Revision Notes on Respiration in Plants

Significance of respiration:

Respiration plays a significant role in the life of plants. The important ones are given below:

(i) It releases energy, which is consumed in various metabolic processes necessary for life of plant.

(ii) Energy produced can be regulated according to requirement of all activities.

(iii) It converts in soluble foods into soluble form.

(iv) Intermediate products of cell respiration can be used in different metabolic pathways

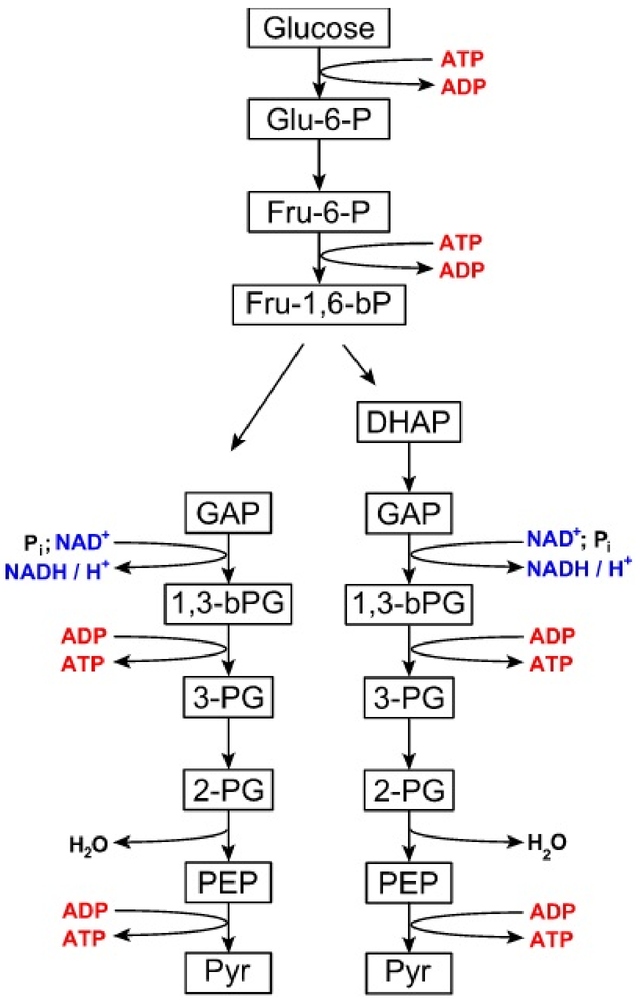
Differences between Photosynthesis and Respiration

Photosynthesis	**Respiration**
Occurs only in chlorophyll containing cells of plants.	Occurs in all plant and animal cells.
Takes place only in the presence of light.	Takes place continually both in light and in the dark.
During photosynthesis, radiant energy is converted into potential energy.	During respiration, potential energy is converted into kinetic energy.
Sugars, water and oxygen are products.	CO_2 and H_2O are products.
Synthesizes foods.	Oxidizeds foods.
CO_2 and H_2O are raw materials.	O_2 and food molecules are raw materials.
Photosynthesis is an endothermal process.	Respiration is an exothermal process.
Stores energy.	Releases energy.
It includes the process of hydrolysis, carboxylation etc.	It includes the process of the dehydrolysis, decarboxylation, etc.
Results in an increase in weight.	Results in a decrease in weight.
It is an anabolic process.	It is a catabolic process.
Require cytochrome.	Also require cytochrome.

Differences between cell respiration and combustion

S.No.	Characters	Cell respiration	Combustion
(i)	**Nature of process**	**Biochemical** and **stepped** process.	**Physico-chemical** and **spontaneous** process.
(ii)	**Site of occurrence**	Inside the cells.	Non-cellular.
(iii)	**Control**	Biological control.	Uncontrolled.
(iv)	**Energy release**	Energy released in steps.	Large amount of energy is released at a time.
(v)	**Temperature**	Remain within limits.	Rises very high.
(vi)	**Light**	No light is produced.	Light may be produced.
(vii)	**Enzymes**	Controlled by enzymes.	Not controlled by enzymes.
(viii)	**Intermediates**	A number of intermediates are produced.	No intermediate is produced.

