

Oxygen and life: energy *vs* death

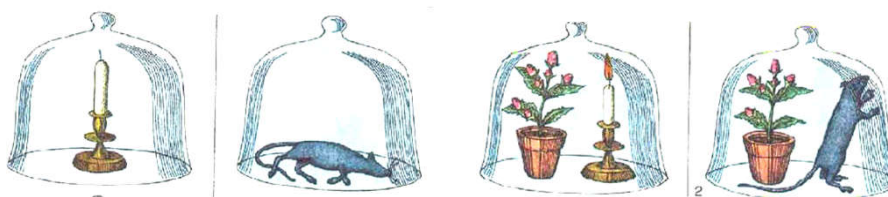
Dr. Alexander Galkin



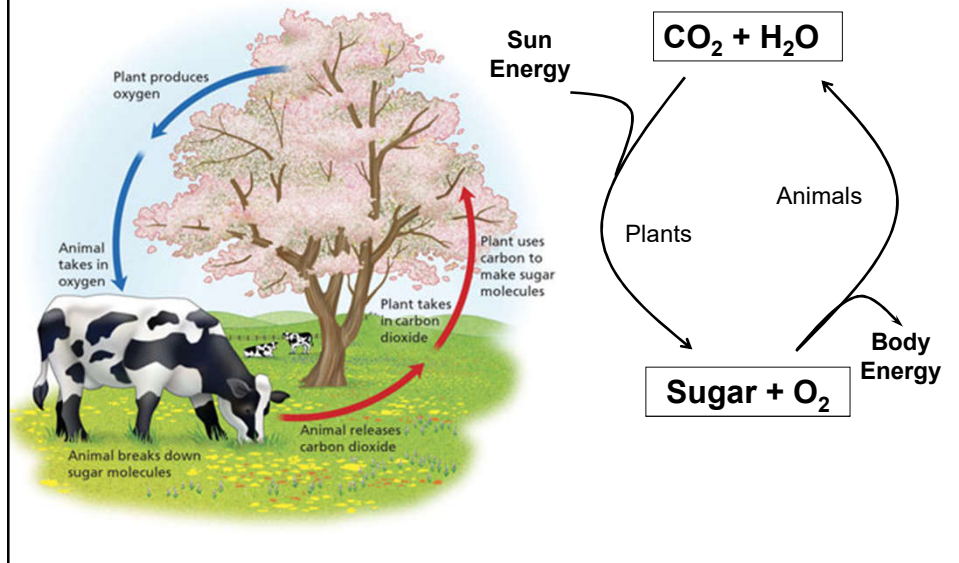
Joseph Priestley

Discovery of oxygen 1774-1779

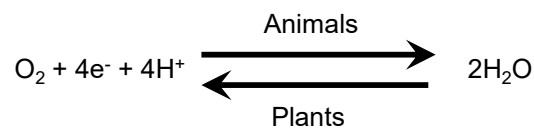
He found that a mouse kept with a plant would survive. These kinds of observations led Priestley to offer an interesting hypothesis that plants restore to the air whatever breathing animals and burning candles remove - what was later coined by Lavoisier "oxygen".



Energy and oxygen



What is happening with oxygen?



Oxygen molecules are being reduced by our body into water (O_2 accept electrons)

