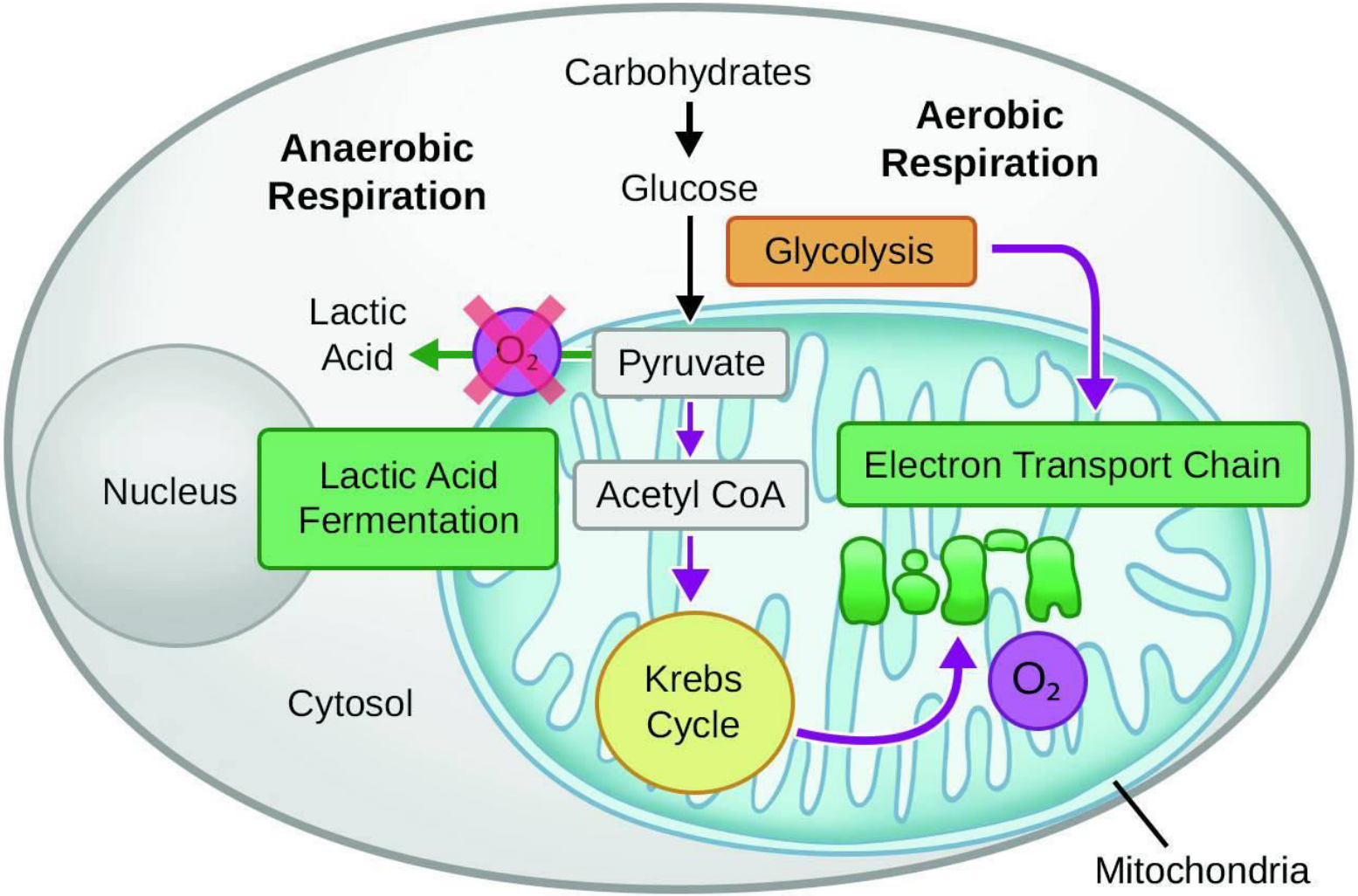
