RESPIRATION IN PLANTS

RESPIRATORY QUOTIENT

RESPIRATORY QUOTIENT OR R.Q.:

- R.Q. is the ratio of the volume of CO_2 released to volume of oxygen taken in respiration.

$$RQ = \frac{\text{Volume of } CO_2 \text{ released}}{\text{Volume of } O_2 \text{ Consumed}} = \frac{CO_2}{O_2}$$

- RQ is determined by respirometer.
- Rate of respiration is measured by **Ganong's respirometer**.

1. R.Q. of carbohydrates:

When carbohydrates are the respiratory substrate than R.Q. is one

$$C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O + 686 \text{ K. cals.}$$

$$R.Q = \frac{6CO_2}{6O_2} = \frac{6}{6} = 1$$

2. R.Q. of Fats:

When fats are the respiratory substrate, the value of R.Q. become less than one because the fats are poorer in oxygen and they require more O_2 for their oxidation.

$$2C_{51}H_{98}O_6 + 145O_2 \longrightarrow 102CO_2 + 98H_2O + E$$

(Tripalmitin)

$$R.Q = \frac{102CO_2}{145O_2} = \frac{102}{145} = 0.70$$

3. R.Q. of Proteins:

When proteins are the respiratory substrate, the value of R.Q. become less than one **(usually 0.9)**.

4. **R.Q. of organic acid:**

When organic acid (in succulent plants in presence of light) are oxidized in respiration the R.Q. become more than one because organic acids are rich in oxygen and requires less oxygen for their oxidation.

$$2(COOH)_2 + O_2 \longrightarrow 4CO_2 + 2H_2O + E$$

(Oxalic acid)

$$R.Q = \frac{4CO_2}{O_2} = \frac{4}{1} = 4$$

$$C_4H_6O_5 + 3O_2 \longrightarrow 4CO_2 + 3H_2O + E$$

(Malic acid)

$$R.Q = \frac{4CO_2}{3O_2} = \frac{4}{3} = 1.33$$

5. **R.Q. in succulent plants:**

In some fleshy or succulent plants e.g. Opuntia, Bryophyllum, Carbohydrates are incompletely oxidized to organic acid in dark without the evolution of CO_2 thus the value of R.Q. remain 0.

$$2C_6H_{12}O_6 + 3O_2 \longrightarrow 3C_4H_6O_5 + 3H_2O + E$$

(Glucose) (Malic acid)

$$R.Q = \frac{0CO_2}{3O_2} = \frac{0}{3} = 0$$

6. **R.Q. of fatty seeds:**

It is less than one (<1)

7. **R.Q. during anaerobic respiration:**

Due to absence of O_2 the value of R.Q. is infinite because CO_2 is evolved without the intake of oxygen.

$$C_6H_{12}O_6 \longrightarrow 2C_2H_5OH + 2CO_2 + E$$

(Glucose)

$$R.Q = \frac{2CO_2}{O_2} = \frac{2}{0} = \infty \text{ (Infinite)}$$

FACTORS AFFECTING RESPIRATION:

1. Temperature
2. Light
3. CO_2
4. O_2
5. Water
6. Mineral salt
7. Respiratory substrate
8. Pollutants
9. Age
10. Protoplasmic factor

1. **Temperature:** Optimum temperature = 30° C, Q_{10} value = 2–2.5 or 3. Below 0°C the rate of respiration is greatly reduced. Although in some plants respiration takes place even at –20° . Dormant seeds kept at –50° C survive.
2. **Light:** Light affects the rate of respiration indirectly. Increase in light → increase in rate of photosynthesis → increase in concentration of respiratory substrate → increase in the rate of reaction.
3. **CO_2:** If the amount of CO_2 in the air is more than the usual, rate of respiration is decreased, germination of seed is reduced and rate of growth falls down.
4. **O_2 :** On slight increasing or decreasing the amount of oxygen in the environment, rate of respiration is not affected. On decreasing the amount of oxygen 1.9% in the atmosphere aerobic respiration become negligible, this is called extinction point of aerobic respiration. But anaerobic respiration takes place.
5. **Water:** Rate of respiration ∝ amount of water. Dry seeds show very low rate of respiration but as they imbibe water, rate of respiration is increased.
6. **Mineral salts:** Chlorides of alkali cations as well as divalent cations of alkali increase (Li, Ca, Mg) the rate of respiration.
7. **Respiratory substrate:** Increase in respiratory substrate leads to increase in rate of respiration, but it shows saturation.
8. **Pollutants:** High concentration of gaseous air pollutants like SO_2, NO_x and O_3 inhibit respiration by damaging cell membrane. These gaseous pollutant cause increase in pH which in turn affect ETS.
9. **Age:** Rate of respiration decreases with maturity and increasing age.
10. **Protoplasmic factor:** More protoplasm → High rate of respiration. Meristematic cells have higher rate of respiration than mature cells.

