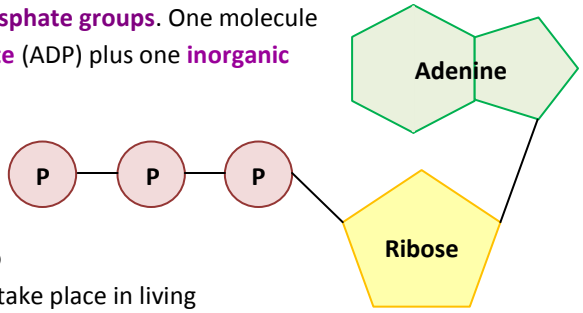
4.1 Respiration

Why organisms undergo respiration

What is respiration and why do we need it?

Respiration is the process whereby energy is released from food molecules (most usually glucose). It takes place inside living cells, both eukaryotic and prokaryotic. The process takes place inside the cytoplasm and the mitochondria. Energy is used to synthesise **adenosine triphosphate** (ATP), which acts as a short-term energy store in cells. All living organisms need energy to drive their metabolic reactions.

A molecule of ATP consists of one **adenosine** molecule and three **phosphate groups**. One molecule can be hydrolysed to produce one molecule of **adenosine diphosphate** (ADP) plus one **inorganic phosphate** (Pi). This hydrolysis reaction releases 30.6kJ of energy so energy is immediately available to all cells in small amounts that will not damage the cell or be wasted.



ATP is described as the **universal energy currency** of cells. This is because it is a high-energy molecule which can be used at any time to release energy for all **metabolic** reactions (biological reactions which take place in living organisms). It can be used for both *anabolic* reactions (building large molecules) and *catabolic* reactions (breaking large molecules into smaller ones).

Aerobic and anaerobic respiration

There are two very different versions of respiration which occur under different conditions. Eukaryotic organisms undergo **aerobic respiration** under conditions where oxygen is present. Where oxygen is not present, **anaerobic respiration** occurs. Both types of respiration begin with one stage, *glycolysis*, which is also called the common pathway (as both aerobic and anaerobic use it). Under aerobic conditions, there are a further three key stages which you will meet in this chapter. Under anaerobic conditions, there is only an extension on the glycolysis pathway which you will again meet later.

Enzymes and coenzymes

During respiration (particularly under aerobic conditions), there are a number of enzymes and coenzymes involved. The key enzymes used are:

- *decarboxylase* – an enzyme which removes carbon dioxide from a molecule
- *dehydrogenase* – an enzyme which removes hydrogen from a molecule

Although these enzymes are useful in catalysing metabolic reactions, they are not very useful for **oxidation** and **reduction** reactions (adding and removing oxygen, hydrogen or electrons). For these reactions, a number of **coenzymes** are used. The key coenzymes are *NAD* (nicotinamide adenine dinucleotide) and *CoA* (coenzyme-A). Also important during one stage of aerobic respiration is the **cofactor** *FAD* (flavine adenine dinucleotide).

Mitochondria

The common pathway series of reactions, or *glycolysis*, takes place not in the mitochondrion, but in the cytoplasm. During this stage, one molecule of glucose is taken and broken down into two molecules of a compound called *pyruvate* (see 4.2 Glycolysis). The pyruvate produced is then transported into the mitochondrion, into the **mitochondrial matrix**, where the following two stages occur. The final stage then occurs across the mitochondrial matrix, the inner mitochondrial membrane and the intermembrane space of the mitochondrion.

It should be noted that as anaerobic respiration does not involve any of the steps beyond glycolysis, anaerobic respiration does not concern the mitochondrion, as nothing takes place there.