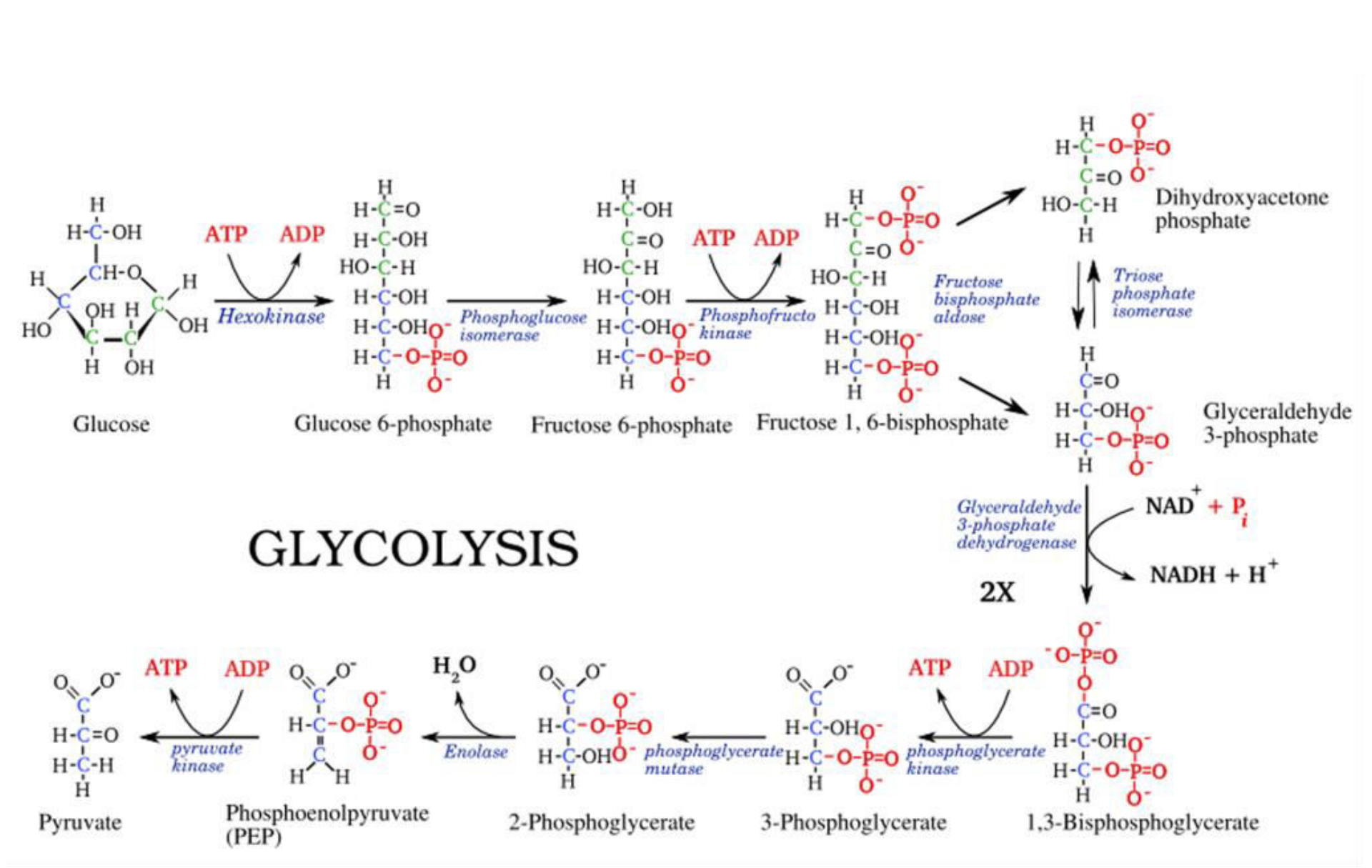
