5. Cell energy systems - photosynthesis

We take for granted that life on Earth depends on one parameter – energy from the Sun. This energy is captured and transformed by an incredibly complex process called photosynthesis. All the energy released by the burning of coal, firewood, liquid fuels, natural gas and produced by our bodies as a result of burning all the food we eat has been captured from sunlight by photosynthesis. We are surrounded by trillions of energy generating factories and these units are the green leaves of plants.

The process of photosynthesis is very ingenious. It uses carbon dioxide and water to obtain sugars and other carbohydrates. These compounds work in the cell as fuels which are energizing all the cell's functions. Describing its function is beyond this blog, although in my book I provide an easy to understand description of the whole process.

The process of photosynthesis is based on atomic physics, where electrons and protons play the most important role. The energy from the Sun is collected by chlorophyll which is a green pigment located in plant leaves. Chlorophyll molecules absorb light of certain wavelengths. Normally there are several different chlorophylls in plant leaves which absorb blue, violet and red light, and reflect yellow and green light giving them a green color. This pigment is built from 137 atoms, it has a very intricate structure and its biosynthesis is extremely complex.

The photosynthesis process is carried out by two large molecular complexes known as photosystem I and photosystem II. Each photosystem is a network of chlorophyll molecules, accessory pigments and associated proteins. The complexity of photosystems I and II is extraordinary. They includes many thousands of amino acids and are built from about 150,000 and 100,000 atoms respectively. They are very efficient energy generating machines. For example, in saturated light photosystem II can have an energy throughput equivalent to 60 MW per mole which would be more than the power of the largest gas turbine.

Photosystem II and photosystem I work in sequence. A photon of light ejects a high-energy electron from photosystem II. The energy of that electron is used to pump a proton across the thylakoid membrane, contributing to the production of a molecule of ATP. Eventually this electron arrives at photosystem I where a second photon

pushes it to a higher energy level. This electron is used to generate an NADPH molecule.

ATP is a special molecule which is used to deliver energy to every cell of every living organism. What is interesting is that all organisms from the simplest bacteria, fungi and plants, to all animals, mammals and man use exactly the same type of molecule.

The last stage of photosynthesis is to make organic molecules, such as sugars, from carbon dioxide. This process takes place during the Calvin cycle where the enzyme Rubisco binds carbon dioxide and incorporates it into the carbohydrate. Rubisco is a very large enzyme made of about 70,000 atoms. During the Calvin cycle carbon dioxide comes from air and the energy needed for the reactions comes from photosynthesis in the form of ATP. Overall thirteen enzymes are required to catalyze the reactions in the Calvin cycle.

Do not worry if you cannot follow these processes. They are so complex that only a few scientists can really understand them. I just want to show you how incredibly complex the process of photosynthesis is and to make you aware that this process has been working right from the beginning of life on Earth.