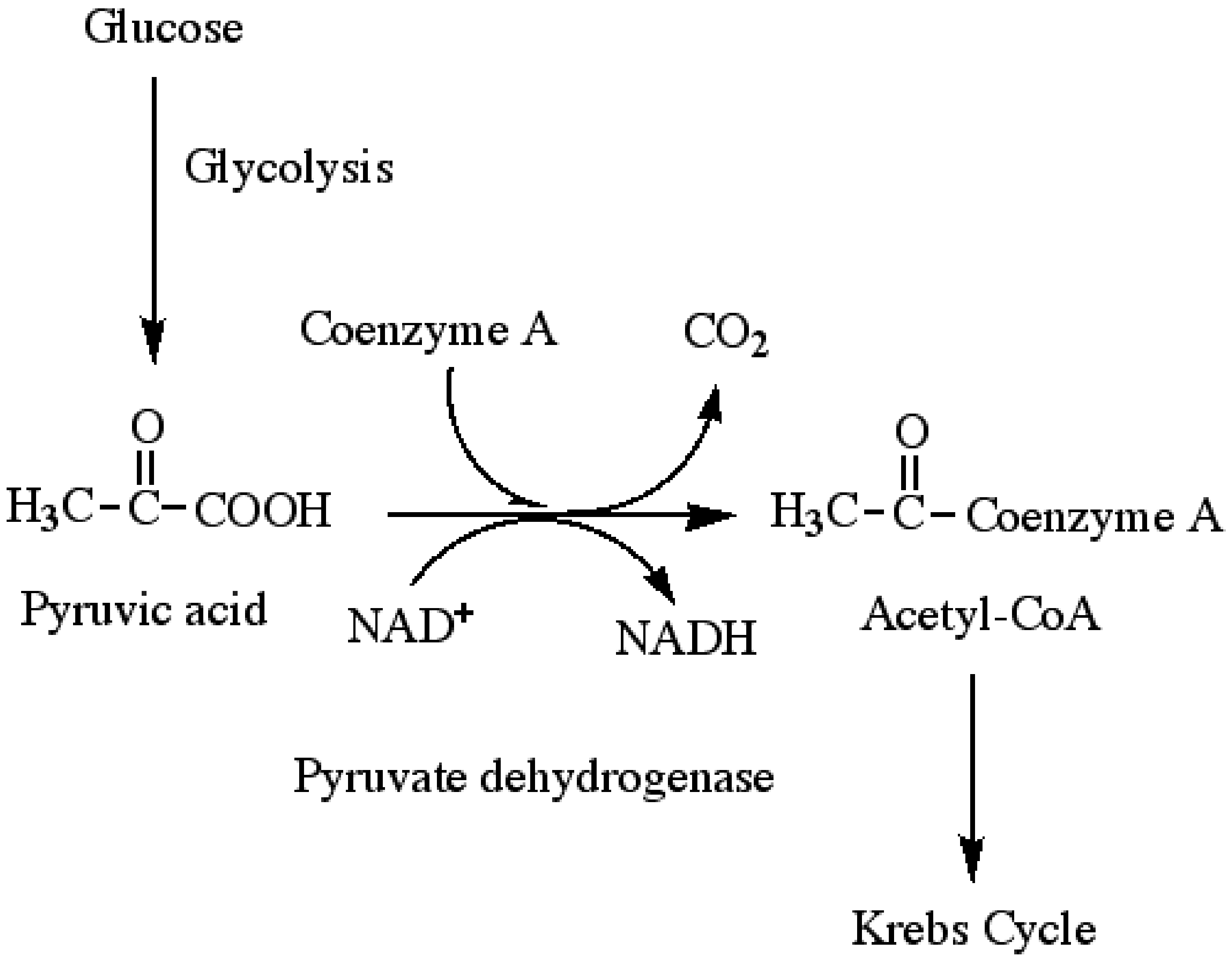
