OUTLINE

- Plant cell, tissues, organs: basic structure and function
- Transport and translocation of water and solutes
- Photosynthesis and Respiration
- Plant growth and development
- Plant and light response
- Plant hormone and plant tissues culture
- Plant – environment interactions

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VIETNAM FRANCE UNIVERSITY

Bachelor 2: Plant physiology

Lesson 4:

RESPIRATION

Instructor: LE Thi Van Anh

le-thi-van.anh@usth.edu.vn

Learning outcome

By the end of this course, students are able to:

- Give the definition of “cellular respiration”

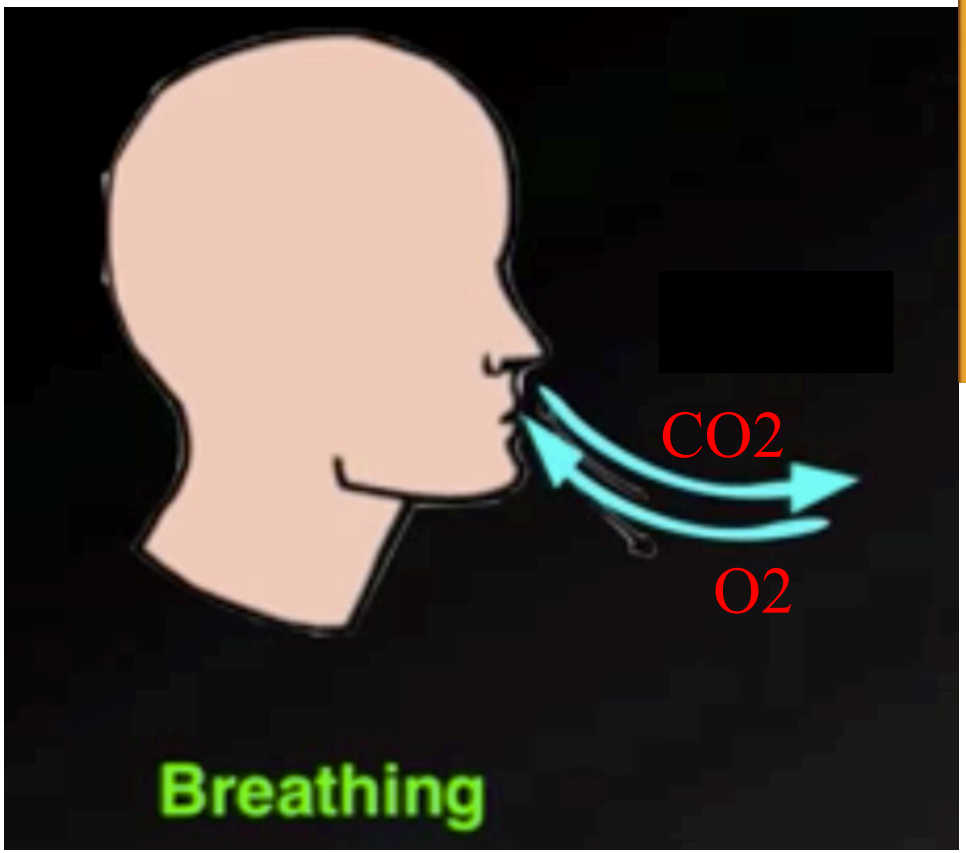
- Analyze mechanism of pathways/stages in cellular respiration: Glycolysis, Krebs cycle, electron transport chain, oxydative pentose phosphate

- Compare energy efficiency between Glycolysis + Krebs and oxydative pentose phosphate pathways

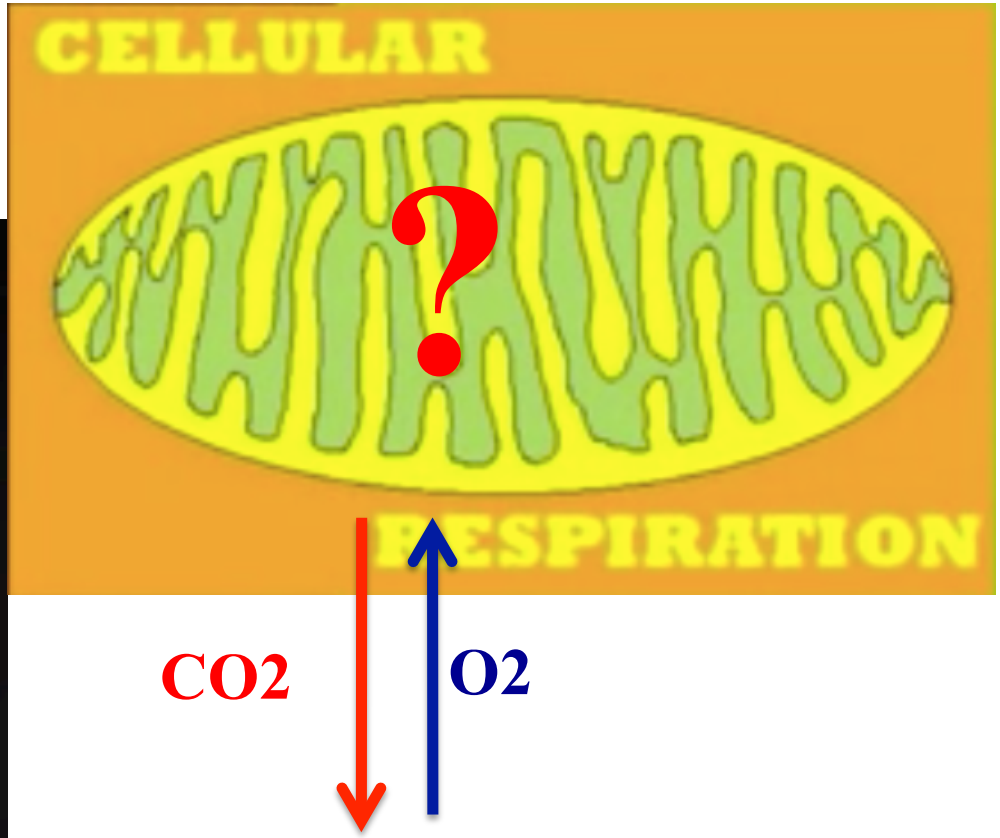
-Analyze relationships between respiration and phototsynthesis

Concept

What is the respiration?



Gas exchange



- Metabolic reactions in cell
- Convert chemical energy from nutrient to ATP

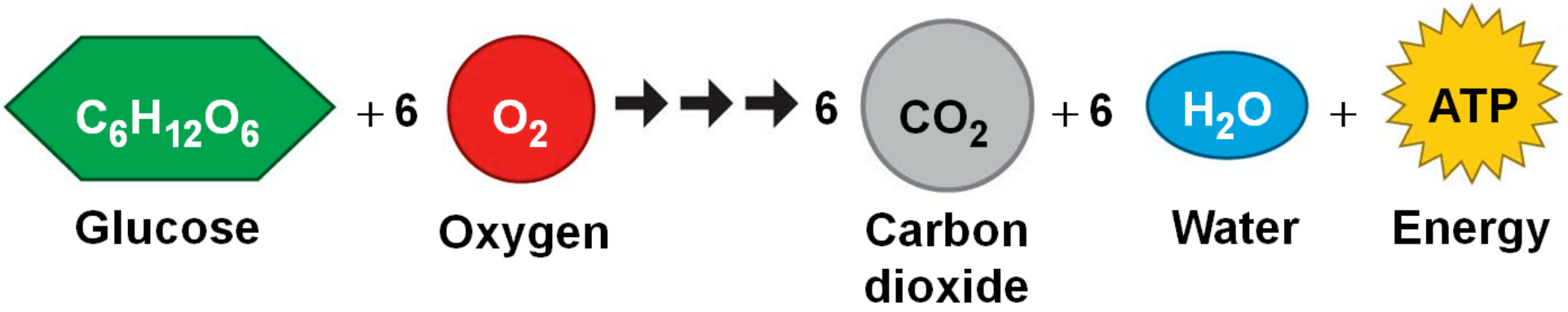
Concept

Which steps?
Where does it occur?
Input and Output?