Glycolysis Cycle



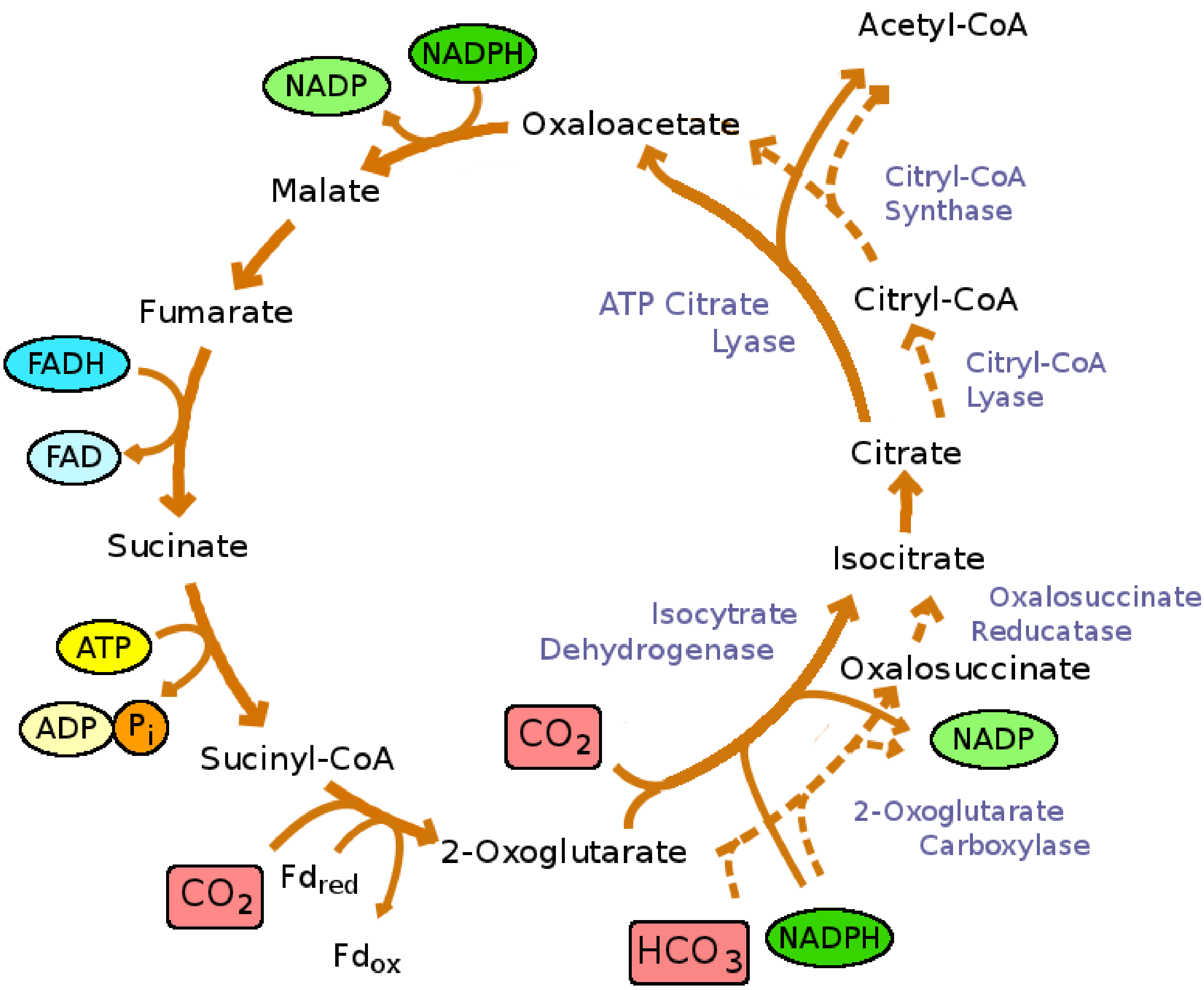
Enzymes of glycolysis and their co-factors

S. No.	Enzyme	Coenzyme (s) and cofactor	Activator (s)	Inhibitor (s)	Kind of reaction catalyzed
(i)	Hexokinase	Mg^{2+}	ATP^{4-}, Pi	Glucose 6-phopshate	Phosphoryl transfer
(ii)	Phosphogluco-isomerase	Mg^{2-}	-	2-dioxyglucose 6-phosphate	Isomerization
(iii)	Phosphofructo-kinase	Mg^{2+}	Fructose 2, 6-diphosphate, AMP, ADP, cAMP, K^{+}	ATP $^{4-}$, citrate	Phosphoryl transfer
(iv)	Aldolase	Zn^{2+} (in microbes)	-	Chelating agents	Aldol cleavage
(v)	Phosphotriose isomerase	Mg^{2+}	-	-	Isomerization
(vi)	Glyceraldehyde 3-phosphate dehydrogenase	NAD	-	Iodoacetate	Phosphorylation coupled to oxidation
(vii)	Phosphoglycerate kinase	Mg^{2+}	-	-	Phosphoryl transfer
(viii)	Phosphoglycerate mutase	Mg^{2+} 2,3-diphos phoglycerate	-	-	Phosphoryl shift
(ix)	Enolase	Mg^{2+}, Mn^{2+}, Zn^{2+}, Cd^{2+}	-	Fluoride+ phosphate	Dehydration
(x)	Pyruvate kinase	Mg^{2+}, K^{+}	-	Acetyl CoA, analine, Ca^{2+}	Phosphoryl transfer

Total input and output materials in glycolysis

Total Inputs	Total Outputs
1 molecule of glucose (6 C)	2 molecules of pyruvate (2×3 C)
2 ATP	4 ATP
4 ADP	2 ADP
2 × NAD^{+}	2× NADH + $2H^{+}$
2 Pi	2×H_2O