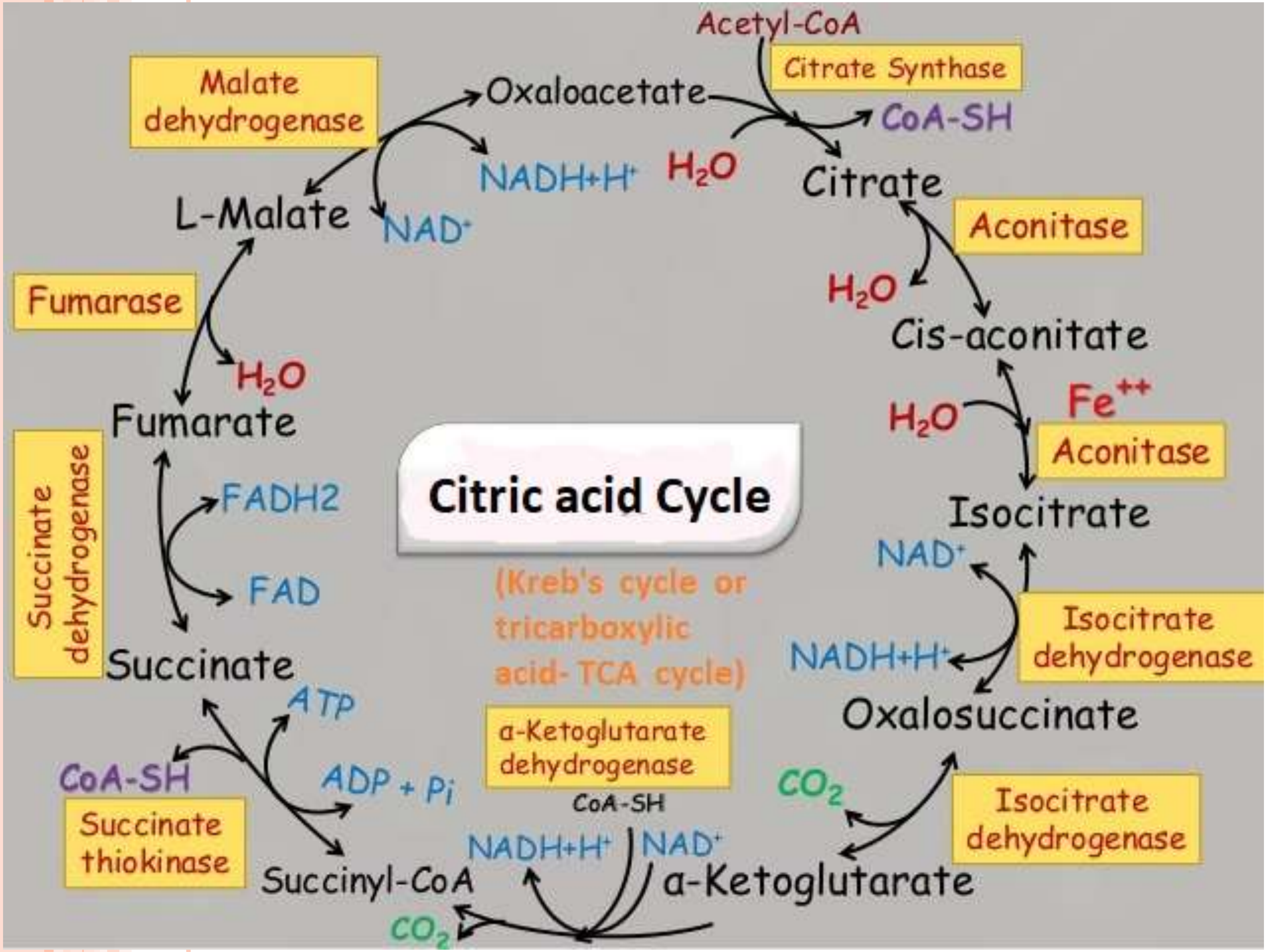