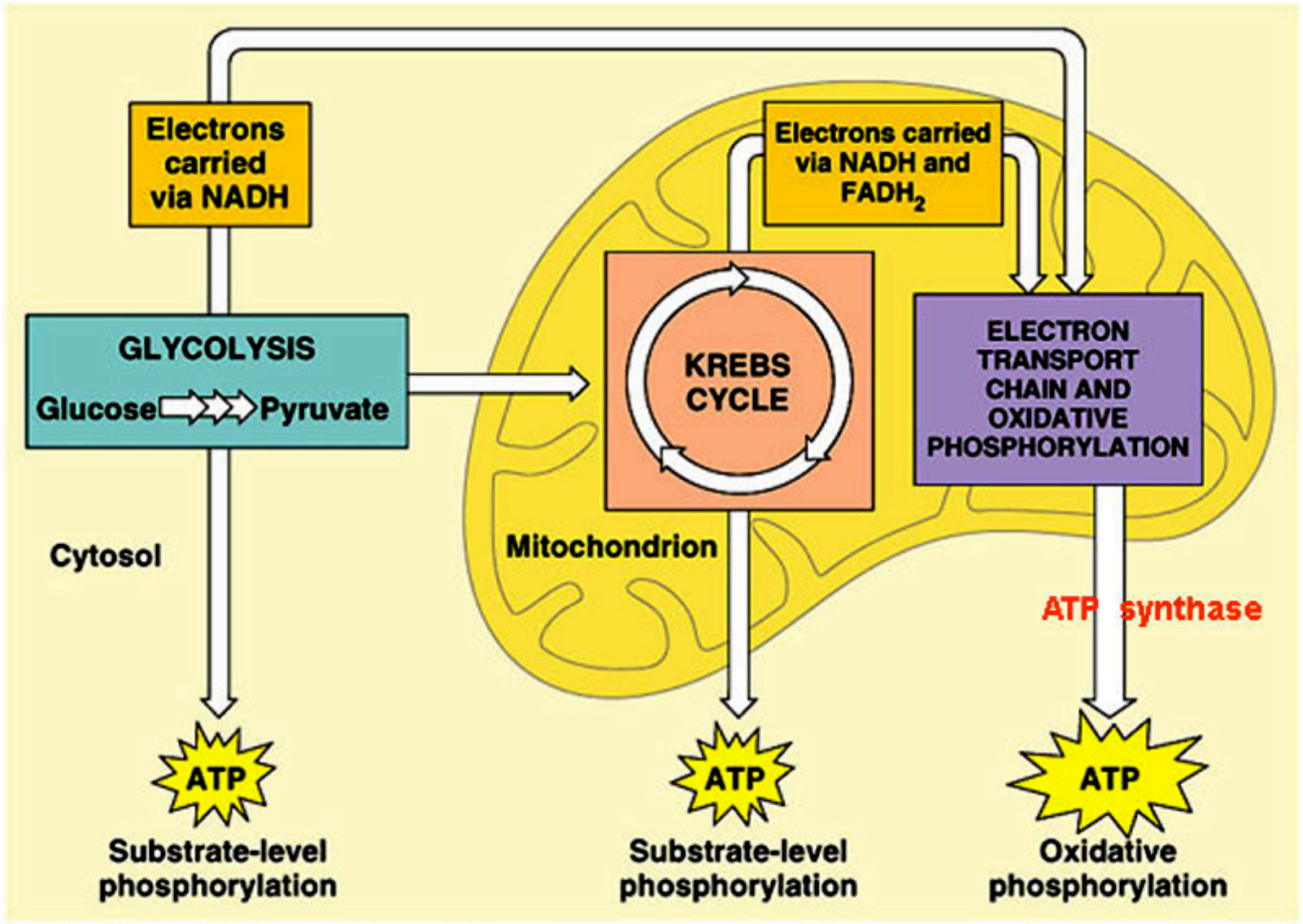
Including 3 steps

- Glycolysis: splitting sugar: cytosol
- Krebs cycle: Matrix of mitochrondia
- Electron transport: membrane of mitochrondia

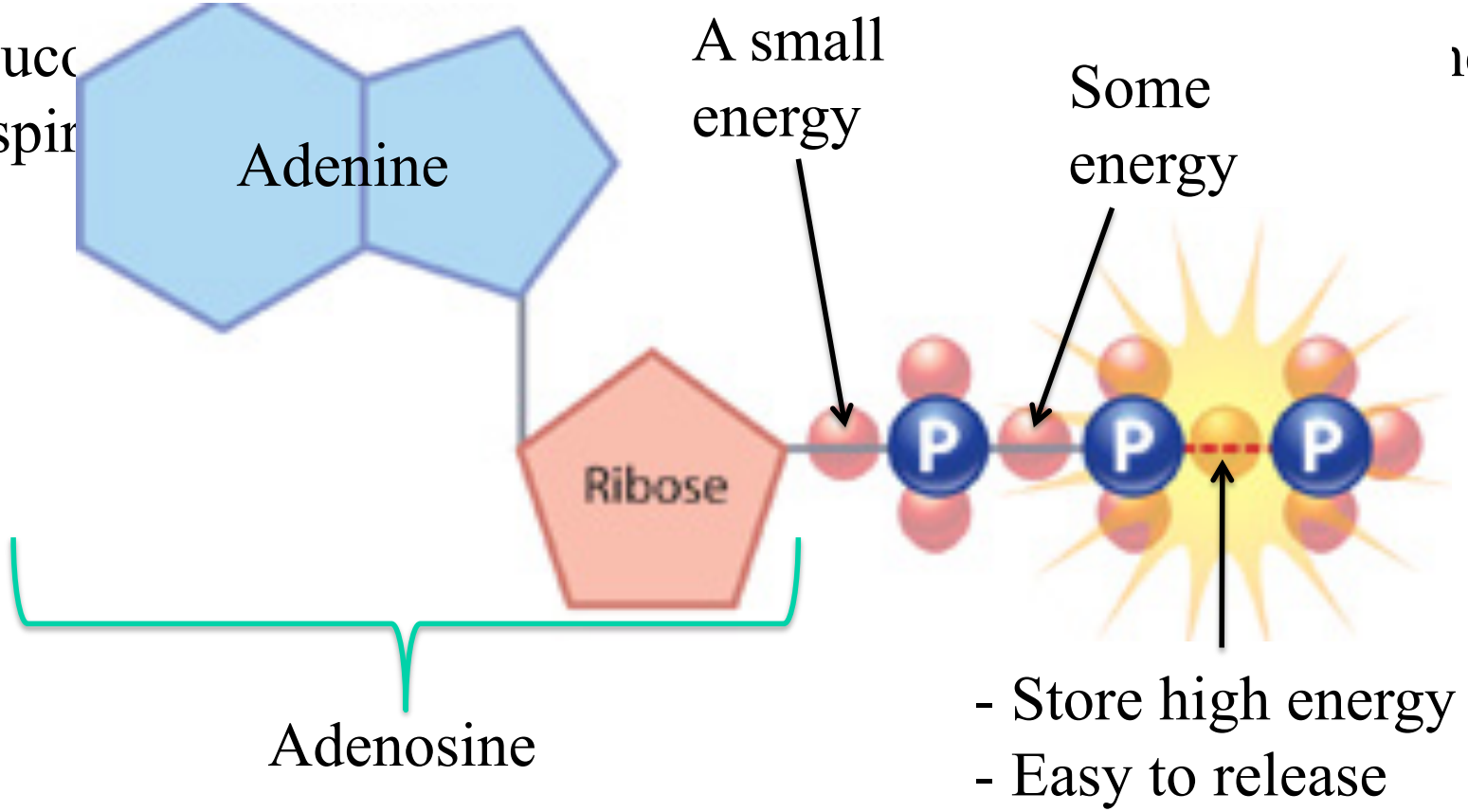
Produce: ATP



3 steps to oxidize totally



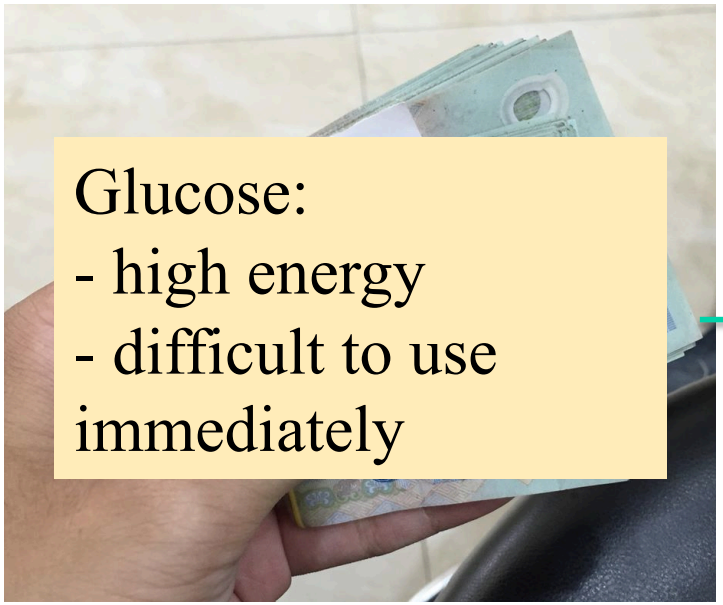
ATP (Adenosine Triphosphate)



ATP is energy storage potential

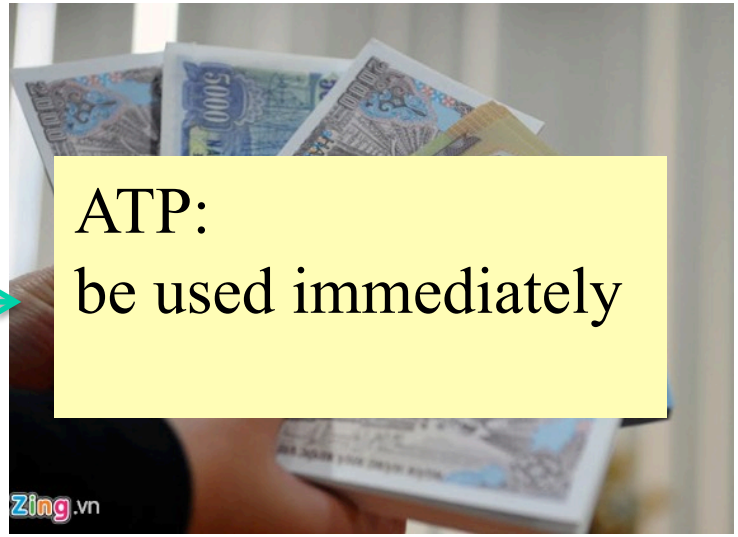
ATP is energy storage potential

I'd like 500g of potato, pls!

