

The origins of mitochondria

Fact sheet

Our story begins 2 Billion years ago.

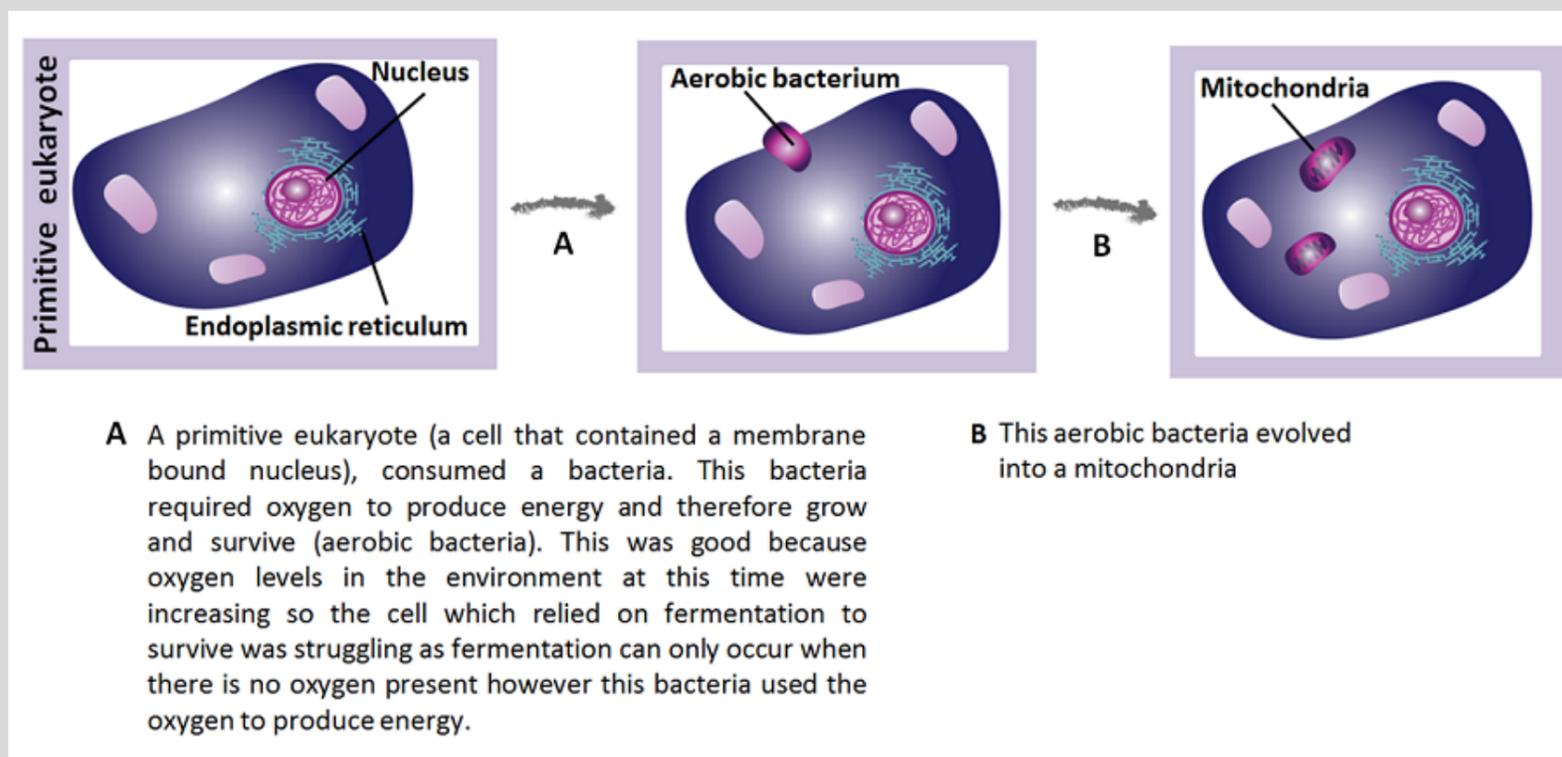
The earth was still developing and changing, life was becoming more complex. The earliest life on earth survived by breaking down the compounds around them into something less complicated (by a process of fermentation) which generated energy that they could use to survive and reproduce. Fermentation can only occur when there is no oxygen present.

However, a new type of cell was developing that could use light to generate energy (by a process of photosynthesis), in the same manner that plants do today. This process uses carbon dioxide and produces oxygen. These cells were increasing in number at an alarming rate and because of this the concentration of oxygen in the atmosphere was increasing. This was bad news for the organisms that relied on fermentation, or that could not tolerate high oxygen levels.

It was good news however for organisms such as *Rickettsia prowazekii* (let's call them Ricke for short!). These bacteria belong to a family of bacteria called the α -proteobacteria and are the bacteria responsible for human Typhus, a disease estimated to have killed 20-30 million people in the years following the First World War. Billions of years ago, Ricke had the advantage, they could use oxygen to produce energy to survive and reproduce. However Ricke is a small bacterium (less than one thousandth of a millimetre in size) and was probably consumed by other organisms. All life on earth had to adapt to survive and exist within the changing atmosphere.

It is likely that at some point Ricke were taken up by a larger host cell but was not broken down. The host cell could now survive since Ricke provided a way to produce energy that used the increasing levels of oxygen within the atmosphere. The benefit for Ricke was the protection from other predatory cells. This mutually beneficial relationship has lasted for millennia.

Over the past billion years Ricke has changed and become what we now call mitochondria. It has lost most of its independent function and much of its DNA to the nucleus of the host cell. A small amount of DNA however has been retained by mitochondria and it uses this DNA to make the components necessary to produce energy. The mitochondria could now no longer survive as an independent organism and relies entirely on the host cell to carry out its functions. This process is illustrated in the diagram below:



There is a lot of evidence to support this theory for the origin of mitochondria, this evidence includes;

1. The fact that the DNA contained within mitochondria is circular which is different to the DNA on our chromosomes and is similar to the DNA found within bacteria.
2. Mitochondria have two membranes.
3. The DNA contained within the mitochondria is very similar to the DNA of Ricke but is much smaller, due to the donation of information to the nucleus.

Without this relationship, these mitochondria and their energy generation, organisms would not have been able to grow bigger and become more complicated. In short we would not be here today.