Fig.: Glycolysis or EMP-pathway.

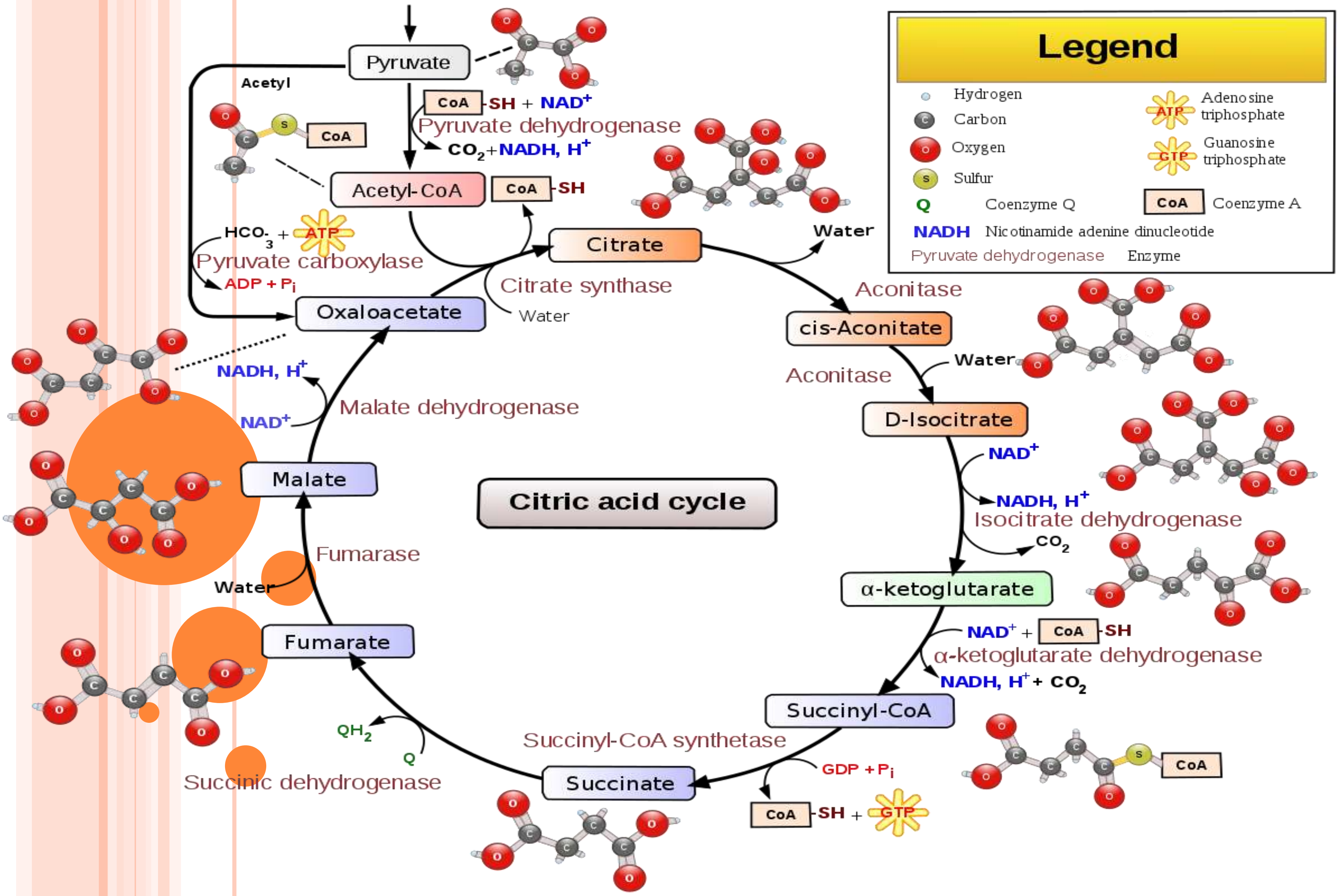
Schematic Representation of Link Reaction or Acetylation of Pyruvate