Kreb's Cycle



Enzymes of Kreb's cycle

Step	Enzyme	(Location in mitochondria)	Coenzyme(s) and cofactor (s)	Inhibitor(s)	Type of reaction catalyzed
(a)	Citrate synthetase	Matrix space	CoA	Monofluoro-acetyl-CoA	Condensation
(b)	Aconitase	Inner membrane	Fe^{2+}	Fluoroacetate	Isomerization
(c)	Isocitrate dehydrogenase	Matrix space	NAD^+, $NADP^+$, Mg^{2+}, Mn^{2+}	ATP	Oxidative decarboxylation
(d)	alpha-ketoglutarate dehydrogenase complex	Matrix space	TPP,LA,FAD,CoA, NAD^+	Arsenite,Succinyl-CoA, NADH	Oxidative decarboxylation
(e)	Succinyl-CoA synthetase	Matrix space	CoA	-	Substrate level phosphorylation
(f)	Succinate dehydrogenase	Inner membrane	FAD	Melonate, Oxaloacetate	Oxidation
(g)	Fumarase	Matrix space	None	-	Hydration
(h)	Malate dehydrogenase	Matrix space	NAD^+	NADH	Oxidation

Products formed during aerobic respiration by Glycolysis and Kreb's cycle

Total formation of ATP

ATP formation in Glycolysis			
	Steps	**Product of reactions**	**In terms of ATP**
ATP formation by substrate phosphorylation	1, 3-diphosphoglyceric acid (2 moles) ® 3 phosphoglyceric acid (2 moles) Phosphoenolpyruvic acid (2 moles) ® Pyruvic acid (2 moles)	2 ATP 2 ATP	2 ATP 2 ATP
		Total	4 ATP
ATP formation by oxidative phosphorylation or ETC	1, 3 - disphosphoglyceraldehyde (2 moles) 1, 3 – diphosphoglyceric acid (2 moles)	2 $NADH_2$	6 ATP
	Total ATP formed	4 + 6 ATP =	10 ATP
ATP consumed in Glycolysis	Glucose (1 mole) ® Glucose 6 phosphate (1 mole) Fructose 6 phosphate (1 mole) ® Fructose 1, 6-diphosphate (1 mole)	– 1 ATP – 1 ATP	– 1 ATP – 1 ATP
		Total	2 ATP
	Net gain of ATP = total ATP formed – Total ATP consumed	**10 ATP – 2ATP**	**8 ATP**

ATP formation in Kreb's cycle			
ATP formation by substrate phosphorylation	Succinyl CoA (2 mols) ® Succinic acid (2 mols)	2 GTP	2 ATP
		Total	2 ATP
ATP formation by oxidative phosphorylation or ETC	Pyruvic acid (2 mols) ® Acetyl CoA (2 mols) Isocitric acid (2 mols) ® Oxalosuccinic acid (2 mols) a-Ketoglutaric acid (2 mols) ® Succinyl CoA (2 mols) Succinic acid (2 mols) ® Fumaric acid (2 mols)	2 $NADH_2$ 2 $NADH_2$ 2 $NADH_2$ 2 $FADH_2$	6 ATP 6 ATP 6 ATP 4 ATP

	Malic acid (2 mols) ® Oxaloacetic acid (2 mols)	2 $NADH_2$	6 ATP
		Total	28 ATP
	Net gain in Kreb's cycle (substrate phosphorylation + oxidative phosphorylation)	2ATP + 28 ATP	30 ATP
Net gain of ATP in glycolysis and Kreb's cycle	Net gain of ATP in glycolysis + Net gain of ATP in Kreb's cycle	8 ATP + 30 ATP	38 ATP
Over all ATP production by oxidative phosphorylation or ETC	ATP formed by oxidative phosphorylation in glycolysis + ATP formed by oxidative phosphorylation or ETC.	6 ATP + 28 ATP	34 ATP

Difference between Aerobic, Anaerobic Respiration and Fermentation

Aerobic Respiration	Anaerobic Respiration	Fermentation
Molecular oxygen is the ultimate electron acceptor for biological oxidation. The ETS serves to transfer electrons from oxidisable donor to molecular oxygen. The early enzymatic steps involve dehydrogenation whereas the final steps are mediated by a group of enzyme called cytochromes. Ultimately the electrons are transferred to oxygen which is reduced to water. During aerobic respiration ATP is generated by coupled reaction	The ultimate electron acceptor is an inorganic compound other than oxygen. The compounds accepting the hydrogen (electrons) are nitrates, sulphates, carbonates or CO_2. Anaerobic respiration produces ATP through phosphorylation reaction involving electron transfer systems. (mechanism not known)	The final electron acceptors are organic compounds. Both electron donors (oxidizable substrate) and electron acceptors (oxidizing agent) are organic compounds and usually both substrates arise from same organic molecules during metabolism. Thus part of the nutrient molecule is oxidised and part reduced and the metabolism results in intramolecular electron rearrangement. ATP is generated by substrate level phosphorylation. This reaction differs from oxidative phosphorylation because oxygen itself is not required for ATP generation.