Energy Conversion in Biology

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Oxygen evolving life may have begun on earth about 3,400 billion years ago. The interpretation of geochemical evidence, for example in the Buck Reef Chert, is disputed, but evidence from fossilised stromatolites in Australia is perhaps more convincing. Modern oxygen evolving photosynthesis requires more than 1000 proteins, many of them organised in complex membrane bound structures. Light energy from the sun is trapped in carbohydrates and fats, providing our food with its calorific value. We release the energy by respiration, consuming in the process most of the oxygen that we have breathed in. More than 1000 proteins are involved in cellular respiration, and about 100 of them are organised in the inner membranes of mitochondria as the respiratory enzyme complexes that function as molecule machines to convert the redox energy derived from energy in food-stuffs into adenosine triphosphate (ATP), the energy currency of biology. The final synthetic step is achieved by a remarkable molecular machine with a mechanical rotary action. Its closest man-made analogue is the Wankel rotary engine. The rotor of the biological machine is driven at about 100-200 rpm by a trans-membrane proton-motive force (analogous to the electron-motive force in electricity). The mechanical action of the rotor drives the chemistry of the formation of ATP from ADP and phosphate in the three catalytic sites of the enzyme. How this biological machine works, the medical consequences of dysfunctional energy conversion, and the possible evolutionary origins of the rotary machine will be discussed in the lecture.