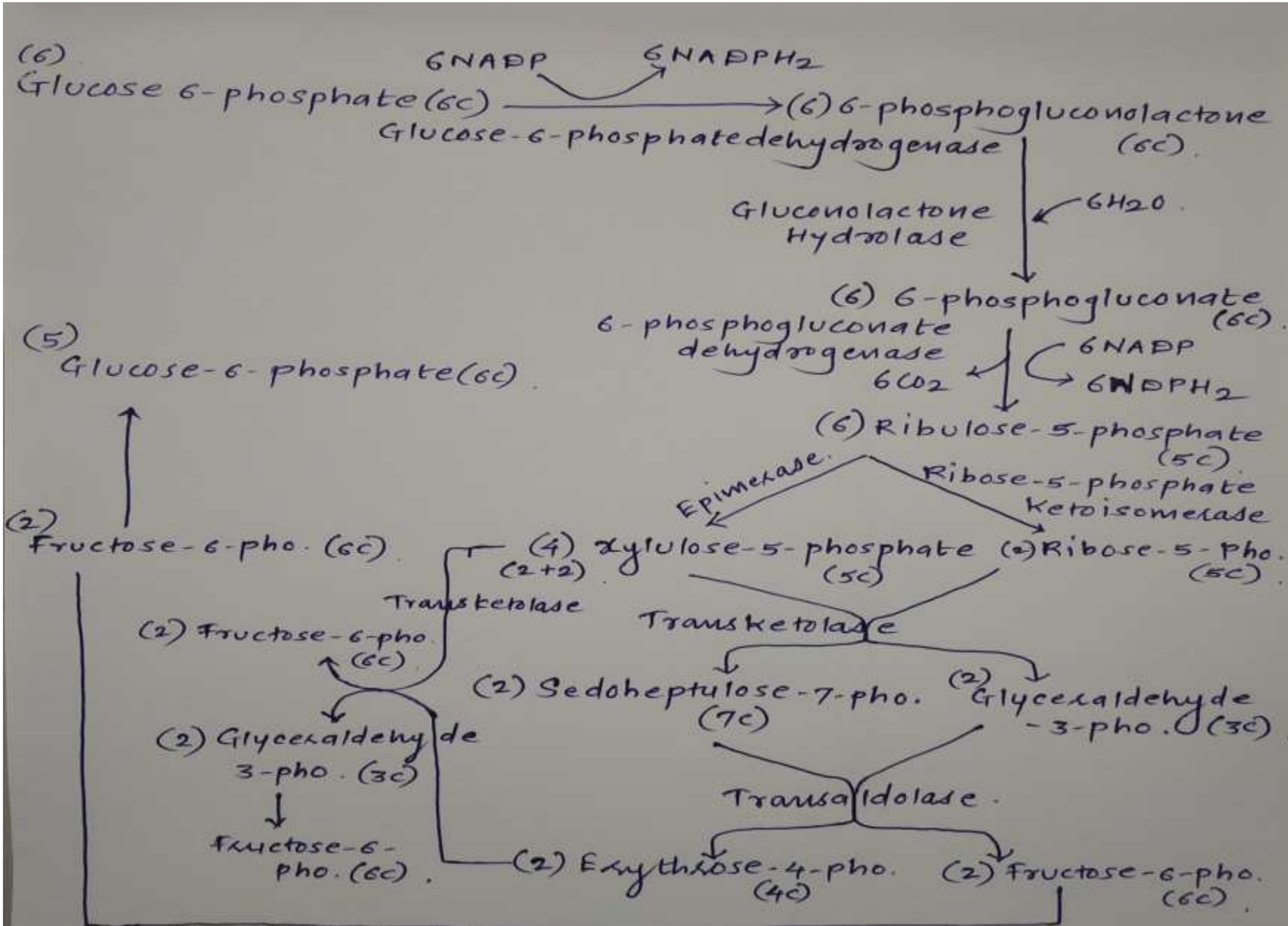
Schematic Representation of Krebs Cycle or TCA Cycle



Schematic Representation of Krebs Cycle or TCA Cycle



SCHEMATIC REPRESENTATION OF PENTOSE PHOSPHATE PATHWAY OR HMP SHUNT



OVERALL REACTION OF PPP

$$6\text{-Glucose-6-phosphate} + 12\,NADP + 6H_2O \longrightarrow 6CO_2 + 12\,NADPH_2 + 5\text{ Glucose-6-phosphate.}$$

Energy release during Respiration or Balance sheet of Respiration

Stages	ATP produce by substrate phospho-rylation	Formation of NADH / FADH	ATP produce through ETS in Mito-chondria
Glycolysis in cytoplasm	2	2NADH (one NADH on oxidation) through ETS form 3 or 2 ATP depending upon shuttle system	$2 \times 3 = 6$
Formation of Acetyl ~ CoA in matrix of mitochondria	–	2 NADH	$2 \times 3 = 6$
Krebs cycle	2	2 $FADH_2$ 6 NADH	$2 \times 2 = 4$ $6 \times 3 = 18$
	4		34 (or 32)
Total net gain of ATP = 36 or 38 depending upon type of aerobic respiration.			

Energy release during Respiration or Balance sheet of Respiration

ATP ACCOUNT / Balance Sheet (At a glance)

ATP account	Direct synthesis	In ETS: From $[NADH + H^+]$*	In ETS: From $FADH_2$ **	ATP consumed	Net gain
From glycolysis	**4**	**6** From 2 × $[NADH + H^+]$	Nil	**2**	**8**
From acetylation of pyruvic acid	Nil	**6** (From 2 pyruvic acid)	Nil	Nil	**6**
From Krebs' cycle (from 2 cycles)	**2**	**18** From 6 × $[NADH + H^+]$ (3 in each cycle)	**4** From 2 × $[FADH_2]$	Nil	**24**
Total gain	**6**	**30**	**4**	-2	**38**