RESPIRATION



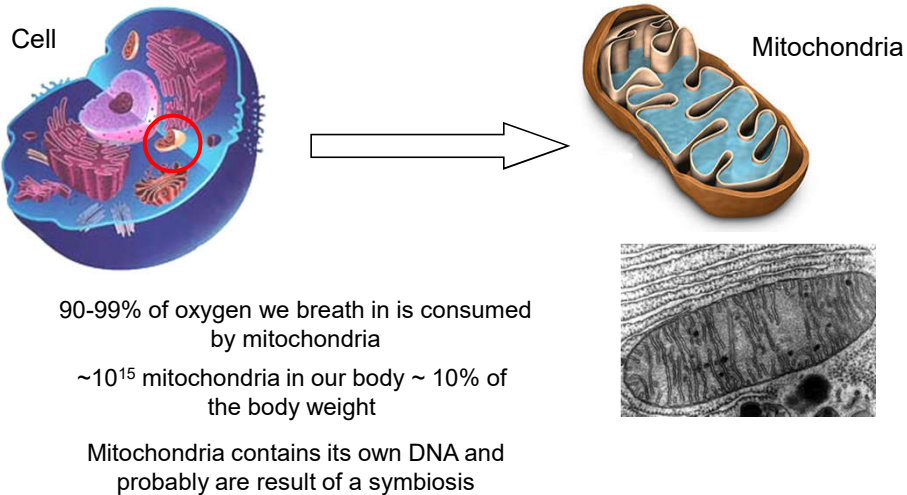
Plants are able to oxidise water molecules and release O_2 (H_2O loses electrons)

PHOTOSYNTHESIS



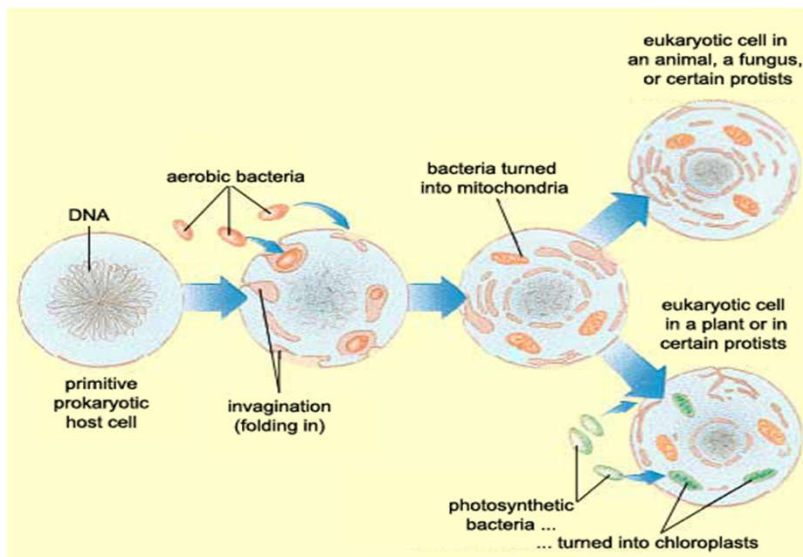
Where is it happening?

Adult consumes around 380 litres of O_2 each day
(top athletes can sustain 10 times greater rate)

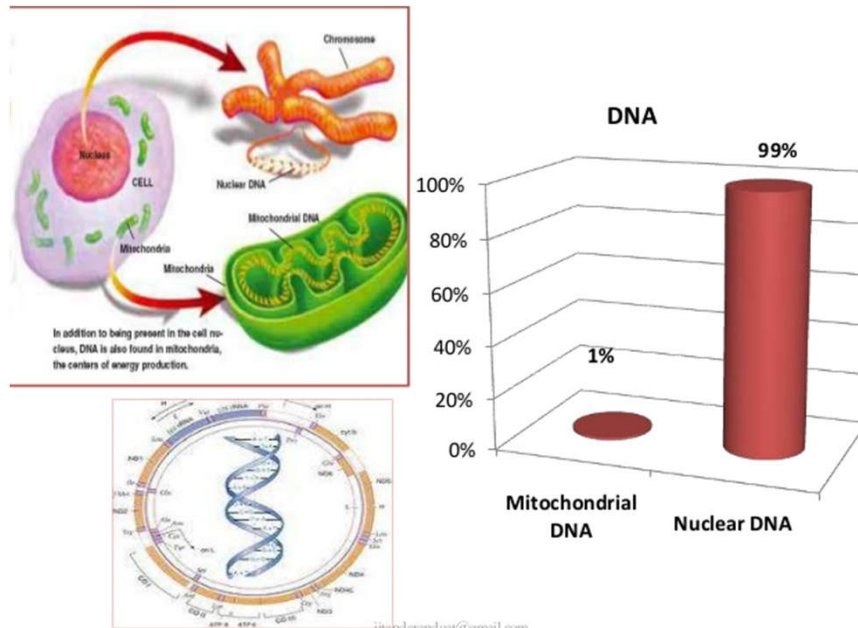


Origin of mitochondria?

