Respiratory Substrates

Introduction

Any biological molecule that can be broken down in respiration to release energy is called a respiratory substrate. Cells respire glucose, but they also have the ability to respire other carbohydrates, lipids, and proteins – these are all respiratory substrates. Different respiratory substrates enter respiration at different stages – glucose begins at glycolysis. Proteins and lipids enter respiration at the Krebs cycle.

Respiratory quotients

When an organism respire a specific respiratory substrate, the respiratory quotient (RQ) can be calculated. The respiratory quotient is the ratio of the volume of carbon dioxide evolved to that of oxygen consumed by an organism, tissue, or cell in a given time. The equations are as follows;

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

$$RQ = \frac{\text{Molecules of } CO_2 \text{ released}}{\text{Molecules of } O_2 \text{ consumed}}$$

The lower the RQ value, the more oxygen is needed to oxidise the molecule.

Respiratory Substrate	Respiratory Quotient
Lipids (triglycerides)	0.7
Proteins or amino acids	0.9
Carbohydrates	1.0
Oxalic acid	4.0

Example

Oleic acid ($C_{18}H_{34}O_2$) is a fatty acid that can be respired. The equation for aerobic respiration using oleic acid is as follows:

$$2C_{18}H_{34}O_2 + 51O_2 \rightarrow 36O_2 + 34H_2O + \text{energy}$$

Therefore, the RQ value for oleic acid is = (Molecules of CO_2 released)/(Molecule of O_2 released)

36/51

0.71

Uses of the respiratory quotient

You can work out the respiratory quotient for a whole organism as well as a particular substrate. The RQ value for a whole organism is an average of all the respiratory quotients for all the molecules an organism is respiring, it is worked out by directly measuring the volume of oxygen consumed and the volume of carbon dioxide released.

The RQ value for an organism is useful because it tells you what substrate an organism is respiring and whether aerobic or anaerobic respiration is occurring.

- Under normal conditions, the RQ value for a human is between 0.7-1.0. Showing both lipids and carbohydrates are being respired. Protein isn't respired unless there is nothing else.
- High RQ values, greater than 1.0, mean the organism is short of oxygen and is having to respire anaerobically.
- Plants have a low RQ, this is because the CO_2 released is used in photosynthesis.