Respiration

Plant respiration

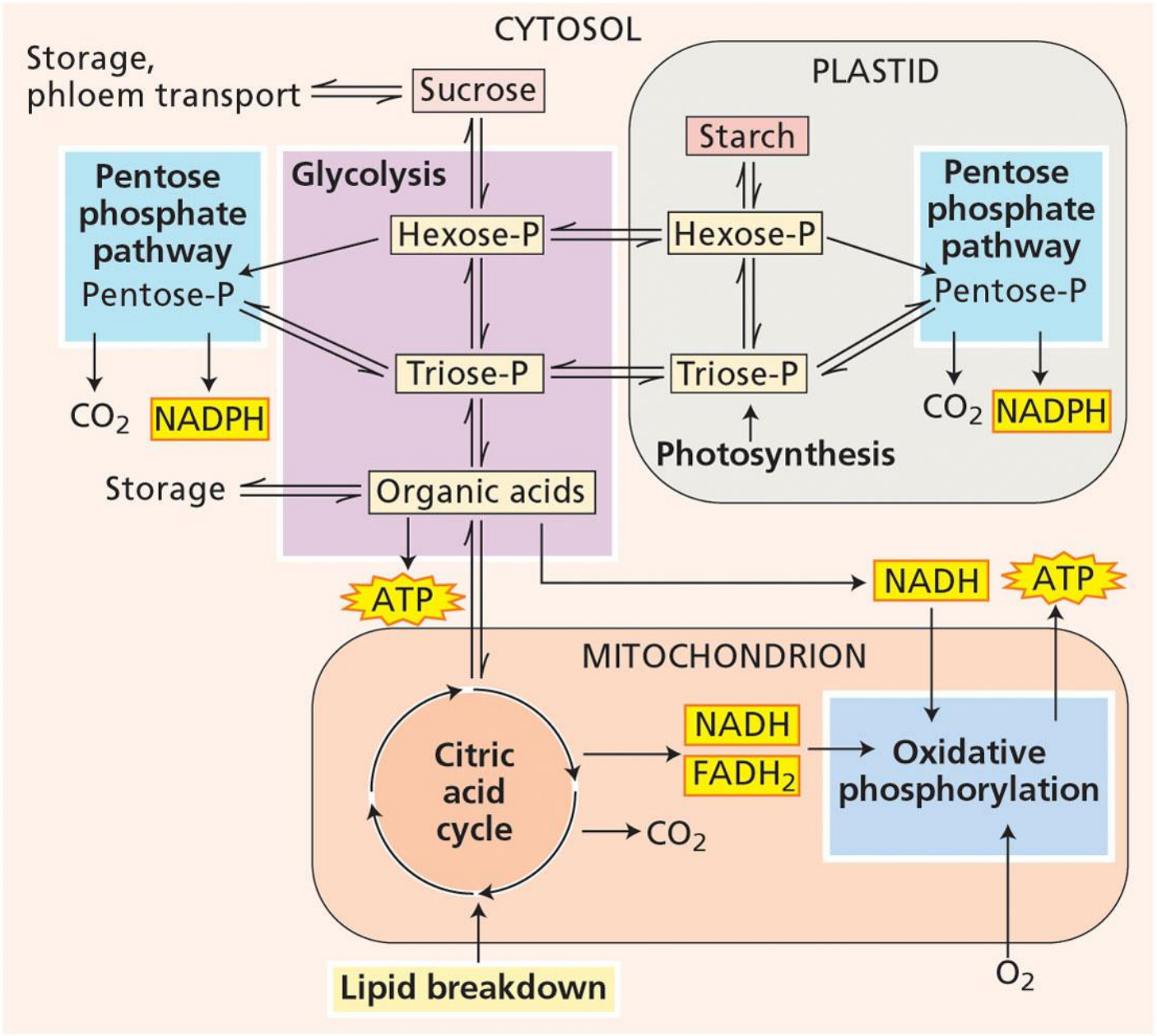
Simple definition: The oxidation of sugars to produce usable energy (ATP), reductant (NADH), and carbon "skeletons" for biosynthesis.

$$C_{12}H_{22}O_{11} + 12O_2 \text{ --> } 12\ CO_2 + 11\ H_2O$$

$$60\ ADP + 60\ P_i \text{ --> } 60\ ATP + 60\ H_2O$$

What are the major steps?