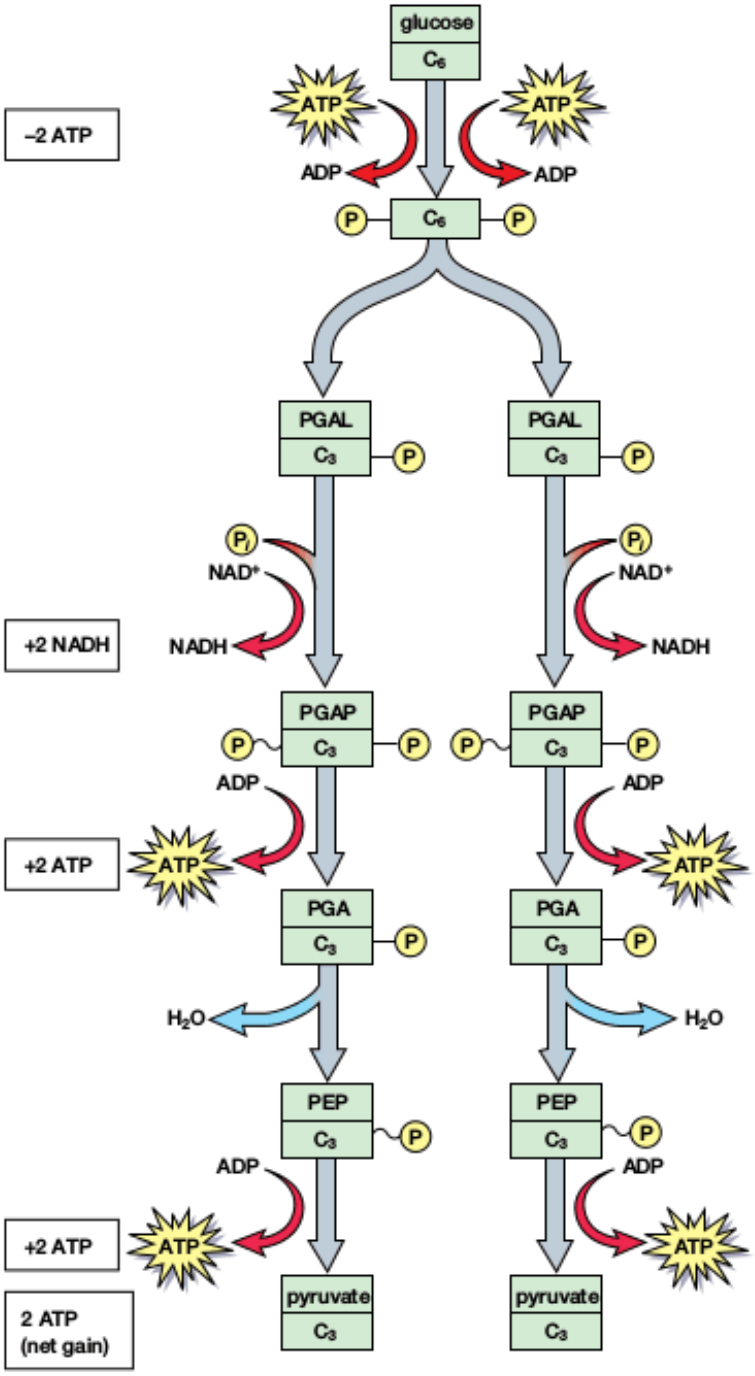
# RESPIRATION