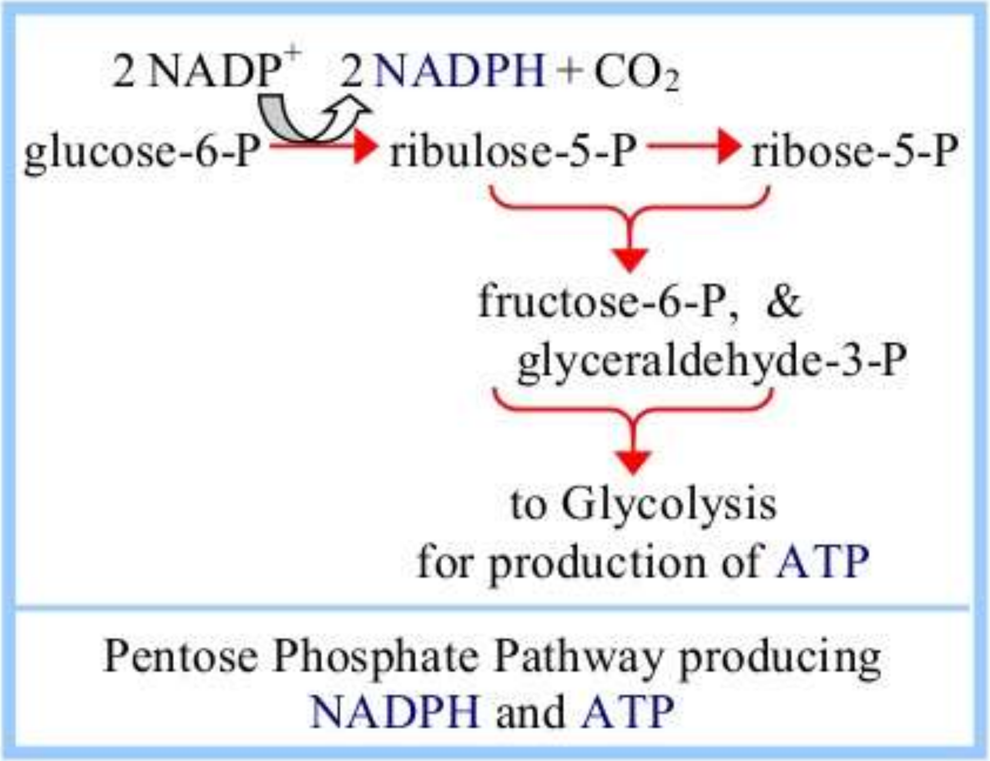
* One $[NADH + H^+]$ can give 3 ATPs (when enters the ETS)

** One $FNDH_2$ can give only 2 ATP (when enters the ETS)

In this calculation, two turns of Krebs' cycle have been considered. This is because, one glucose produces two pyruvic acid and two acetyl CoA. Hence two cycles occur for each glucose molecule.

Mitochondria which are produced outside of mitochondria (i.e., in cytoplasm) can give only 2 ATPs under physiological conditions. So, final net gain per glucose is only **36 ATPs.**

ENERGY RELEASE DURING PENTOSE PHOSPHATE PATHWAY



Glyceraldehyde-3-P and fructose-6-P, formed from 5-C sugar phosphates, may enter **Glycolysis** for **ATP** synthesis.

The pathway also produces some **NADPH**.

Significance of Respiration

- Energy: Respiration provides energy for biosynthesis of biomolecules like Carbohydrates, Fats, Lipids, Vitamins, Pigments etc also source of energy for cell division, growth, repairs, movement & locomotion.

- Balance of O2 & CO2: Coupled with photosynthesis to maintain balance between oxygen & carbon dioxide

- Intermediate of Krebs cycle are used as building blocks for synthesis of other complex compounds

- Anaerobic respiration (fermentation) is used in various industries such as dairies, bakeries, leather industries, bakeries, distilleries, leather industries, paper industries etc. It is used in commercial production of alcohol, organic acids, vitamins, antibiotics etc.