1) Glycolysis
2) Citric acid cycle
3) Electron transport/oxidative phosphorylation



Steps of respiration

- Glycolysis
- Pentose phosphate pathway
- Citric acid cycle
- Oxidative phosphorylation

Glycolysis

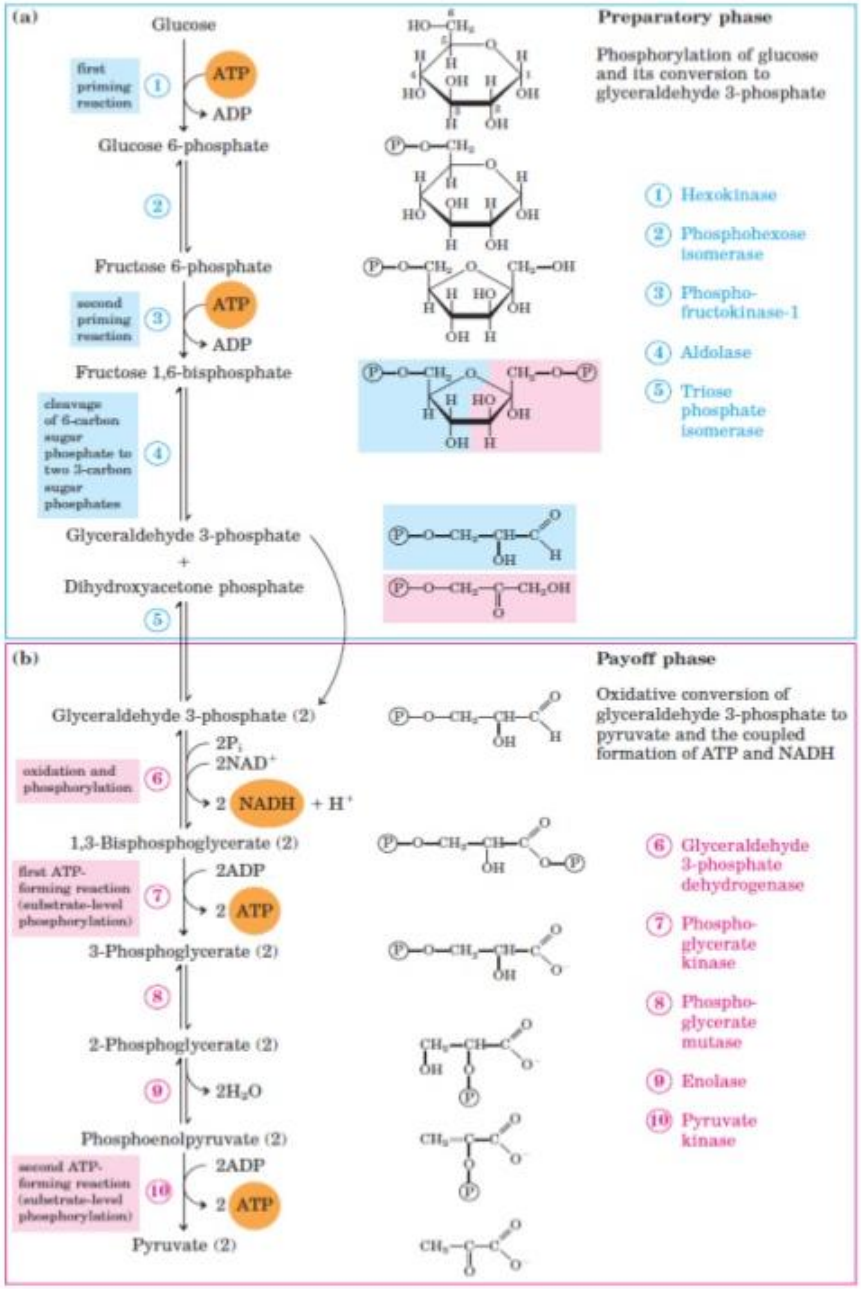
- conversion of carbohydrates into pyruvate producing some ATP and NADH in cytoplasm and plastids

