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Aerobic Respiration: Oxidation-Reduction Reactions and Electron Carriers

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Electron carriers are any of various molecules that are capable of accepting one or two electrons from one molecule and donating them to another in the process of electron transport. During the process of aerobic respiration, coupled oxidation-reduction reactions and electron carriers are called an electron transport chain (ETC). The diffusible electron carriers NADH and $FADH_2$ in an ETC carry hydrogen atoms (protons/electrons) from substrates in exergonic catabolic pathways such as glycolysis and the citric acid cycle to other electron carriers that are embedded in membranes. These membrane-associated electron carriers include NADH dehydrogenases, flavoproteins, iron-sulfur proteins, quinones, and cytochromes. The last electron carrier in the ETC transfers the electrons to the terminal electron acceptor, oxygen. The ETC of each eukaryotic cell is simple, whereas that of each prokaryotic cell shows differently for each bacterium. The following example is the ETC of eukaryotic cells after the TCA cycle. NADH dehydrogenase oxidizes NADH, reduced in various catabolic pathways, to NAD^+. It contains FMN and forms with iron-sulfur proteins a complex I. FMN is reduced with NADH and iron-sulfur proteins and carries protons from $FMNH_2$ to quinines. Flavoproteins contain FMN and FAD, and their redox potential not vary due to the flavin structure, but to the differences in the protein component. Iron-sulfur proteins contain iron-sulfur clusters (2Fe-2S or 4Fe-4S), and carry protons as well as electrons. There are many [Fe-S] proteins transferring elections in the membrane. Enzymes catalyzing oxidation-reduction proteins including hydrogenase, formate dehydrogenase, pyruvate: ferrodoxin oxidoreductase and nitrogenase are [Fe-S]. Two structurally different quinines (ubiquinone and menaquinone) are involved in the ETC, and served as coenzyme Q. Ubiquinone is found in mitochondria, and menaquinone exists in bacteria. Quinones are highly hydrophobic and mobile in the semi-solid lipid phase of the membrane, and can carry protons as well as electrons. Cytochromes are hemoproteins classified according to their prosthetic heme structures and absorb light at 550-650 nm. Cytochrome b_{562} (cyt b) absorbs with the max. wave length at 562 nm. Heme is covalently bound to cyt c. As Cytochromes carry only one electron, reduced electrons from coenzyme Q should be transferred by two steps (Q-cycle). Redox potential in the ETC ($E^{o'}$; mV): calculated based on Q-cycle is as follows;

NAD/NADH (-320)→FMN/$FMNH_2$ (-110)→Ubiquinone/ubiquinol (113)→cyt c1 (230)→cyt c (254)→cyt aa3 (290)→H_2O/0.5O_2 (820)

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