FREE NOTES · NCERT + NEET LEVEL

Respiration in Plants

Do plants breathe, glycolysis, fermentation, aerobic respiration (link reaction, Krebs cycle, ETS, oxidative phosphorylation), the respiratory balance sheet, amphibolic pathway and respiratory quotient.

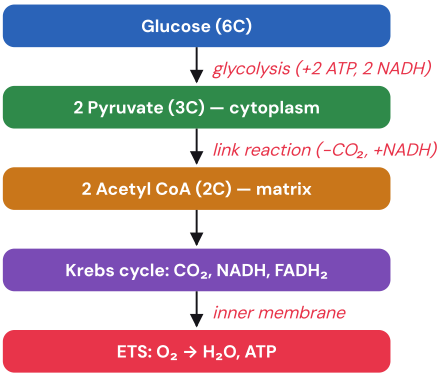
01 Do plants breathe?
02 Glycolysis (EMP pathway)
03 Fermentation
04 Link reaction and Krebs cycle
05 ETS and oxidative phosphorylation
06 Balance sheet, amphibolic pathway, RQ
07 Extra + tricks
08 Important Q&A
09 Common mistakes
10 Practice (NEET style)
11 Quick revision

01 Do plants breathe?

- Plants have no special respiratory organs; gas exchange through stomata and lenticels. Each part takes care of its own gas needs; little transport needed.
- Cells are near the surface (living cells are mainly in thin layers; inside of woody stems is dead), so diffusion is enough.
- Respiration: breakdown of C–C bonds of food (oxidation) in cells to release energy, trapped as **ATP** (energy currency). Respiratory substrates: carbohydrates mainly, also fats and proteins.

02 Glycolysis (EMP pathway)

- Embden, Meyerhof, Parnas. In cytoplasm of all living organisms; only process in anaerobes.
- Glucose → (hexokinase) glucose-6-P → fructose-6-P → fructose-1,6-bisP → DHAP + PGAL (3-phosphoglyceraldehyde).
- PGAL → BPGA (1,3-bisphosphoglycerate) gives **NADH**; BPGA → 3-PGA gives ATP; PEP → pyruvate gives ATP.
- Net per glucose: **2 ATP** (4 made - 2 used) + **2 NADH** + 2 pyruvate.



Overview of aerobic respiration

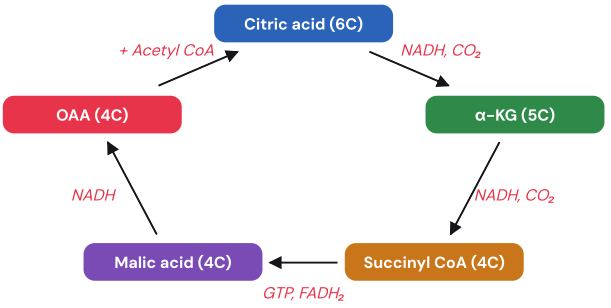
03 Fermentation

Type	Reaction	Where
Alcoholic	Pyruvate → acetaldehyde + CO_2 (pyruvic acid decarboxylase) → ethanol (alcohol dehydrogenase)	Yeast
Lactic acid	Pyruvate → lactic acid (lactate dehydrogenase), NADH reoxidised	Some bacteria, muscles in vigorous exercise (O_2 shortage)

Less than 7% of glucose energy released; not all converted to ATP. Yeast dies when alcohol reaches about 13%. In both, NADH is oxidised to NAD^+ so glycolysis continues.

04 Link reaction and Krebs cycle

- In mitochondrial matrix. **Pyruvate dehydrogenase** (needs NAD^+, CoA, Mg^{2+}): pyruvate + CoA + NAD^+ → acetyl CoA + CO_2 + NADH + H^+.
- **Krebs / TCA / citric acid cycle** (Hans Krebs): acetyl CoA + OAA → citric acid (citrate synthase).
- Per acetyl CoA: 3 NADH, 1 $FADH_2$, 1 GTP (≈ATP), 2 CO_2. Per glucose: double.
- Succinate dehydrogenase is the only Krebs enzyme on the inner membrane.



Krebs cycle (simplified)

05 ETS and oxidative phosphorylation

- Inner mitochondrial membrane. Complex I (NADH dehydrogenase) → ubiquinone → Complex III (cyt bc_1) → cytochrome c (mobile) → Complex IV (cyt $a–a_3$ oxidase, with copper) → O_2 (final H acceptor) → H_2O. $FADH_2$ enters at Complex II.
- 1 NADH ⇛ 3 ATP; 1 $FADH_2$ ⇛ 2 ATP (as per NCERT).
- Complex V = **ATP synthase**: F_o (proton channel in membrane) + F_1 (headpiece, makes ATP). For each ATP, ~2 H^+ pass through F_o (NCERT).
- Called oxidative phosphorylation because energy of oxidation–reduction drives ATP synthesis (vs light in photophosphorylation).