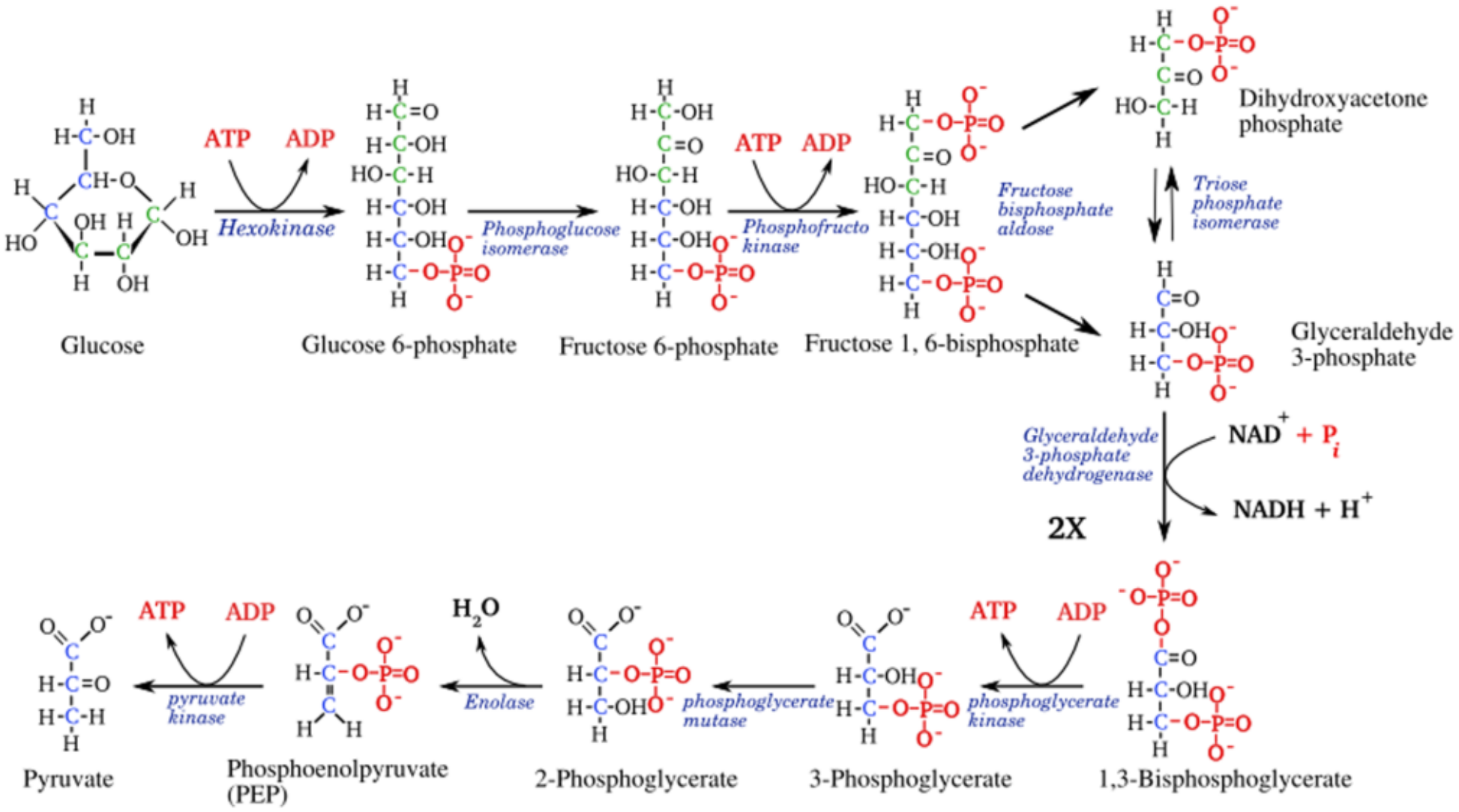


Change money

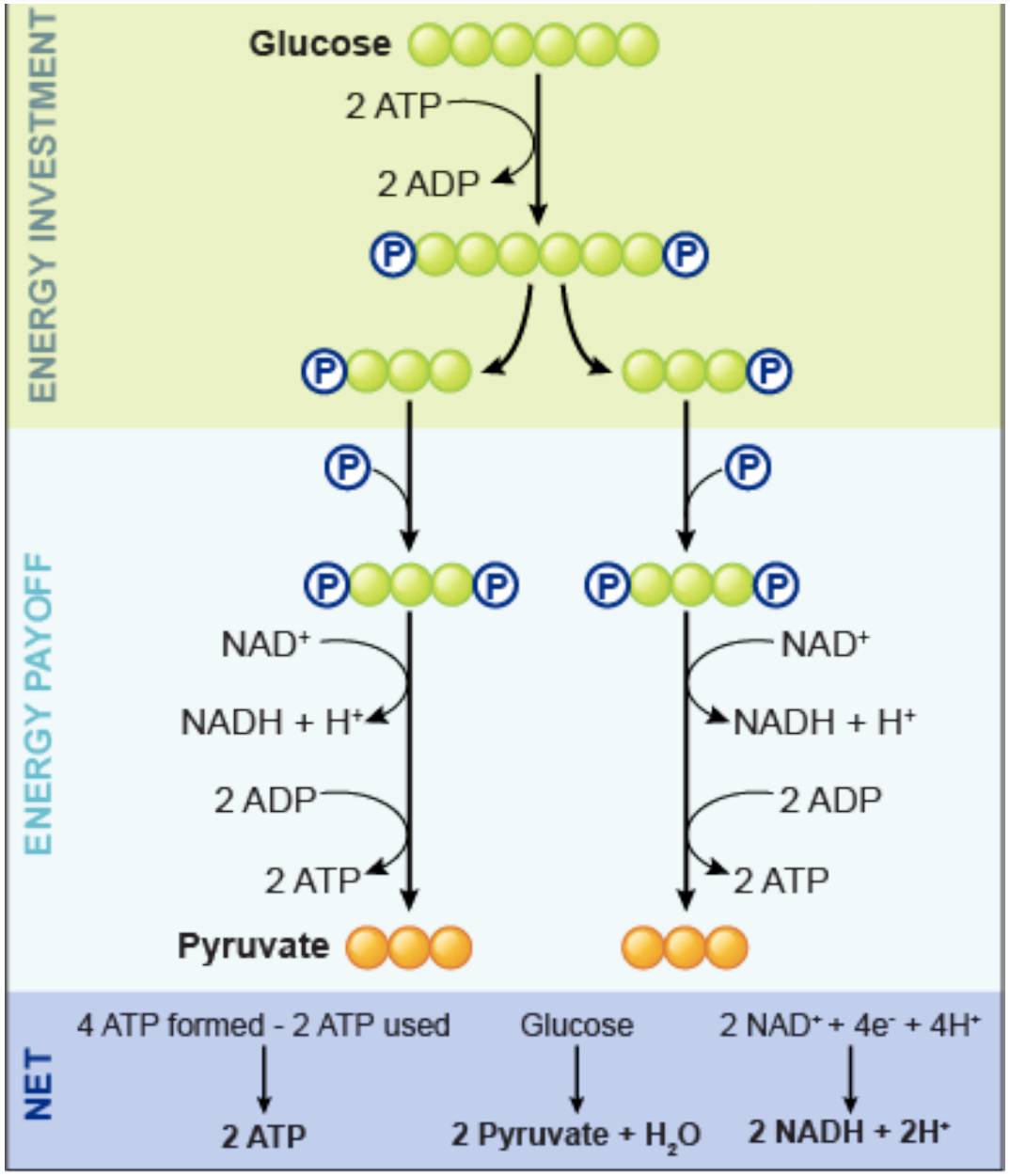
Respiration



Glycolysis

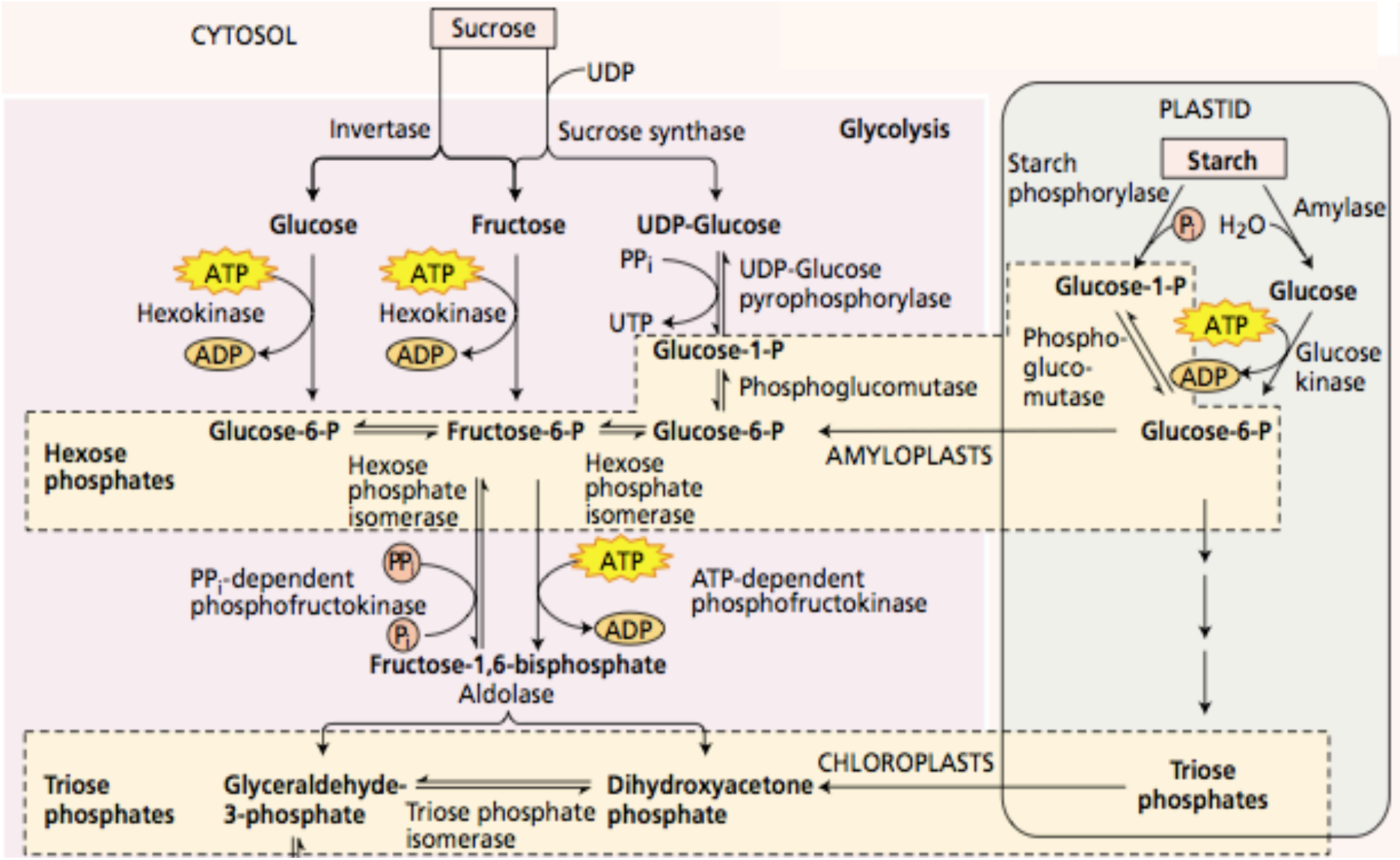

Glucose
ATP
ADP
Hexokinase
Glucose 6-phosphate
Phosphoglucose isomerase
Fructose 6-phosphate
ATP
ADP
Phosphofructo kinase
Fructose 1, 6-bisphosphate
Fructose bisphosphate aldose
Dihydroxyacetone phosphate
Triose phosphate isomerase
Glyceraldehyde 3-phosphate
Glyceraldehyde 3-phosphate dehydrogenase
NAD+ + Pi
NADH + H+
2X
1,3-Bisphosphoglycerate
ATP
ADP
phosphoglycerate kinase
3-Phosphoglycerate
phosphoglycerate mutase
2-Phosphoglycerate
H2O
Enolase
Phosphoenolpyruvate (PEP)
ATP
ADP
pyruvate kinase
Pyruvate