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




**A** Two ATP molecules are used in the first phase of glycolysis to activate glucose.

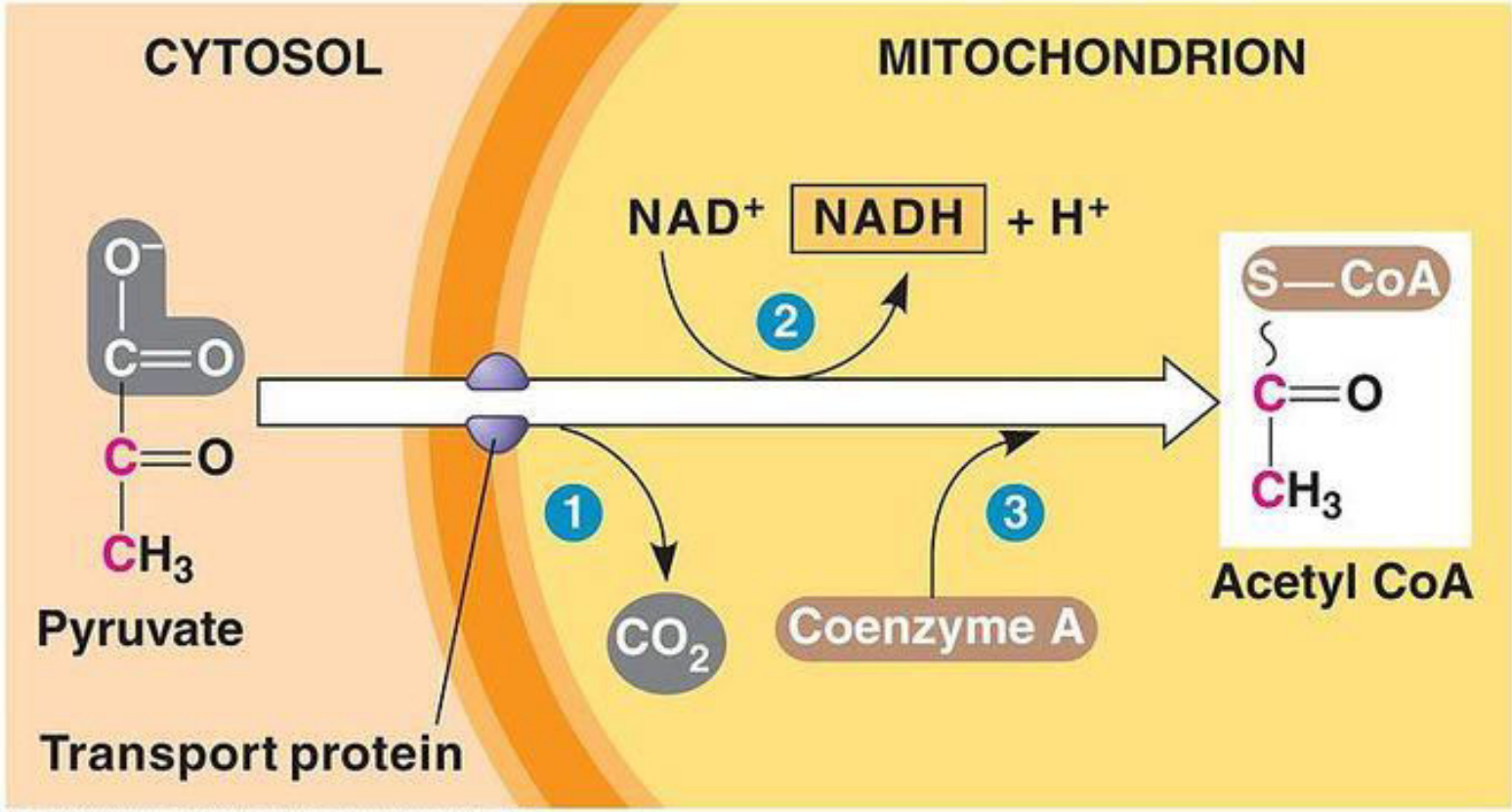
**B** The six-carbon molecule is split to form two molecules of PGAL (glyceraldehyde-3-phosphate).

**C** Oxidation and phosphorylation of PGAL results in the formation of two NADH and two molecules of PGAP (1,3-bisphosphoglycerate).

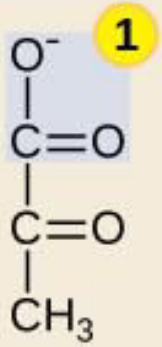
**D** Phosphorylation removes a phosphate group from each PGAL and produces two molecules of ATP and two molecules of PGA (3-phosphoglycerate).