Significance of Pentose Phosphate Pathway Or HMP Shunt

- PPP is unique pathway generating two important products Pentose's & NADPH needed for the biosynthetic reactions

I. **Important of Pentose's:**

In this pathway Hexoses converted into Pentose's the most important being ribose-5-phosphate. This is useful for synthesis of Nucleic acids (RNA & DNA) & many nucleotides such as ATP, NAD, FAD & Co-A

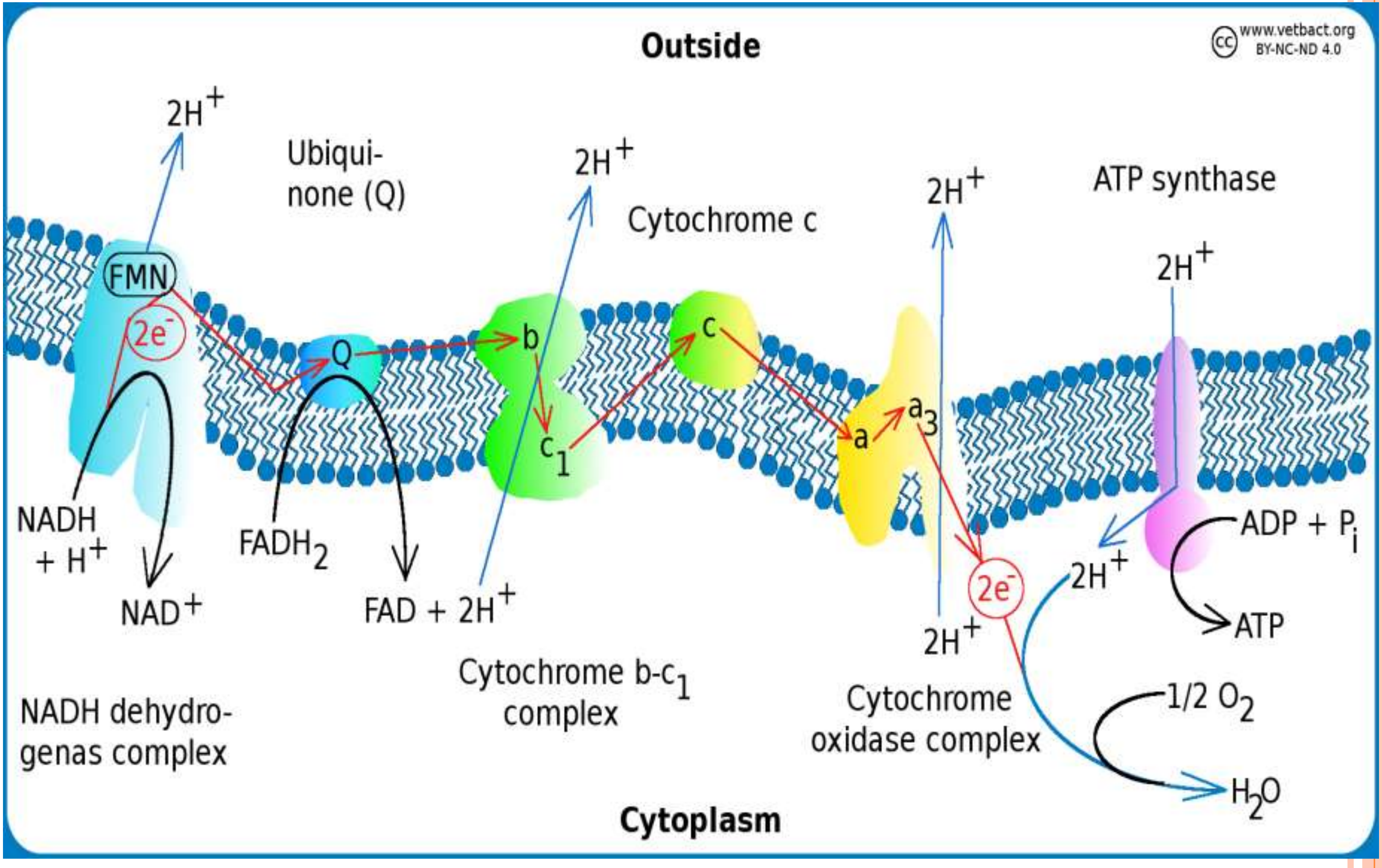
I. **Importance of NADPH:**

a) NADPH is required for reductive biosynthesis of fatty acids & steroids. Hence HMP shunt it is most active in the tissues concerned with lipogenesis eg. Adipose tissue, liver