Glycolysis

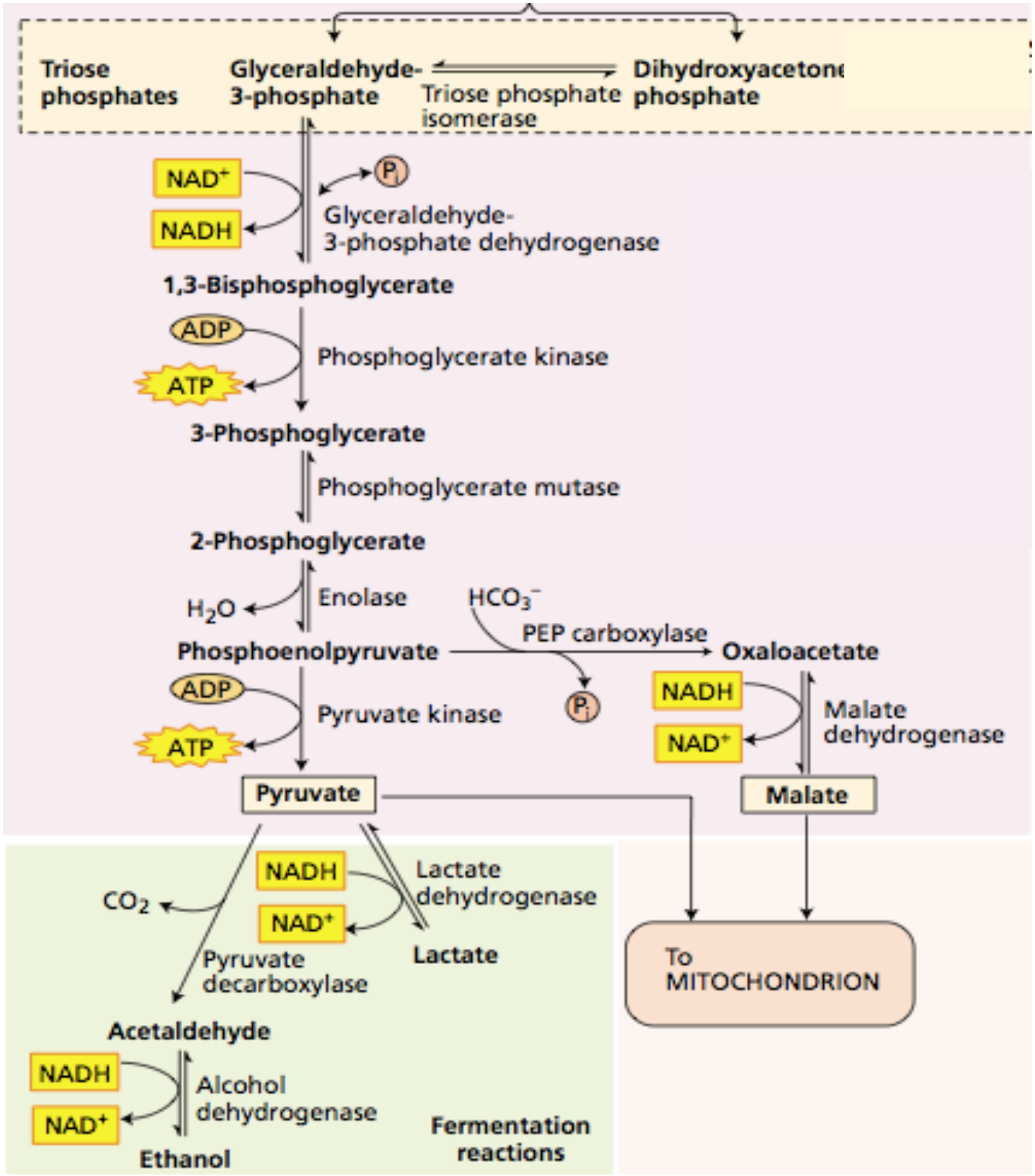


Input: 1 glucose
Output: 2 pyruvates
2 H2O
2ATPs
2 NADH
Occuring in cytosol

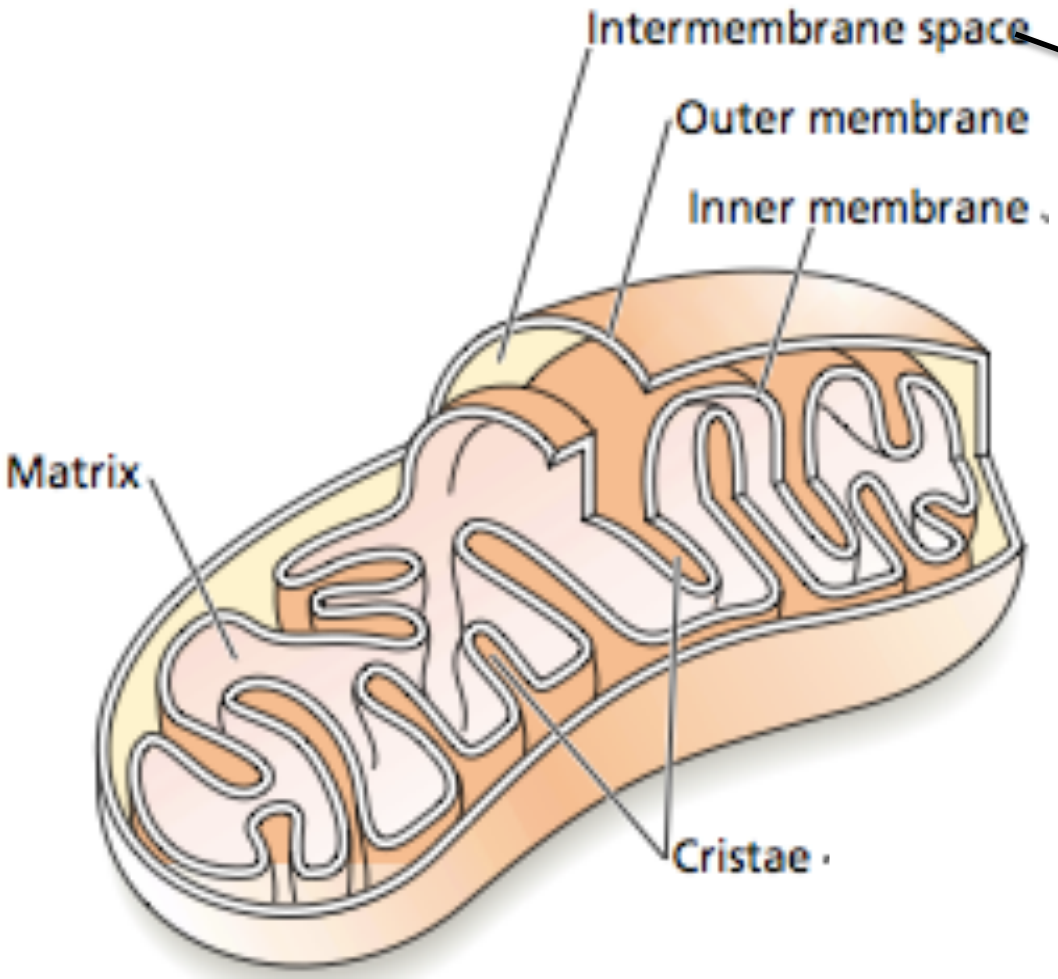
Different source of glycolysis…



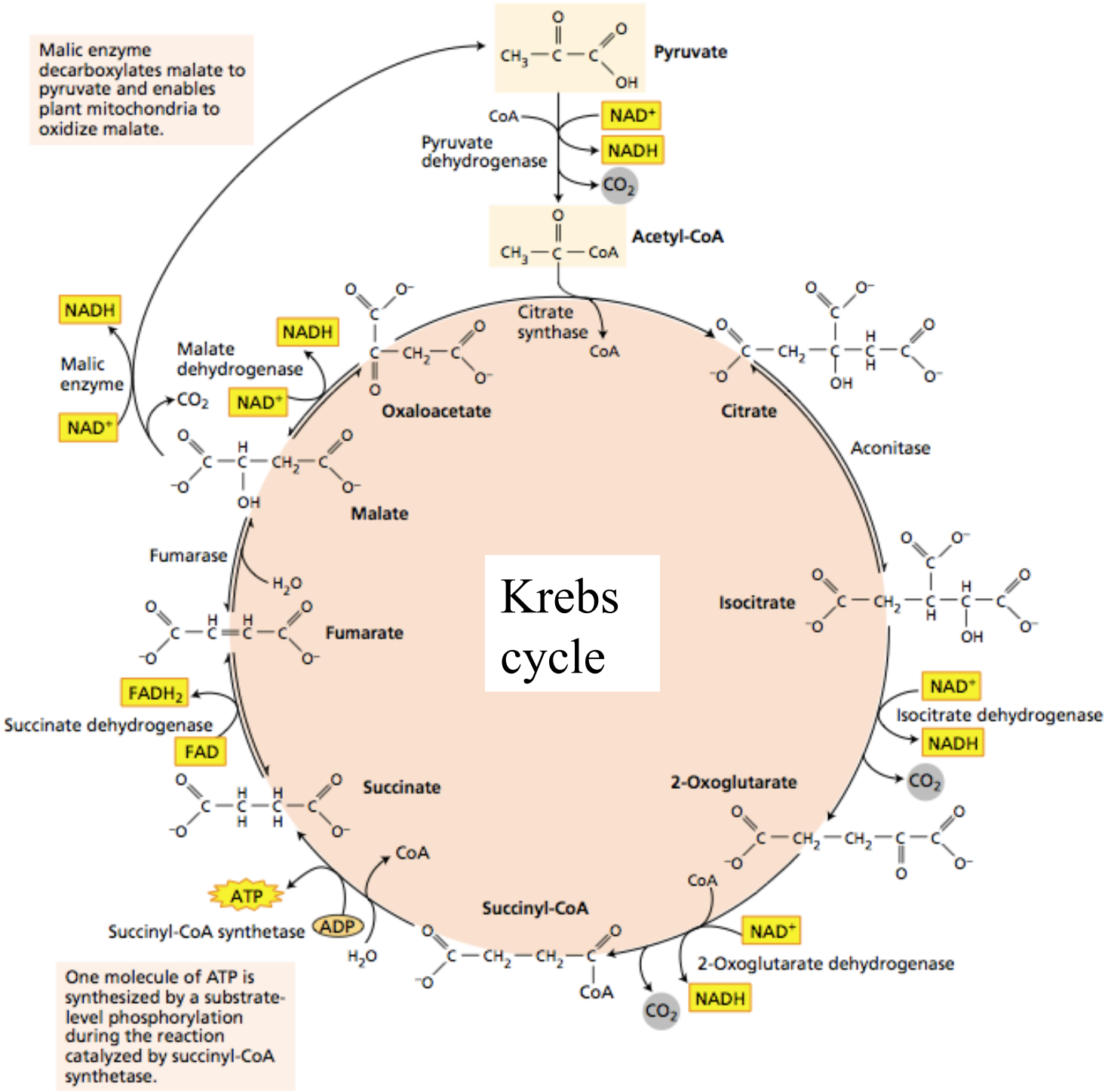
Different ways from pyruvate…



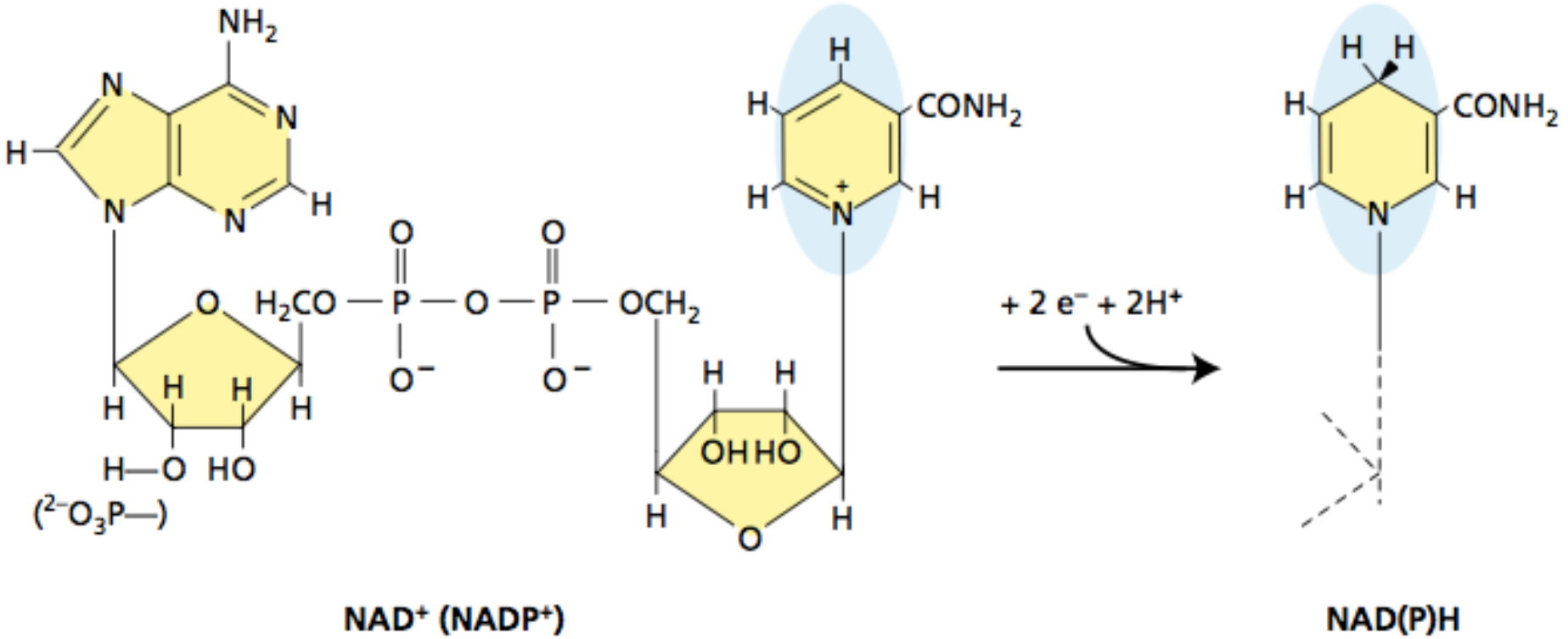
Krebs cycle: occurring in Mitochrondia



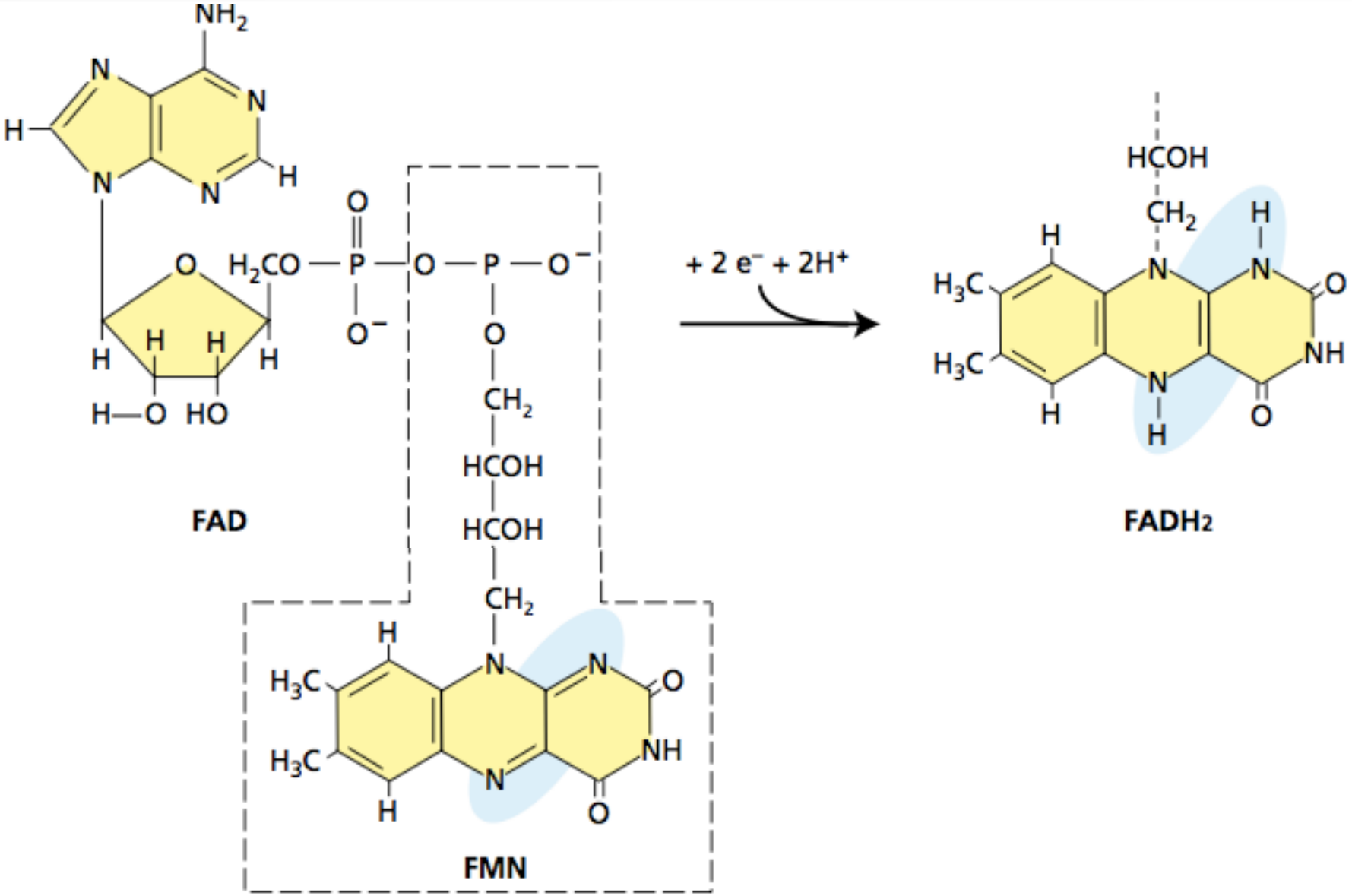
Contain about 50% of the total mitochrondial protein


Malic enzyme decarboxylates malate to pyruvate and enables plant mitochondria to oxidize malate.
Pyruvate
CoA
NAD+
NADH
Pyruvate dehydrogenase
CO2
Acetyl-CoA
Citrate synthase
CoA
Oxaloacetate
Citrate
Aconitase
Isocitrate
NAD+
Isocitrate dehydrogenase
NADH
CO2
2-Oxoglutarate
CoA
NAD+
2-Oxoglutarate dehydrogenase
NADH
CO2
Succinyl-CoA
CoA
ATP
Succinyl-CoA synthetase
ADP
H2O
Succinate
FADH2
Succinate dehydrogenase
FAD
Fumarase
H2O
Fumarate
Malate
NADH
Malate dehydrogenase
NAD+
CO2
Malic enzyme
NADH
NAD+
Krebs cycle
One molecule of ATP is synthesized by a substrate-level phosphorylation during the reaction catalyzed by succinyl-CoA synthetase.