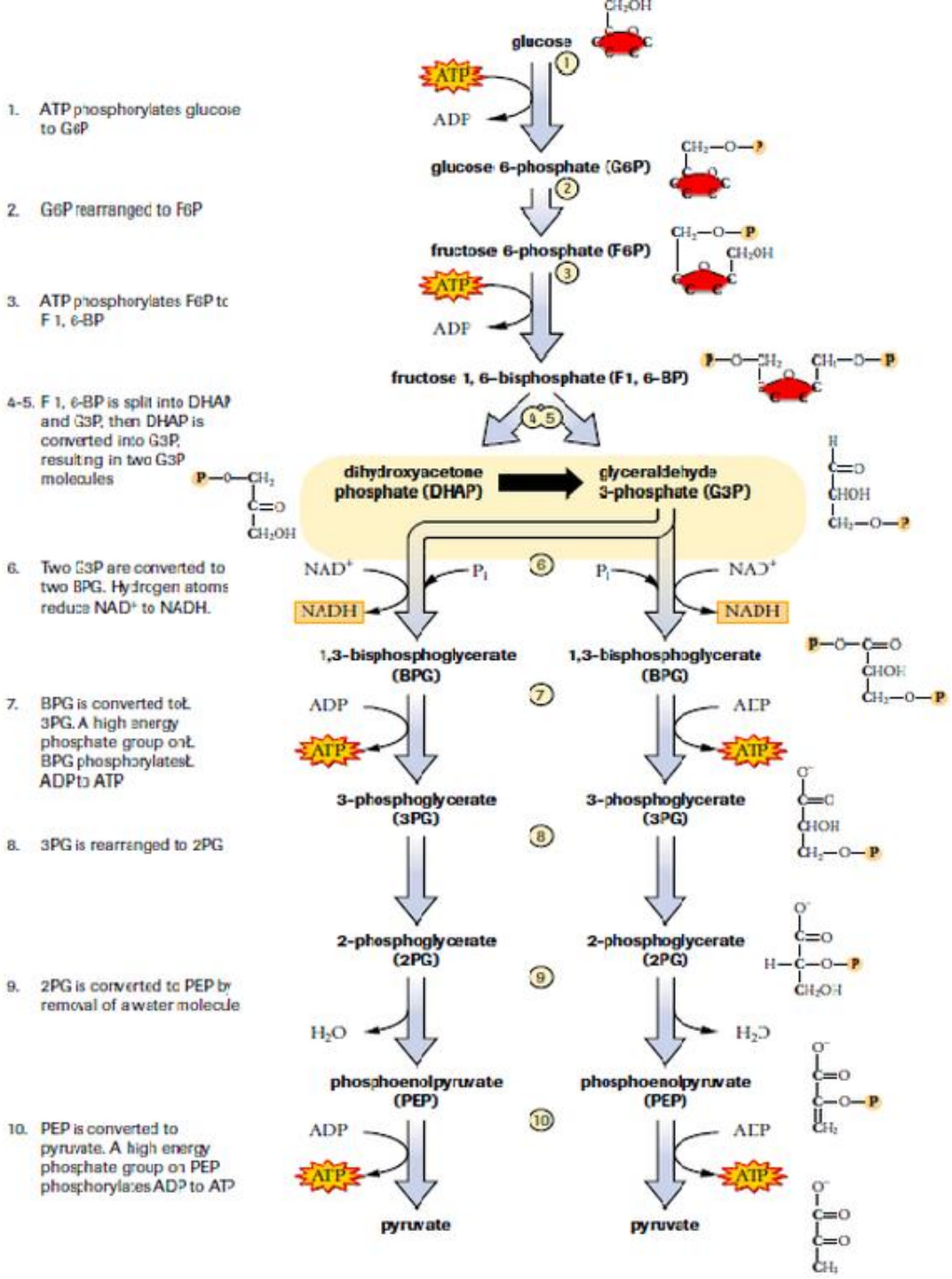
- can happen in presence or absence of O_2