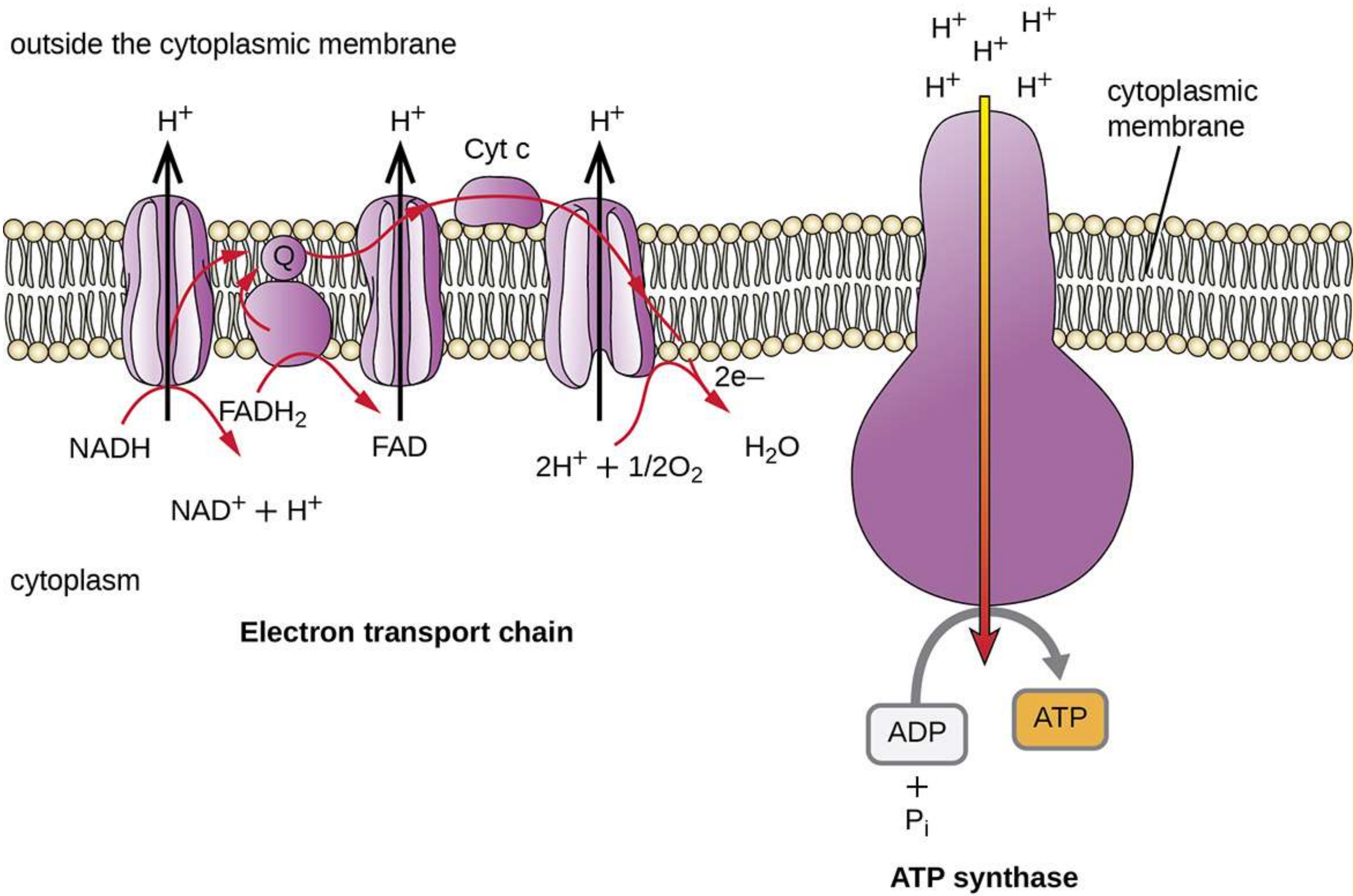
b) NADPH is used in the synthesis of certain amino acids involving the enzyme glutamate dehydrogenase

c) There is continuous production of H2O2 in the living cells which can chemically damaged unsaturated lipids, proteins & DNA. This is however prevented to a large extent through antioxidant reactions involving NADPH. Glutathione mediated reduction of H2O2. Glutathione peroxidase (Reduced) detoxifies H2O2. NADPH is responsible for the regeneration of reduced glutathione from oxidized one