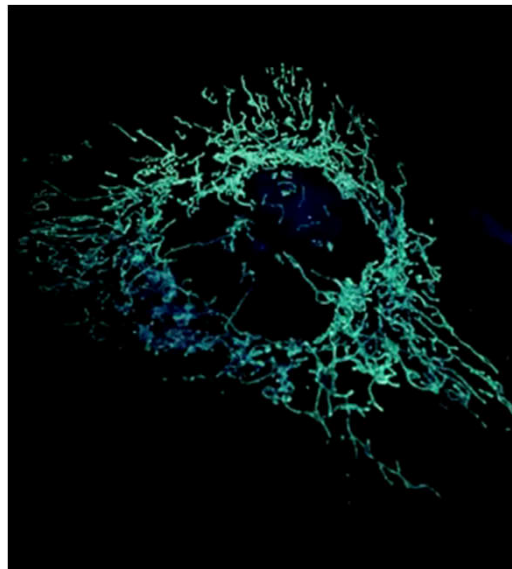
Endocymbiotic theory



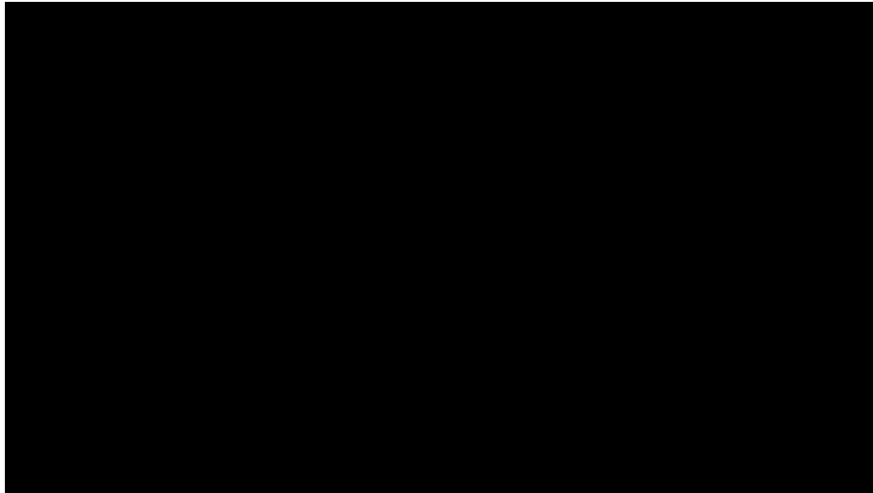
Mitochondrial DNA and nuclear DNA



Mitochondria are not sausages – it is a network!



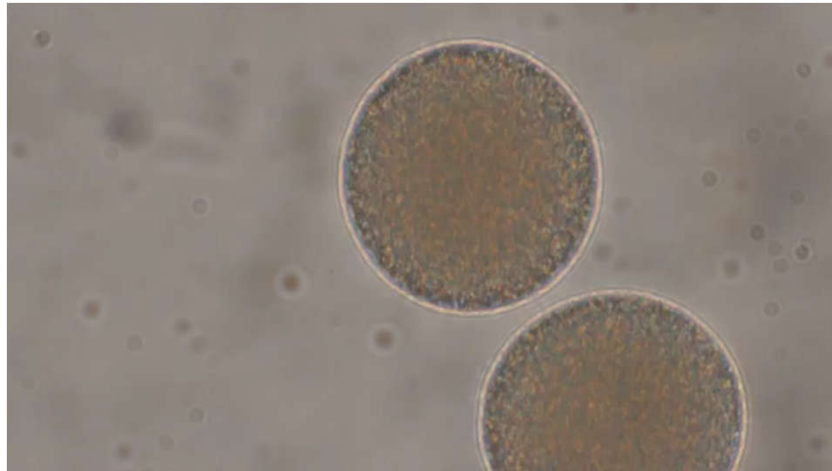
Mitochondria can be transported
within the cell!