READ AND DIGEST:

1. Exchange of respiratory gases (O_2 and CO_2) between an organism and its environment is called **external respiration.**
2. Exchange of respiratory gases between tissue cells and extracellular environment is called **internal respiration.**
3. 1 molecule of glucose yields 56 Kcal or 2 ATP in anaerobic respiration and 686000 calories (686k cal) or total of 38 ATP in aerobic respiration. But net gain of ATP in eukaryotes is 38 or 36 depending upon type of shuttle system. Thus, ratio of ATP in aerobic and anaerobic respiration is 36: 2 i.e, 18 : 1 or 38 : 2 i e., 19 : 1.
4. One molecule of **sucrose** produces **76 ATP**.
5. **Extinction point:** It is the minimum concentration of oxygen below which aerobic respiration is stopped.
6. Photosyntesis is 10 times faster than respiration.
7. PGAL is connecting link between respiration and photosynthesis.
8. **RBC and muscles** obtain **energy** by **glycolysis or anerobic respiration**.
9. **Metabolism of one molecule of palmitic acid yields 129 ATP.**
10. **RQ of Mixed diet is < 1 (0.7).**
11. **1 molecule of Fructose 1, 6–bisphosphate** yields **40 ATP** during respiration.
12. **Krebs cycle** is **amphibolic cycle**. It undergoes **2 decarboxylations** and **4 oxidations** to form CO_2 & H_2O.

1. **Acetic acid fermentation: Acetobacter aceti bacteria forms acetic acid from alcohol.**

(a) $C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$

(b) $C_2H_5OH + O_2 \xrightarrow{A.aceti} CH_3COOH + H_2O$

2. **Butyric acid fermentation - In the presence of hydrogen acceptor & decarboxylase enzyme Anaerobic bacteria Bacillus butyricus and Clostridium butyricum form butyric acid from glucose or lactic acid**

(a) $\underset{\text{(Lactic acid)}}{C_6H_{12}O_6} + 2NAD^+ \xrightarrow{\text{decarboxylase}} \underset{\text{(Butyric acid)}}{C_4H_8O_2} + 2CO_2\,2NADH.H^+$

(b) $\underset{\text{(Glucose)}}{C_6H_{12}O_6} + 2NAD^+ \xrightarrow{\text{decarboxylase}} \underset{\text{(Butyric acid)}}{C_4H_8O_2} + 2CO_2\,2NADH.H^+$

3. **Pentose Phosphate Pathway:**

The alternative pathway of glycolysis to produce the sugars that make up nucleotides is called pentose phosphate pathway.

It is also called the phosphogluconate pathway or the hexose monophosphate shunt

It is special because no energy is formed in the form of ATP.

It generates NADPH and 5-C sugars as well as ribose 5-phosphate (used for synthesis of nucleotides)

It has two phases - oxidative phase leads to formation of 2NADPH while non-oxidative phase leads to synthesis of 5-C sugars.

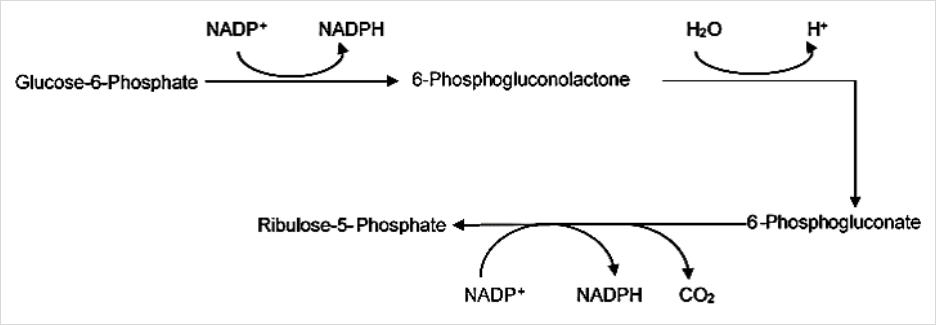
Location: Mostly cytosol but in plants most steps take place in mitochondria.

Outcome: NADPH (for fatty acids synthesis, for prevention of oxidative stress)

Ribose-5-phosphate (for synthesis of nucleotides)

Erythrose-4-phosphate (for synthesis of aromatic amino acids and vitamin B_6)

Reactions of Oxidative phase (Irreversible):



Note: In **oxidative phase,** 3 molecules of glucose-6-phosphate give rise to 3 molecules of CO_2 and 3 molecules of 5-C sugars and 6 molecules of NADPH

Reaction of non-oxidative phase (Reversible):

$3\times$Ribulose 5-phosphate $\longrightarrow$ $2\times$Glucose-6-phosphate + Glyceraldehyde 3-phosphate

Note: The 3 molecules of 5-C sugars are rearranged to regenerate 2 molecules glucose-6-phosphate and 1 molecule of glyceraldehyde 3-phosphate in **non-oxidative phase.**