NADH: high reducing molecule



FADH2: high reducing molecule

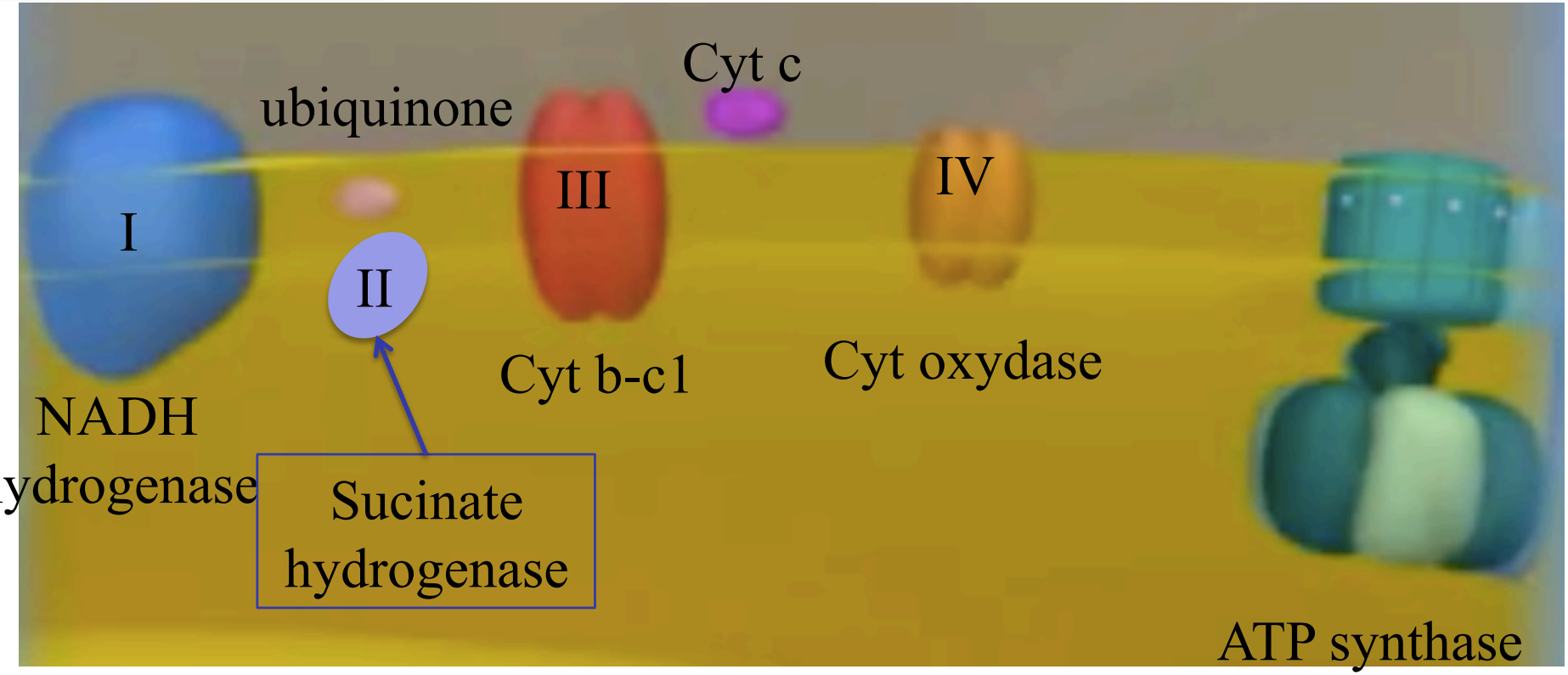


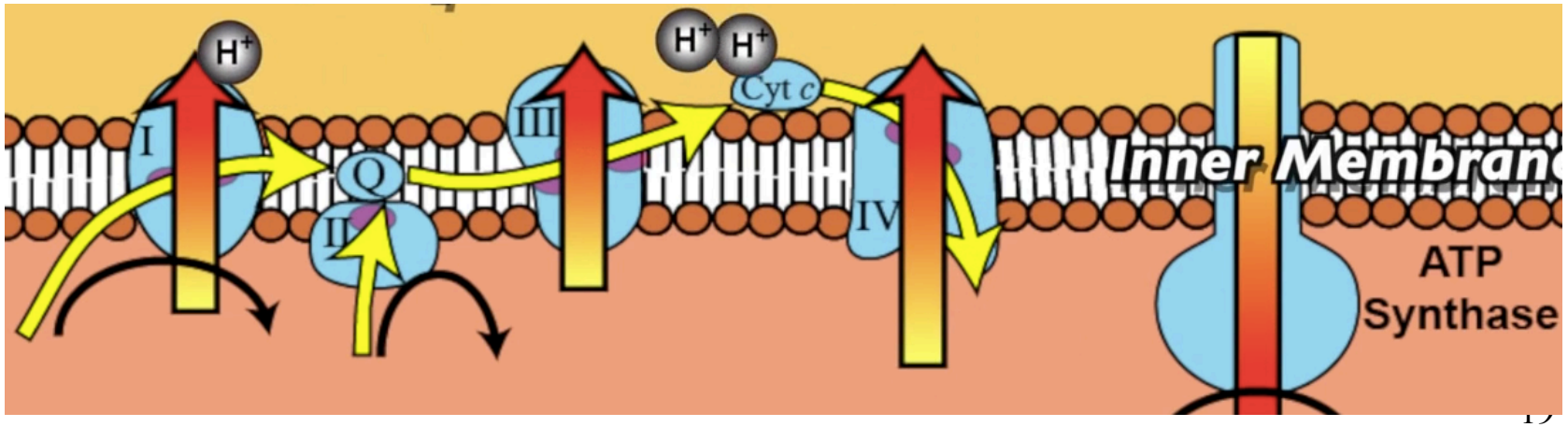
Electron transport, ATP synthesis

Coupled with this transfer is the pumping of hydrogen ions.

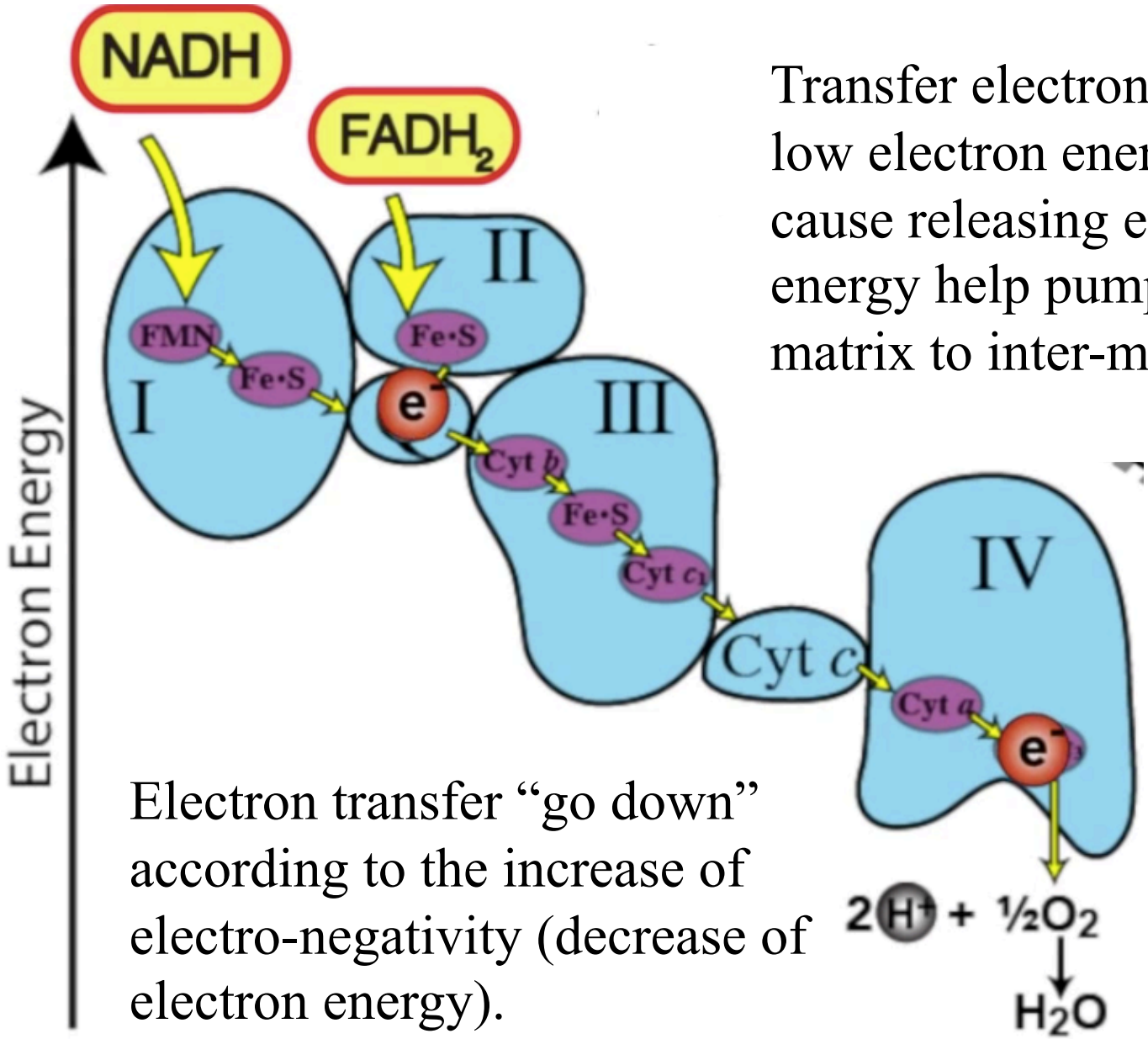
This pumping generates the gradient used by the ATP synthase complex to synthesize ATP.