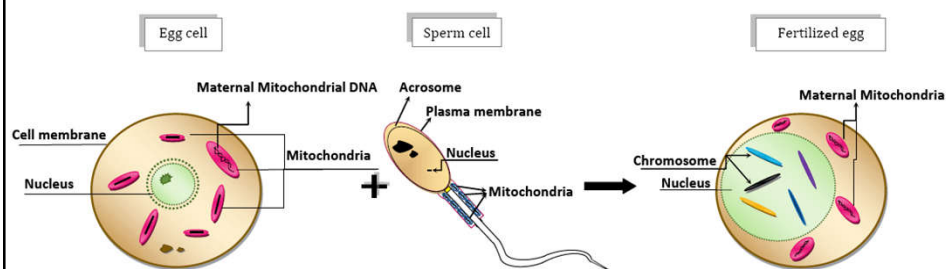
Maternal inheritance



Maternal inheritance

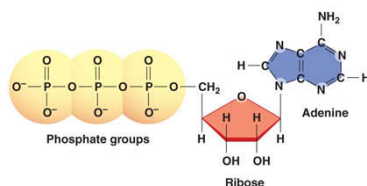


Maternal inheritance

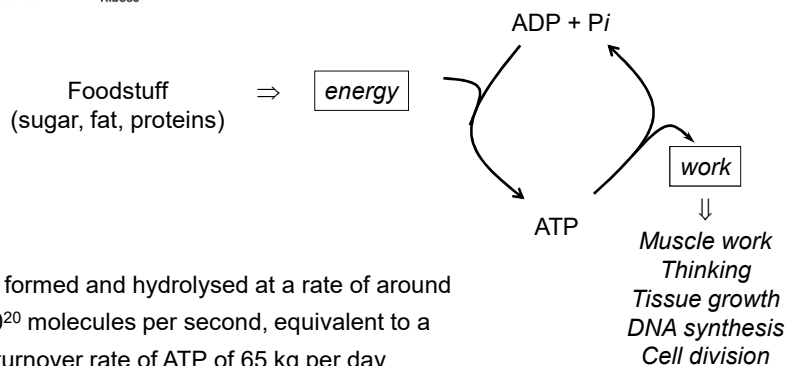


Boys and girls! In all of us
mitochondria come from the mother!!!

How is energy generated?



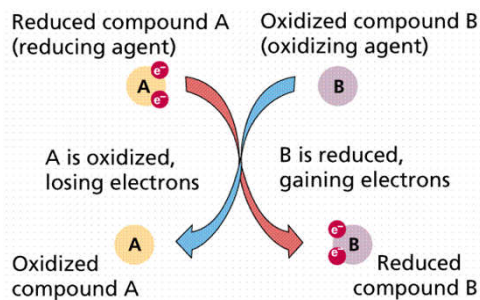
ATP is regarded as a universal source of energy occurring in all cell types. In animals it is produced during the degradation of foodstuff.



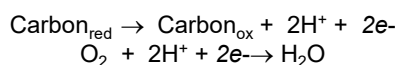
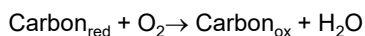
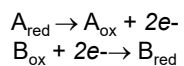
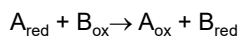
ATP is formed and hydrolysed at a rate of around 9×10^{20} molecules per second, equivalent to a turnover rate of ATP of 65 kg per day