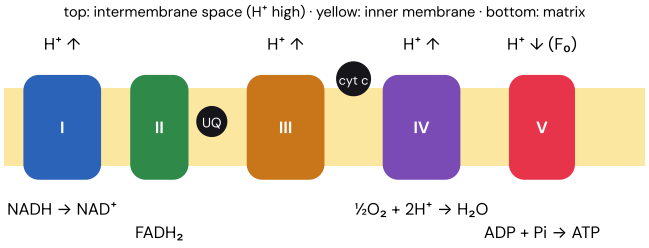
06 Balance sheet, amphibolic pathway, RQ

Net gain: 38 ATP per glucose in aerobic respiration (assumptions: sequential pathway, NADH from glycolysis enters mitochondria, no intermediate used elsewhere, only glucose respired; real values are lower).

Fermentation	Aerobic
Partial breakdown	Complete breakdown to CO_2 + H_2O
Net 2 ATP	Net 38 ATP
NADH oxidised slowly	NADH oxidised vigorously

- **Amphibolic pathway**: respiration is both catabolic and anabolic (acetyl CoA used for fatty acid synthesis; intermediates for amino acids).
- **RQ = CO_2 evolved / O_2 consumed**: carbohydrates 1; fats <1 (tripalmitin 102/145 = 0.7); proteins ~0.9; anaerobic: infinity.

07 Extra + tricks



Electron transport chain on inner mitochondrial membrane

- Glycolysis enzymes in order: hexokinase → phosphoglucoisomerase → **phosphofructokinase** (key regulatory) → aldolase → triose phosphate isomerase → G3P dehydrogenase (NADH) → phosphoglycerate kinase (ATP) → phosphoglyceromutase → enolase → **pyruvate kinase** (ATP).
- **Shuttles**: NADH of glycolysis cannot enter mitochondria directly. Malate–aspartate shuttle (heart, liver, kidney): 3 ATP per NADH ⇒ 38 ATP. Glycerol-phosphate shuttle (skeletal muscle, brain): 2 ATP ⇒ 36 ATP.
- Substrate-level phosphorylation: glycolysis (2 steps) and Krebs (succinyl CoA → succinate, GTP).
- Trick for Krebs intermediates: "**C**an **I** **K**eep **S**ome **S**ucrose **F**or **M**y **O**wn" = Citrate, Isocitrate, α-Ketoglutarate, Succinyl CoA, Succinate, Fumarate, Malate, OAA.

08 Important Q&A

Q1. Why is respiration called an amphibolic pathway?

Because it involves both breakdown (catabolism) and synthesis (anabolism): intermediates like acetyl CoA are withdrawn for making fatty acids and amino acids.

Q2. Calculate RQ of tripalmitin: $2C_{51}H_{98}O_6 + 145\ O_2 \rightarrow 102\ CO_2 + 98\ H_2O$.

RQ = 102/145 = 0.7.

Q3. What is the final acceptor of electrons in ETS?

Oxygen; it forms water with H^+.

09 Common mistakes

- Saying glycolysis occurs in mitochondria (it is cytoplasm).
- Writing 4 ATP as net gain of glycolysis (net is 2).
- Forgetting succinate dehydrogenase is membrane-bound.
- Writing RQ of fats as more than 1.

10 Practice (NEET style)

1. Net ATP from aerobic respiration of 1 glucose?
2. Enzyme converting pyruvate to acetyl CoA?
3. First product of Krebs cycle?
4. RQ of carbohydrates?
5. Mobile electron carrier between III and IV?

ANSWERS

1) 38 · 2) Pyruvate dehydrogenase · 3) Citric acid · 4) 1 · 5) Cytochrome c

11 Quick revision: 5 minutes before the exam

GLYCOLYSIS

- Cytoplasm
- Net 2 ATP + 2 NADH
- Glucose → 2 pyruvate

KREBS

- Matrix; OAA + acetyl CoA
- Per turn: 3 NADH, 1 $FADH_2$, 1 GTP

ETS

- Inner membrane
- NADH 3, $FADH_2$ 2 ATP
- O_2 final acceptor

RQ

- Carb 1, fat 0.7
- Protein 0.9
- Anaerobic ∞

Have a doubt? Ask the AI Doubt Solver at padhaiadda.netlify.app, or take the mock test on this chapter.