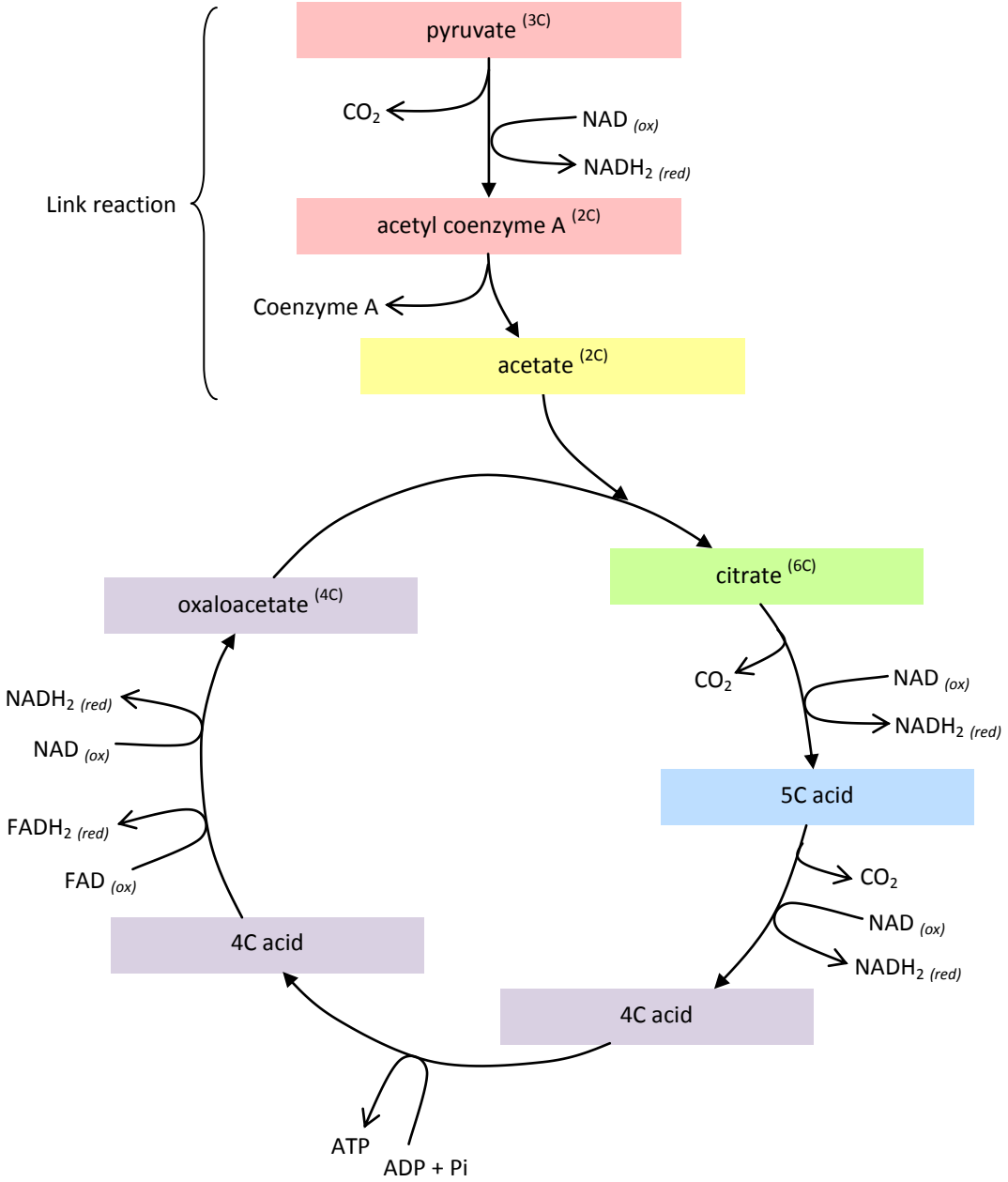
4.3 Krebs cycle

The link reaction and Krebs cycle as stages of aerobic respiration in the mitochondrion

The link reaction

The first stage in respiration, whether it's aerobic or anaerobic, is glycolysis. This produces two molecules of ATP, two molecules of reduced NAD and two molecules of pyruvate. It is these pyruvate molecules which we are interested in for the next stage of *aerobic respiration*. The **link reaction** does not concern anaerobic respiration. The link reaction takes pyruvate and involves dehydrogenation and decarboxylation to produce **acetate**.



During the link reaction, the pyruvate molecule must undergo **decarboxylation** and **dehydrogenation**. The enzymes pyruvate decarboxylase and pyruvate dehydrogenase remove the carboxyl group (which will become a carbon dioxide molecule) and the hydrogen atoms respectively from the pyruvate molecule.

The coenzyme **NAD** (nicotinamide adenine dinucleotide) accepts the two hydrogen atoms becoming reduced $NADH_2$ and the **coenzyme-A** accepts **acetyl** (from pyruvate) to become **acetyl coenzyme A**. The function of coenzyme-A is simply to carry the acetyl from the link reaction to Krebs cycle.

Krebs cycle

The link reaction takes place inside the mitochondrial matrix (the liquid centre of the mitochondrion). The process which follows, **Krebs cycle**, also takes place here. Krebs cycle consists of a number of reactions which (in one turn of the cycle):

- produces two molecules of carbon dioxide
- produces one molecule of ATP
- reduces three molecules of NAD to $NADH_2$ and reduces one molecule of FAD to $FADH_2$

The chain of reactions for Krebs cycle are as follows:

1. The acetate is offloaded from acetyl coenzyme A (leaving the coenzyme-A free to collect more acetyl and repeat) and joins with **oxaloacetate**, a four-carbon compound, to form **citrate**, a six-carbon compound
2. Citrate is decarboxylated (one molecule of CO_2 removed) and dehydrogenated (two hydrogen atoms removed) to form a five-carbon compound; and the hydrogen atoms are accepted by an NAD molecule, which gets reduced
3. The five-carbon compound is decarboxylated and dehydrogenated to give a four-carbon compound and another reduced NAD molecule
4. This four-carbon compound is changed into a different four-carbon compound, and in this reaction, one molecule of ADP is phosphorylated to produce one ATP molecule (this is the only ATP produced directly from Krebs cycle)
5. The new four-carbon compound is again changed into a third and final four-carbon compound – this being a 'regenerated' oxaloacetate – and during this reaction, one molecule of the molecule FAD is reduced to $FADH_2$ and one molecule of NAD is reduced to $NADH_2$

One complete cycle occurs for each pyruvate molecule. Therefore, for every molecule of glucose (since that produces *two* molecules of pyruvate), there are *two* turns of the cycle. This means that for one molecule of glucose, two molecules of ATP are produced directly from Krebs cycle; six molecules of reduced NAD are produced and two molecules of reduced FAD are produced, as well as four carbon dioxide molecules being released.

Whilst the ATP are not produced directly from Krebs cycle, the reduced NAD and FAD molecules go on to produce the ATP in the process which follows Krebs (see 4.4 Electron transport chain).