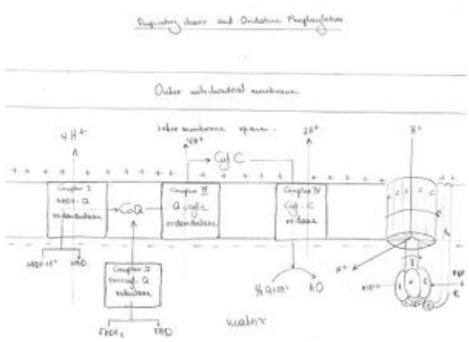
Respiratory chain Oxidative phosphorylation

Respiratory chain and Oxidative phosphorylation

Respiratory chain

The repiratory chain is a collection of enzymes that induce the electrochemical gradient of protons (H^+), necessary for the ATP synthesis. Fatty acid, amino acid and monosaccharide metabolism yields acetyl-CoA, a molecule that is oxidized in the Citric acid cycle producing reduced coenzymes ($NADH+H^+$, $FADH_2$) and GTP. These coenzymes are subsequently collected and transported by the repsiratory chain, directing them to their final reaction with O_2 to form H_2O. The respiratory chain consists of enzymes that are found only in the inner membrane of mitochondria, thus only mitochondrion-containing cells are able to produce energy through oxidative phosphorylation (aerobic respiration). Mitochodrionless cells, such as erythrocytes, produce energy only through glycolysis, an anaerobic process of glucose oxidation into pyruvate.



The respiratory chain

Oxidative phosphorylation

It is the process through which the liberated free energy provided by the electrochemical gradient of protons (H^+), is trapped as high energy phosphate. The electrochemical built-up of hydrogen ions, by the respiratory chain is used to drive protons through an enzyme called ATP synthase. The kinetic energy of protons is used by the synthase to store energy as high energy phosphate in ATP by binding ADP and P_i.

Components of the respiratory chain

Electrons flow through the repsiratory chain, passing through three large protein enzyme complexes.

1. **NADH-Q oxidoreductase/Complex I:** the electrons are transported from the $NADH+H^+$ to coenzyme Q
2. **Q-Cytochorme c oxidoreductase/Complex III:** coenzyme Q passes the electrons to the cytochrome c
3. **Cytochrome c oxidase/Complex IV:**completes the chain, passing the electrons to O_2 and causing it to be reduced to H_2O
4. **Succinate-Q reductase/Complex II:**the electrons are transferred from $FADH_2$ to coenzyme Q

The flow of electrons through the respiratory chain generates ATP through the process of oxidative phosphorylation. Enzyme complexes I, III and IV act as proton pumps which cause the accumulation of protons in the intermembrane space of mitochondria constituting it more positive than the intramembrane space (matrix) which becomes progressively more negative building an electrochemical gradient with protons hving the tendency to return back into the matrix which is more negative. The only way to do that is passing through the ATP synthase which exploits their energy to form ATP.

Inhibitors

Inhibitors of the respiratory chain:

- Barbiturates: they inhibit complex I/NADH-Q oxidoreductase, preventing electron transfer from $NADH+H^+$ to coenzyme Q
- CO_2, H_2S and CN^-: they inhibit complex IV/cytochrome c oxidase preventing reduction of O_2 to H_2O
- Antimycin A: it inhibits complex III/Q-cytochrome c oxidoreductase preventing transfer of electrons from CoQ to cyt c.

Inhibitors of the oxidative phosphorylation: atractyloside which inhibits ATP synthase by blocking the flow of protons through the F_0 subunit. **Uncouplers of oxidative phosphorylation:** 2,4 dinitrophenol which uncouples proton pumping from ATP synthesis because it carries protons across the inner mitochondrial membrane (no ATP synthase inhibiton, rather elimination of the proton electrochemical gradient built-up)

Links

Bibliography

MURRAY, Robert K. – BENDER, David A.. *Harper's Illustrated Biochemistry.* 29th edition. McGraw-Hill Companies, Inc., 2012. ISBN 978-0-07-176576-3.