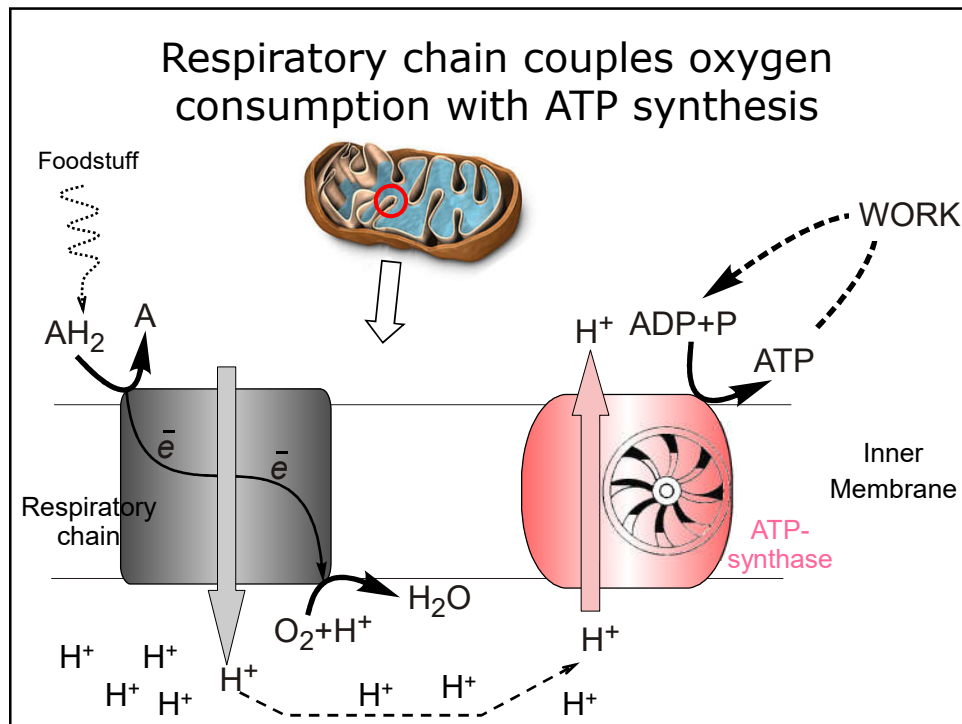
Redox reactions

(reduction-oxidation reactions)



Electrons sitting on A have higher energy than electrons sitting on B !!!



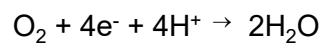


Mitochondria are main source of energy production in a cell

Most likely mitochondria are responsible for production of 90% of our ATP.

Inner mitochondrial membrane ~1400m²

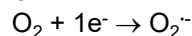
During respiration in mitochondria oxygen undergoes 4-electron reduction:



but...

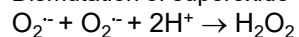
Reactive oxygen species (ROS)

One electron reduction of molecular oxygen



Superoxide radical
(photochemistry or biological systems)

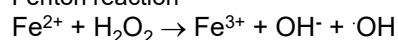
Dismutation of superoxide radical



Hydrogen peroxide
(hair lightening)

Transition metal ions catalyse

Fenton reaction



Hydroxyl radicals
(house bleach)

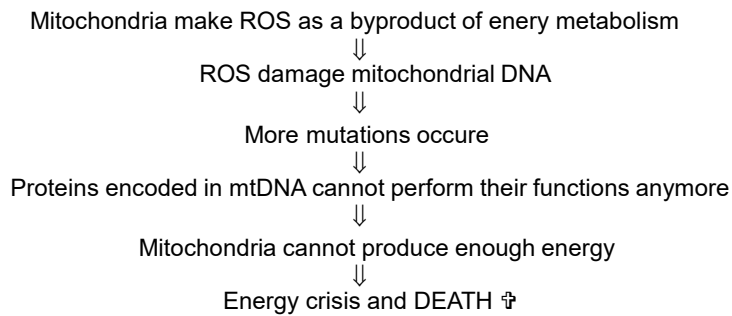
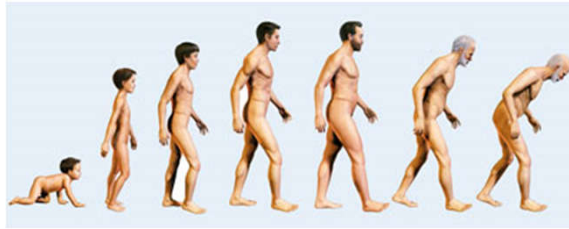
Small fraction of electrons can “leak” from the respiratory chain. Some of oxygen molecules can be reduced by less than 4 electrons and form “free oxygen radicals” or reactive oxygen species (ROS) – these molecules urgently want to accept or to release electrons to go to the low energy state \Rightarrow they are highly reactive and can interact with other molecules in a cell – proteins, DNA and membrane lipids.