**E** Oxidation of each PGA molecule removes water and forms two molecules of PEP (phosphoenolpyruvate).

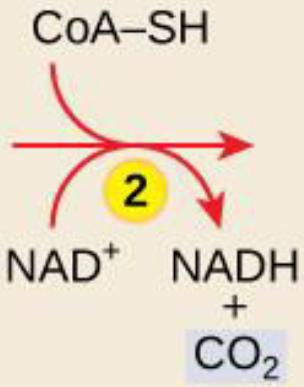
**F** Phosphorylation removes a phosphate group from each PEP molecule to form two molecules of ATP and two molecules of pyruvate.



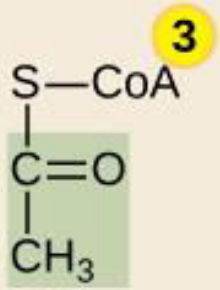
## Oxidation of Pyruvate




Pyruvate




Oxidation reaction




Acetyl CoA

**1**

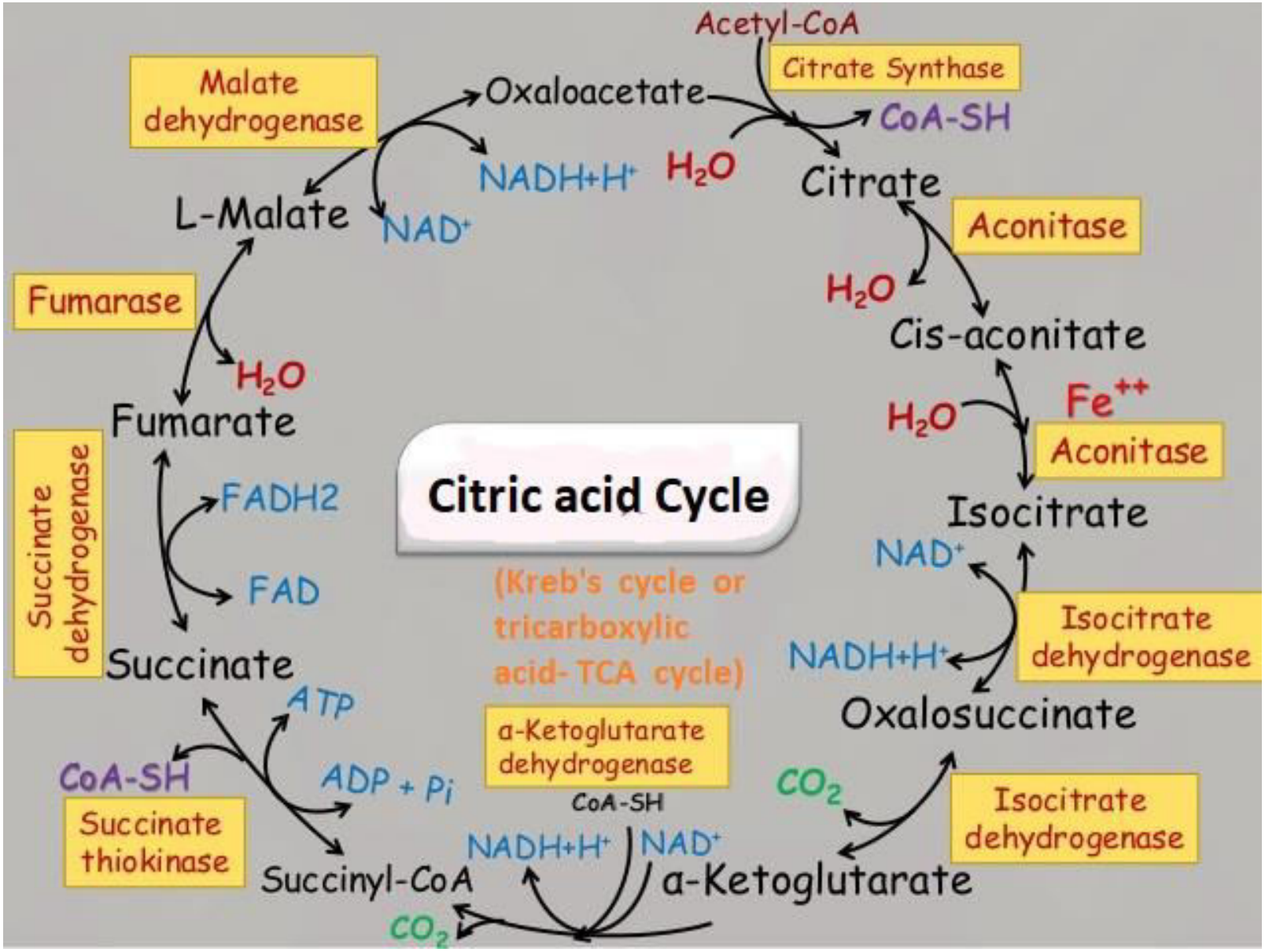
A carboxyl group is removed from pyruvate, releasing carbon dioxide.