Protein complexes in the electron transport chain





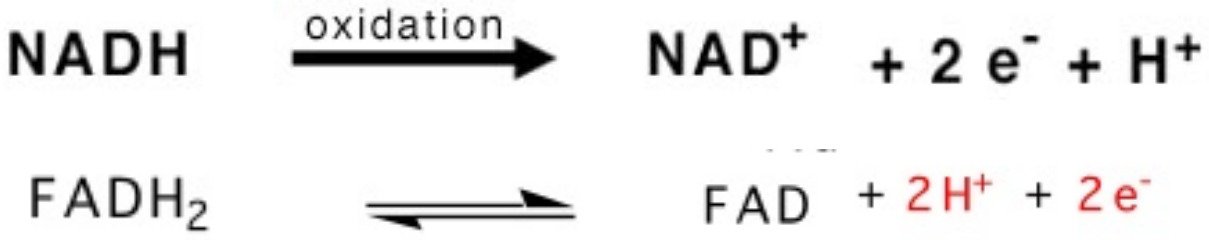
Electron transport, ATP synthesis



Transfer electron from high to low electron energy gradually cause releasing energy. This energy help pumping proton from matrix to inter-membrane space

Electron transfer "go down" according to the increase of electro-negativity (decrease of electron energy).

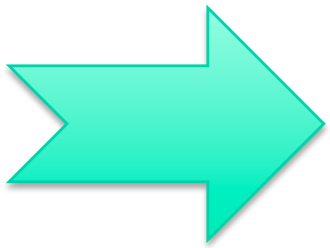
Electron transport, ATP synthesis



- NADH donates the electrons that transfer from complex I, then to mobile protein Q that bring it to complex III. Here once more, electron is transferred to complex IV by other mobile protein named Cytc
- At the same time FADH2 donates the electrons that transfer from complex II, then transfer similarly to Q protein, complex III, cyt complex and finally to complex IV
- At complex IV, electrons are transferred to oxygen to form ion Oxygen

Electron transport, ATP synthesis (cont)

- Oxygen ion reacts with proton to form water
- At complex I, III, IV, there is proton pump that use energy come from electron transfer to pump proton from matrix to intermembrane space.
- With high concentration intermembrane space, proton diffuse though ATP synthase, that provide energy for ATP synthesis



The oxidative pentose phosphate pathway

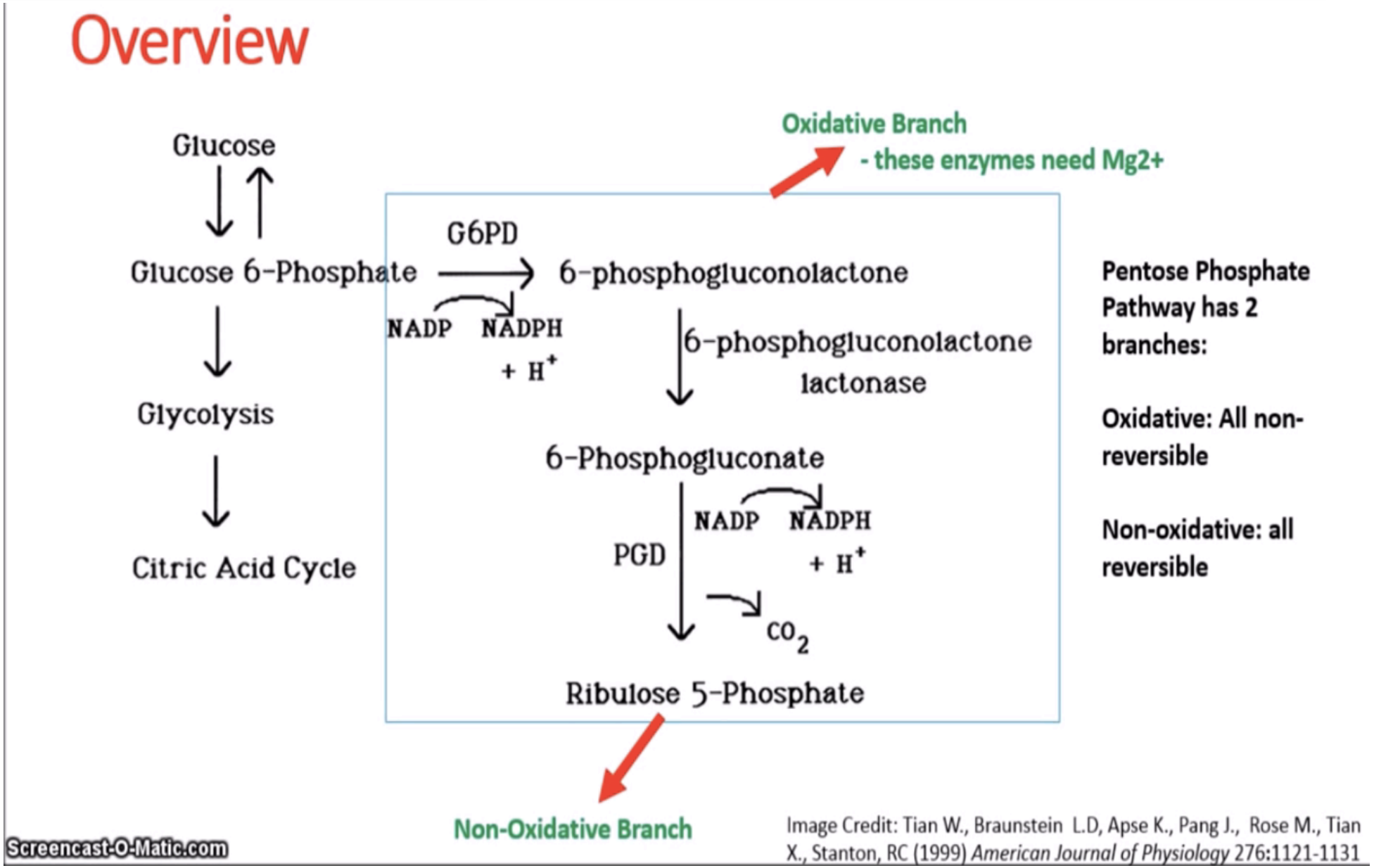
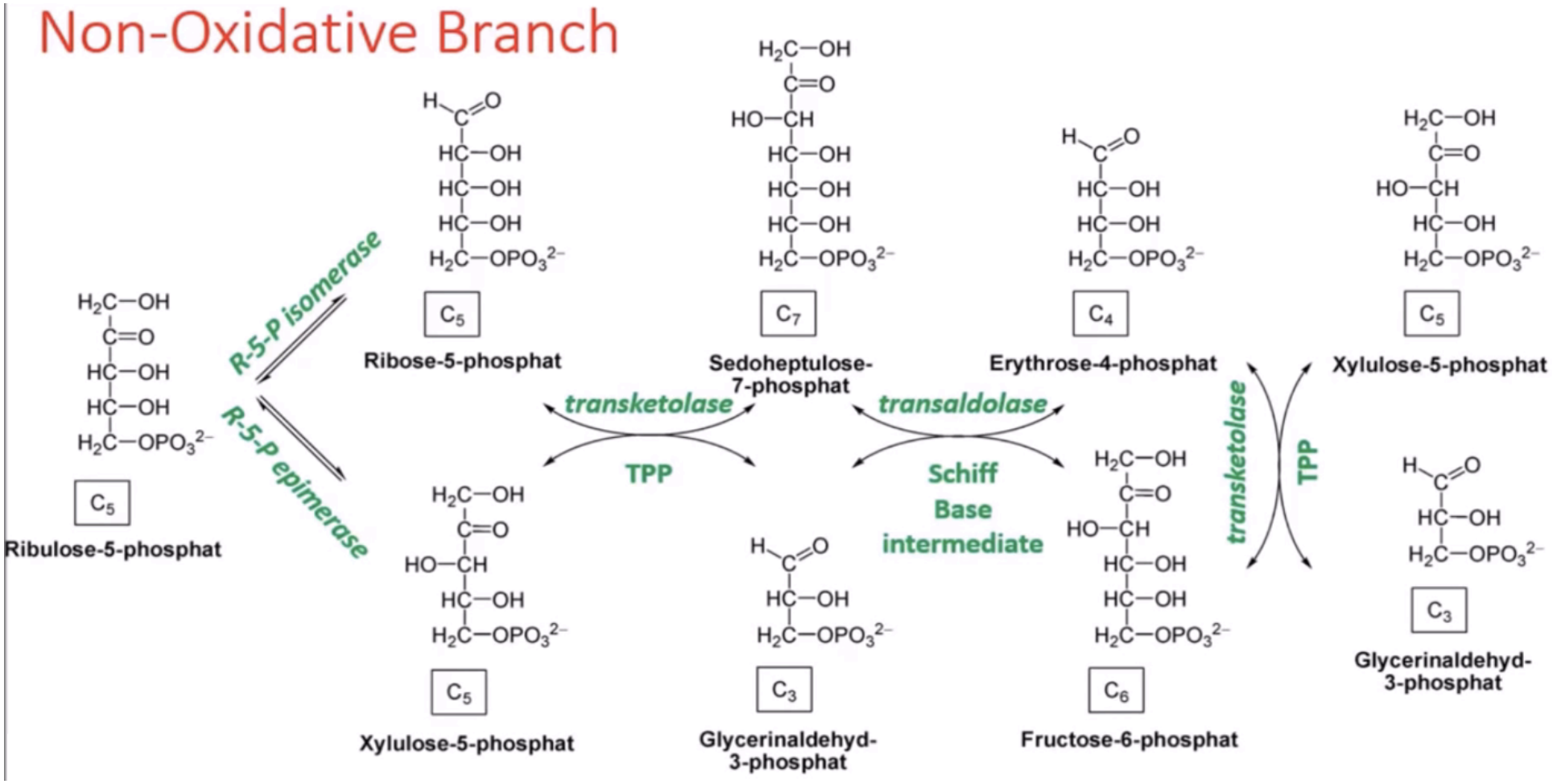


