

Living Cells

Part D Respiration

Energy is measured in joules (J) and kilojoules (kJ). 1000 J is the same value as 1 kJ. Our food is a store of chemical energy - when it is burnt the energy is released as heat energy. Scientists use a calorimeter to determine the energy content of different foods.

Our cells release the energy stored in our food by the process known as respiration. Respiration is a series of enzyme-controlled reactions. The energy released from our food by respiration is used for other chemical reactions and to maintain our bodies at a constant temperature.

The series of enzyme-controlled reactions known as respiration releases a huge amount of energy. This energy is taken up by the molecule adenosine diphosphate (ADP) causing it to bind an additional inorganic phosphate (Pi) making adenosine triphosphate (ATP). An ATP molecule stores energy that the cell can access as and when it requires.

To release the energy stored in ATP, enzymes catalyse the breakdown of ATP into ADP and Pi. Cells may use this energy for other cellular processes e.g. the manufacture of protein molecules.

When sufficient oxygen is available to a cell, then it will perform aerobic respiration on its food. This releases 38 molecules of ATP per molecule of glucose used.

When insufficient oxygen is available to a cell, then it will perform anaerobic respiration on its food. This releases 2 molecules of ATP per molecule of glucose used.

Aerobic and anaerobic respiration occurs as a series of enzyme-controlled reactions. The first stage of both aerobic and anaerobic respiration is the same.

The process of glycolysis is the first stage of respiration. During glycolysis, one molecule of glucose is converted into 2 molecules of pyruvic acid. The conversion of glucose into pyruvic acid releases sufficient energy to form two molecules of ATP.

(d) Respiration

Under aerobic conditions the pyruvic acid molecules combine with oxygen in another series or cycle of reactions resulting in water and carbon dioxide being produced. As the pyruvic acid molecules combine with oxygen, a huge amount of energy is released. This energy is used by the cell to generate a further 36 molecules of ATP per molecule of glucose used (18 molecules of ATP per pyruvic acid molecule used).

In animals, under anaerobic conditions, the pyruvic acid molecules generated by glycolysis are converted into lactic acid. No molecules of ATP are generated as pyruvic acid is converted into lactic acid.

If lactic acid is exposed to oxygen, it will be converted back into pyruvic acid. The cells can then use lactic acid in the aerobic pathway. The quantity of oxygen required to convert all the lactic acid formed by anaerobic respiration back to pyruvic acid is known as the oxygen debt.

Anaerobic respiration in animal cells is said to be reversible.

In plants, under anaerobic conditions, the pyruvic acid molecules generated by glycolysis are converted into ethanol and carbon dioxide. No molecules of ATP are generated as ethanol and carbon dioxide are formed. The carbon dioxide is released and is therefore lost from the system. Anaerobic respiration in plant cells is irreversible since carbon dioxide is lost from the system. Ethanol cannot be converted back into pyruvic acid.

The rate of respiration is measured using a respirometer. To measure the rate of respiration we measure the volume of carbon dioxide produced in a given time. The greater the volume of carbon dioxide produced in a given time, the faster the rate of respiration.