**2**

$NAD^+$ is reduced to NADH.

**3**

An acetyl group is transferred to coenzyme A, resulting in acetyl CoA.


Acetyl-CoA
Citrate Synthase
Malate dehydrogenase
Oxaloacetate
CoA-SH
NADH+H+
H2O
Citrate
L-Malate
NAD+
Aconitase
H2O
Fumarase
Cis-aconitate
H2O
Fe++
H2O
Aconitase
Fumarate
Isocitrate
Succinate dehydrogenase
FADH2
Citric acid Cycle
NAD+
FAD
(Kreb's cycle or tricarboxylic acid- TCA cycle)
Isocitrate dehydrogenase
NADH+H+
Succinate
Oxalosuccinate
ATP
α-Ketoglutarate dehydrogenase
CO2
CoA-SH
ADP + Pi
Isocitrate dehydrogenase
CoA-SH
NADH+H+
NAD+
Succinate thiokinase
Succinyl-CoA
α-Ketoglutarate
CO2

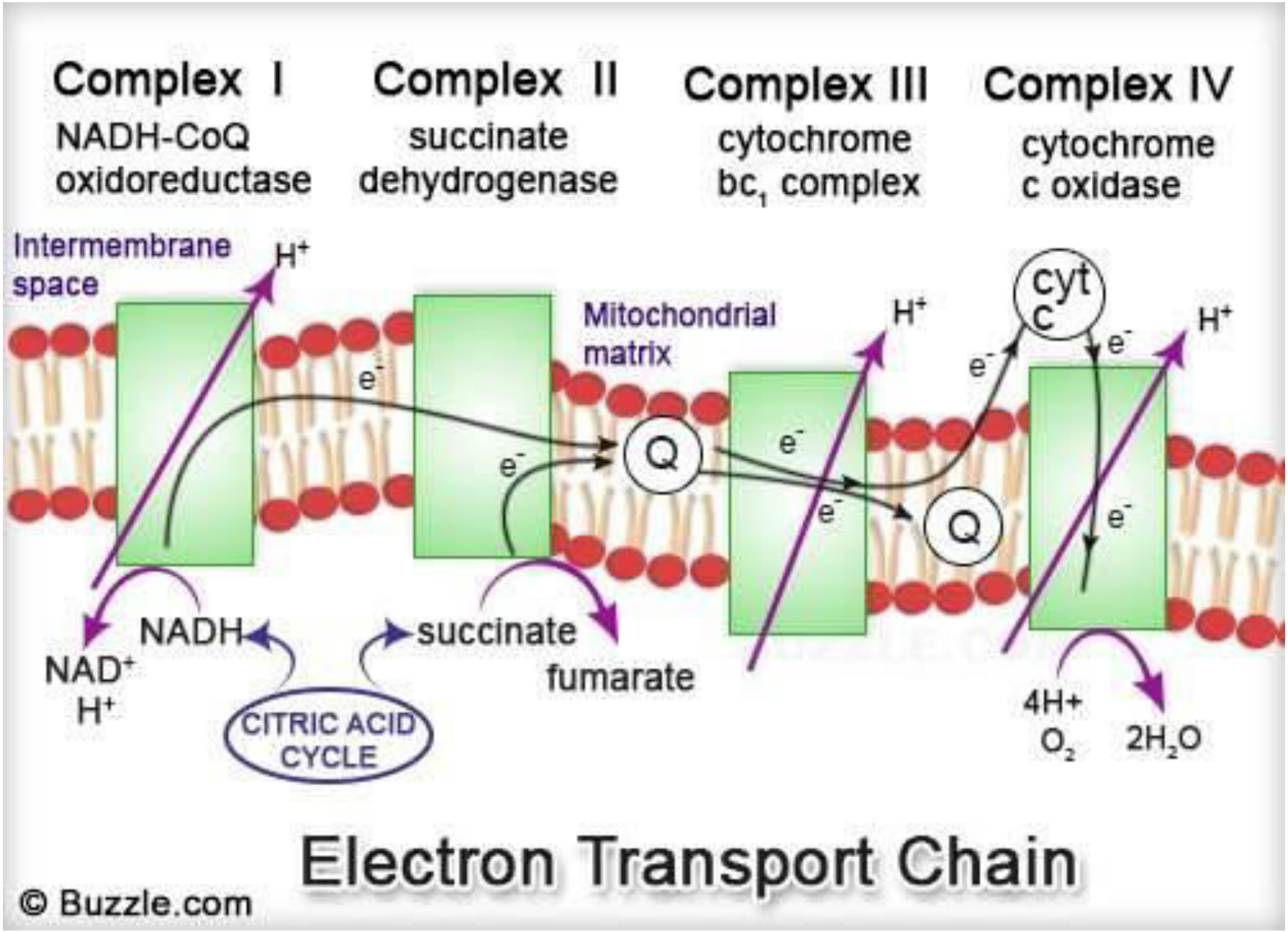

Complex I
NADH-CoQ oxidoreductase
Complex II
succinate dehydrogenase
Complex III
cytochrome bc1 complex
Complex IV
cytochrome c oxidase
Intermembrane space
H+
Mitochondrial matrix
e-
Q
cyt c
NADH
NAD+ H+
succinate
fumarate
CITRIC ACID CYCLE
4H+ O2
2H2O
Electron Transport Chain
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**TABLE 24.3. ATP-yeield from complete oxidation of glucose**

| *Process* | *Direct Product* | *Final ATP* | |