Composition of Electron Transport System



Electron Transport System



ETS Inhibitors

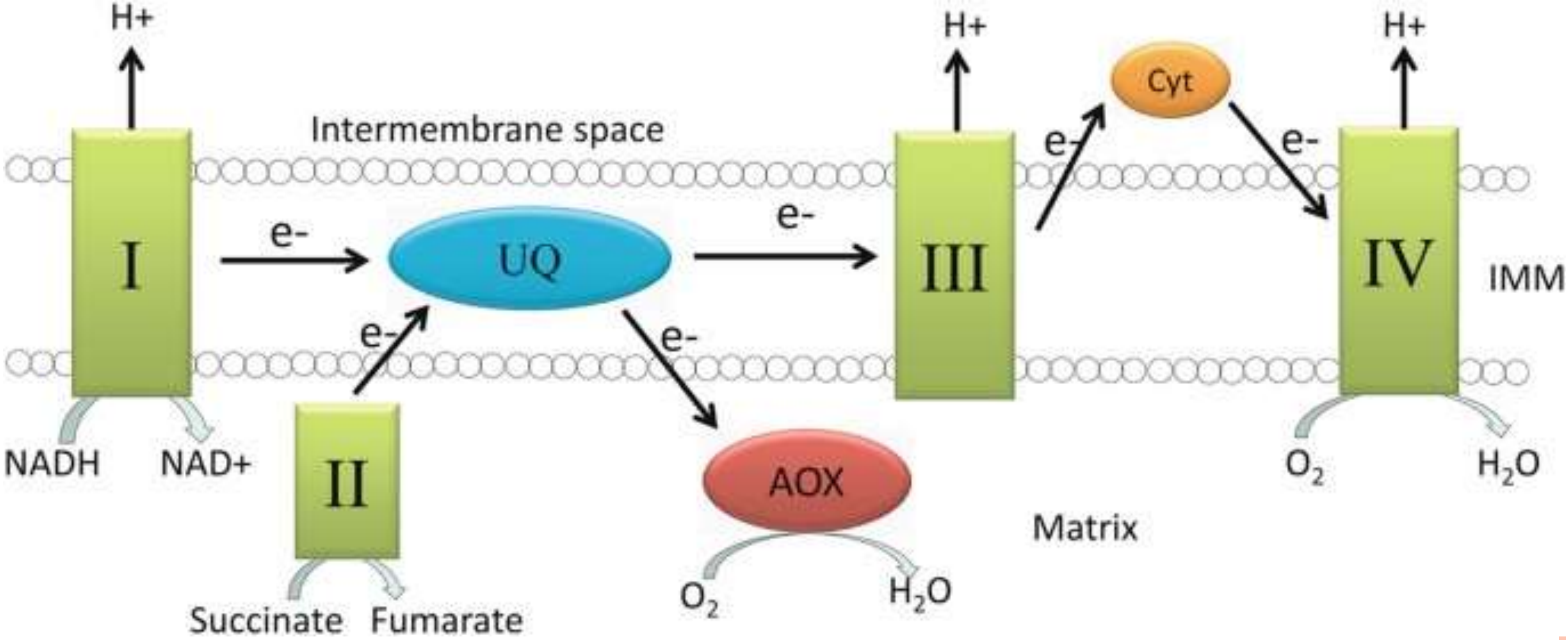
- **NADH Dehydrogenase complex**: Rotenon, Amytal, Peircidin
- **FADH Dehydrogenase complex**: Malonate
- **Cytochrome b-c1 complex**: Antimycin
- **Cytochrome a1-a3**: Cynide, Sodium azide, Hydrogen sulphide
- **ATP Synthase**: Oligomycin, Vitroculin

- **Un-Couplers of ETS**: **Uncouplers** of oxidative phosphorylation in mitochondria inhibit the **coupling** between the electron transport and phosphorylation reactions and thus inhibit ATP synthesis without affecting the respiratory chain and ATP synthase (H(+)-ATPase).
- E.g. 2-4 Dinitrophenol, Asparin, Valinomycine K+ Carrier protein, Gramicidin, Thyroxine, Bilirulin, Dinitrocresol, Pentachlorophenol, Phynyl hydrazine.

Cynide Resistsnt Pathway

- Genevois, in 1929 discovered Cynide resistsnt pathway
- In plants, in presence of cynide ETS can seen
- Extra protein i.e Alternative oxidase present in plants
- Alternative oxidase protein responsible for Quenching of proton in prsence of Cynide & water is formed
- The proton used by alternative oxidase produce a heat which is responsible for thermogenesis in plants
- Due to thermogenesis some phenolic compounds, terpenes, amines & indoles volataise
- Significance: Odour attract insects for pollination

Cynide Resistsnt Pathway



MECHANISM

- The flow of electrons from reduced coenzymes to Ubiquinone is the same as in usual mitochondrial electron transport chain.
- The electrons pass from UQ to a flavoprotein Fpma and direct to a cyanide resistant alternative oxidase and finally to O_2
- In between UQ and oxygen a free energy released as heat

References

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