Image Credit: Tian W., Braunstein L.D, Apse K., Pang J., Rose M., Tian X., Stanton, RC (1999) *American Journal of Physiology* 276:1121-1131

The oxidative pentose phosphate pathway



2 Xylulose-5-P + 1 Ribose-5-P → 2 Fructose-6-P + 1 Glyceraldehyde-3-P

The oxidative pentose phosphate pathway

Role in plant metabolism

- **NADPH** enter in the electron transport chain, therefore it contribute to cell energy metabolism

- NADPH supply in plastid: NADPH is used for biosynthesis reactions (lipid synthesis, nitrogen assimilation)

- Supply substrates for biosynthesis processes: **ribose-5P** is precursor of the ribose and deoxy ribose needed in the nucleic acid synthesis

- Supply the intermediate compound (erythrose-4-phosphate, combines with PEP) for producing secondary plant metabolites

Efficiency…

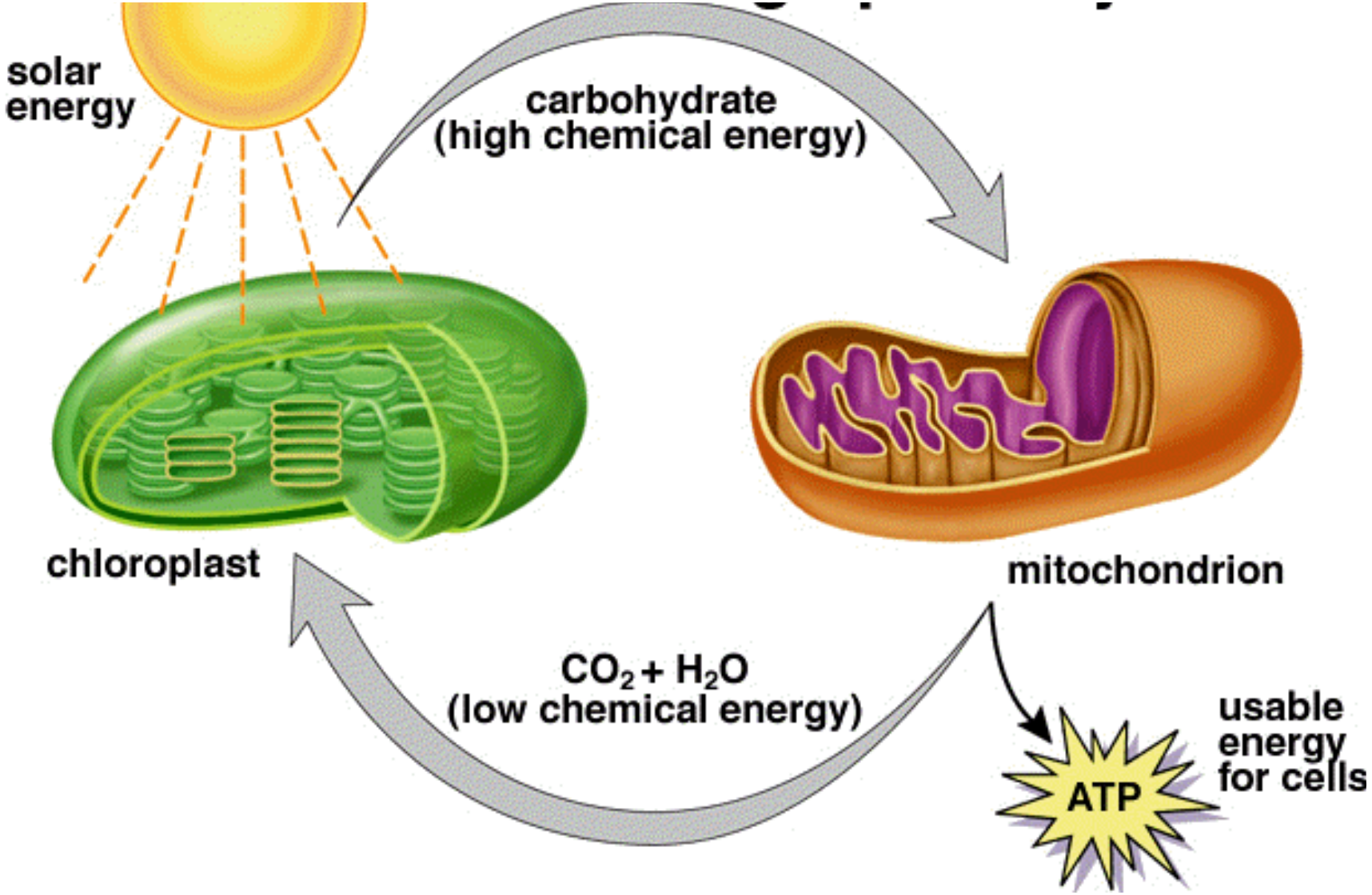
Glycolysis + Kreb's and Electron transport:

– Glycolysis	2 ATP
– Kreb's	2 ATP
– Electron Transport	32 ATP
	36 ATP

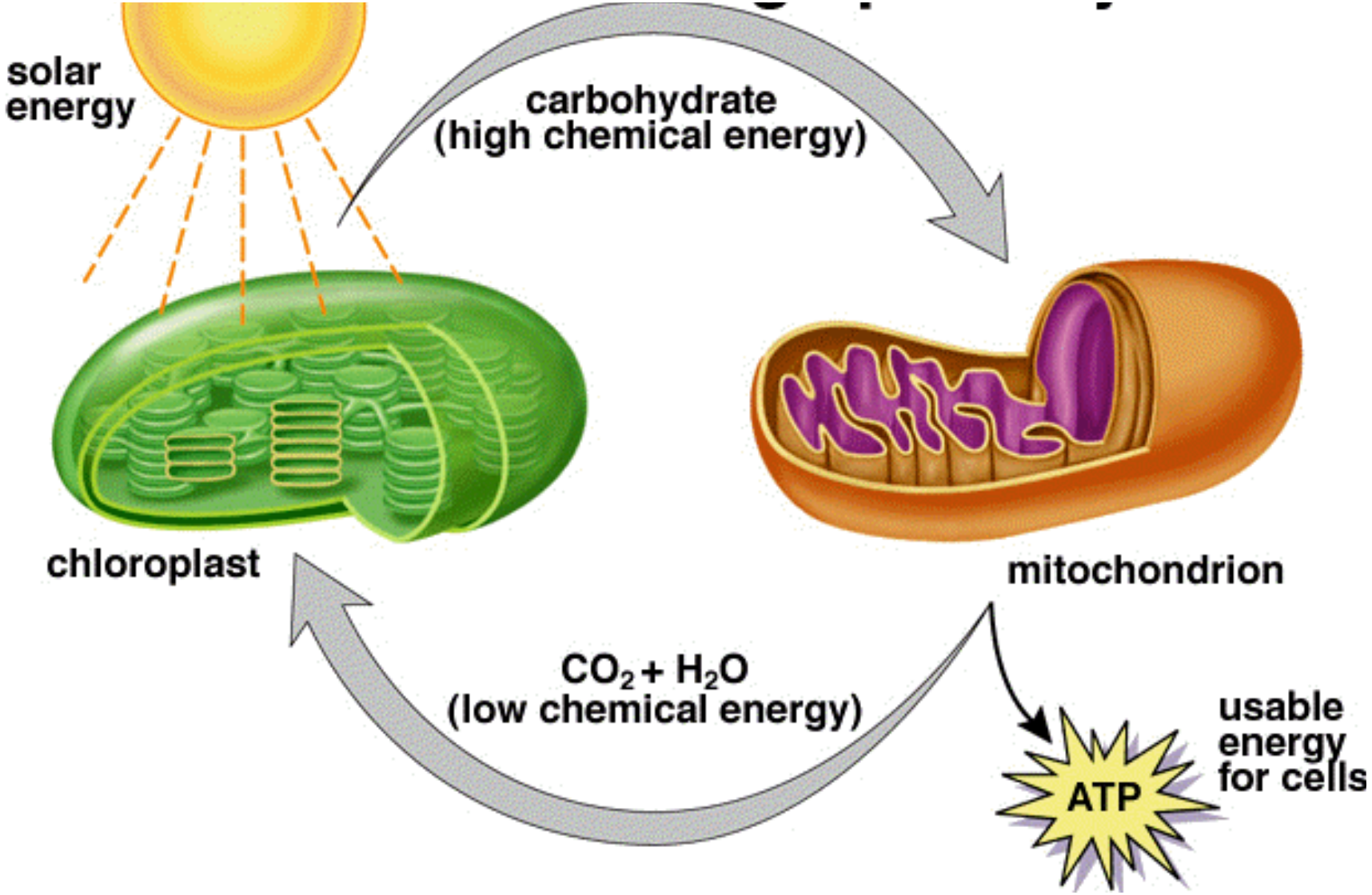
Pentose phosphate:

– Electron Transport (12 NADPH)	**36 ATP**

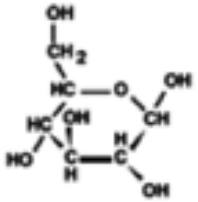
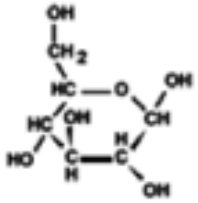
Respiration and photosynthesis



Respiration and photosynthesis



Respiration and photosynthesis

	PHOTOSYNTHESIS	RESPIRATION
Where?	Chloroplasts 	Mitochondria 
When?	In the presence of light 	All the time 
Input	Carbon dioxide and water 	Glucose and oxygen 
Output	Glucose and oxygen 	Carbon dioxide and water 
Energy sources	Light	Chemical bonds
Energy result	Energy stored	Energy released

Respiration and photosynthesis

Respiration	Photosynthesis
Occur in all tissue	Occur in green tissue
Operate during photosynthesis.	40 – 60% of daily gain is lost by respiration
Photorespiration increase the lost of photosynthesis gain.	