Sources of ROS

- Enzymatic = leak from mitochondria and other systems
- Toxic compounds (paraquat, sulfa drugs, antimalarial drugs)
= these can be called “pro-oxidants”
- Smoking
- Ionising radiation and UV

Why mitochondria killed us in the end?

Mitochondrial free radicals theory of ageing



How to change the situation?

Molecules that can scavenge ROS are called antioxidants (found in fruits and vegetables).



Caloric restriction after 40 yo – the less electrons are going through the mitochondria, the less leak would happen.



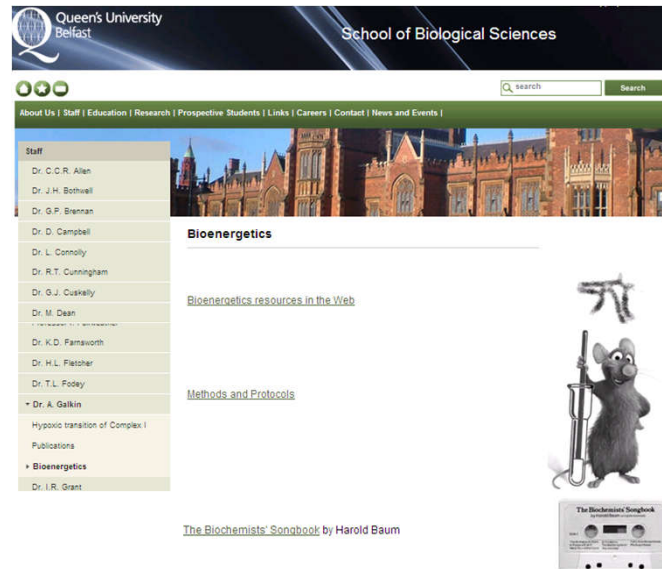
Physical exercises strongly stimulate natural mechanisms of ROS detoxification



Girls and boys! Fruits, caloric restriction after 30-40 yo and physical!

More stuff and bioenergetics links

<http://www.qub.ac.uk/bb/Staff/DrAGalkin/>



The screenshot shows the website for the School of Biological Sciences at Queen's University Belfast. The header includes the university logo and the school's name. A navigation bar lists various links such as 'About Us', 'Staff', 'Education', 'Research', 'Prospective Students', 'Links', 'Careers', 'Contact', 'News and Events'. A search bar is also present. The main content area is titled 'Bioenergetics' and features a large image of a historic building. Below this, there are links for 'Bioenergetics resources in the Web' and 'Methods and Protocols'. A sidebar on the left lists staff members, including Dr. C.C.R. Allen, Dr. J.H. Bothwell, Dr. G.P. Brennan, Dr. D. Campbell, Dr. L. Connolly, Dr. R.T. Cunningham, Dr. G.J. Cuskelly, Dr. M. Dean, Dr. K.D. Farnsworth, Dr. H.L. Fletcher, Dr. T.L. Foley, Dr. A. Galkin, Hypoxic transition of Complex I, Publications, and Bioenergetics. At the bottom, there is a link to 'The Biochemists' Songbook by Harold Baum' and an image of a cassette tape labeled 'The Biochemists' Songbook'.