|---|---|---|---|
| ***Glycolysis*** | | | |
| Glucose → Glucose 6-phosphate | | −1 | |
| Fructose 6-phosphate → Fructose 1, 6-bisphosphate | | −1 | |
| 2 mol. [Glyceraldehyde-3-P → 1, 3-bisphosphoglycerate] | 2 NADH × 2.5 | +3 or 5* | 5 or 7 |
| 2 mol. [1, 3-bisphosphoglycerate → 3-phosphoglycerate] | | +2 | |
| 2 mol. [Phosphoenolpyruvate → Pyruvate] | | +2 | |
| ***Pyruvate to Acetyl-CoA*** | | | |
| 2 mol. [Pyruvate → Acetyl-CoA] | 2 NADH × 2.5 | +5 | 5 |
| ***TCA-Cycle (Krob's Cycle)*** | | | |
| 2 mol. [Isocitrate → α-ketoglutyrate] | 2 NADH × 2.5 | +5 | |
| 2 mol. [α-ketoglutyrate → Succinyl-CoA] | 2 NADH × 2.5 | +5 | |
| 2 mol. [Succinyl-CoA → Succinate] | 2 GTP** | +2 | 20 |
| 2 mol. [Succinate → Fumarate] | 2 $FADH_2$ × 1.5 | +3 | |
| 2 mol. [L-malate → Oxaloacetate] | 2 NADH × 2.5 | +5 | |
| | Total Yield | | 30 or 32 |

* Two more ATPs are formed per molecule of glucose oxidised when the malate-aspartate shuttle rather than glycerol -3-phosphate shuttle is used.

** GTP (Guanosine triphosphate) is a high energy molecule equivalent to ATP.