- if O_2, then pyruvate converted to acetyl CoA and into the citric acid cycle

- if no O_2,then “fermentation” (see later) occurs, pyruvate is reduced to lactic acid and/or ethanol

Glycolysis


(a)
Glucose
first priming reaction
1
ATP
ADP
Glucose 6-phosphate
2
Fructose 6-phosphate
second priming reaction
3
ATP
ADP
Fructose 1,6-bisphosphate
cleavage of 6-carbon sugar phosphate to two 3-carbon sugar phosphates
4
Glyceraldehyde 3-phosphate
+
Dihydroxyacetone phosphate
5
Preparatory phase
Phosphorylation of glucose and its conversion to glyceraldehyde 3-phosphate
1 Hexokinase
2 Phosphohexose isomerase
3 Phospho-fructokinase-1
4 Aldolase
5 Triose phosphate isomerase
(b)
Glyceraldehyde 3-phosphate (2)
oxidation and phosphorylation
6
2Pi
2NAD+
2 NADH + H+
1,3-Bisphosphoglycerate (2)
first ATP-forming reaction (substrate-level phosphorylation)
7
2ADP
2 ATP
3-Phosphoglycerate (2)
8
2-Phosphoglycerate (2)
9
2H2O
Phosphoenolpyruvate (2)
second ATP-forming reaction (substrate-level phosphorylation)
10
2ADP
2 ATP
Pyruvate (2)
Payoff phase
Oxidative conversion of glyceraldehyde 3-phosphate to pyruvate and the coupled formation of ATP and NADH
6 Glyceraldehyde 3-phosphate dehydrogenase
7 Phospho-glycerate kinase
8 Phospho-glycerate mutase
9 Enolase
10 Pyruvate kinase


1. ATP phosphorylates glucose to G6P
2. G6P rearranged to F6P
3. ATP phosphorylates F6P to F 1, 6-BP
4-5. F 1, 6-BP is split into DHAP and G3P, then DHAP is converted into G3P, resulting in two G3P molecules
6. Two G3P are converted to two BPG. Hydrogen atoms reduce NAD+ to NADH.
7. BPG is converted to 3PG. A high energy phosphate group on BPG phosphorylates ADP to ATP
8. 3PG is rearranged to 2PG
9. 2PG is converted to PEP by removal of a water molecule
10. PEP is converted to pyruvate. A high energy phosphate group on PEP phosphorylates ADP to ATP
glucose
ATP
ADP
glucose 6-phosphate (G6P)
fructose 6-phosphate (F6P)
fructose 1, 6-bisphosphate (F1, 6-BP)
dihydroxyacetone phosphate (DHAP)
glyceraldehyde 3-phosphate (G3P)
NAD+
NADH
Pi
1,3-bisphosphoglycerate (BPG)
3-phosphoglycerate (3PG)
2-phosphoglycerate (2PG)
H2O
phosphoenolpyruvate (PEP)
pyruvate

Glycolysis summary

- Inputs:
  - Glucose
  - 2 NAD+
  - 2 ATP
  - 4 ADP + 2 P

- Outputs:
  - 2 pyruvate
  - 2 NADH
  - 2 ADP
  - 2 ATP (net gain)

Have a look at this video

https://youtu.be/hDq1rhUkV-g