UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Natural and Agricultural Sciences

Fakulteit Natuur- en Landbouwetenskappe
Lefapha la Disaense tša Tlhago le Temo

Public Lectures

Solar Energy and Photosynthesis

Dates: 3 – 5 Oct. 2017
Venue: Scienza, University of Pretoria
Time: 17:30 – 19:00

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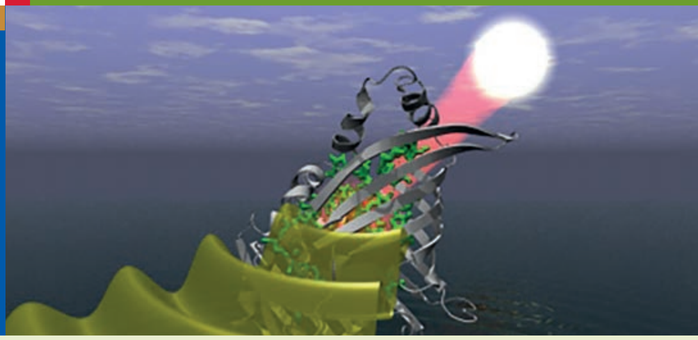

The present global energy demand of approximately 17 TW is predicted to increase twofold by 2050 as the result of population and economic growth. Africa's energy demand will probably be the highest of all continents. The challenge in fulfilling in a sustainable way our high demand for energy is not one of an inherent lack of available energy. In fact, the amount of solar energy reaching the earth's surface in one hour is more than mankind's energy demand for an entire year. The solution is already found in nature: photosynthesis is the only process that converts solar energy into chemical energy on a massive scale. We have reached a stage in mankind's history where scientists know the intricate details of the photosynthetic process sufficiently well to use the underlying design principles as inspiration for solar energy technologies.

In this public lecture series, leading scientists from the Netherlands, Germany and France will reveal the secrets of natural and artificial photosynthesis. Specifically, the remarkable design aspects of energy transfer and charge separation in photosynthetic organisms will be described up to the minutest length and time scales, it will be shown how the photosynthetic process is engineered to give rise to a stable form of energy despite the fact that the overall process seems to defy the Second Law of Thermodynamics, and finally, the way in which we can redesign photosynthesis to meet mankind's enormous energy demands will be detailed.

3 Oct. 2017: Energy Transfer and Charge Separation in Photosynthesis

Speaker: Prof Rienk van Grondelle (Dept. Biophysics, Vrije Universiteit Amsterdam, the Netherlands)

Photosynthetic bacteria, algae and plants convert the energy of solar photons into stable, chemical free energy that is used by the organism to run the processes of life. After the absorption of a photon by one of the photosynthetic pigments, organized in pigment-proteins associated to a photosynthetic membrane, the energy is transferred very efficiently and very rapidly on an ultrafast timescale to reach a reaction centre, a special (bacterio-)chlorophyll-protein complex in which excitation of the pigments within a few picoseconds (1 picosecond = 10^{-12} seconds) leads to a transmembrane charge separation. We have studied the energy transfer and charge separation processes in bacterial and plant pigment-proteins and reaction centres using ultrafast femtosecond laser spectroscopy (1 femtosecond = 10^{-15} seconds). A new ultrafast laser technique, two-dimensional electronic spectroscopy, was applied that reveals the connectivity between the electronic states involved in the process. We discovered that in the primary ultrafast events the resonant coupling between electronic states of the pigments and vibrational states of the environment plays a crucial role in the efficient and fast conversion of light energy into chemical energy in photosynthesis.

4 Oct. 2017: Photosynthesis as an example of a driven process that leads to systems of lower entropy

Speaker: Prof Emil Roduner (Dept. Chemistry, University of Stuttgart, Germany)

The Second Law of Thermodynamics states that all spontaneous processes require an increase of the entropy of the universe. However, many processes in daily life that lead to higher order / lower entropy occur seemingly spontaneously. Examples are crystallisation, separation of mixtures, photosynthesis and reproduction of living organisms. The lecture will explain how and under which conditions such seemingly forbidden processes become possible.
Topics of special interest include the following:

- Spontaneous processes: driving gradients and heat dissipation
- Compatibility of photosynthesis with the Second Law of Thermodynamics
- Photosynthesis as the source of all atmospheric molecular oxygen (unless this is done elsewhere)
- Heat death of the universe: what does this mean?

5 Oct. 2017: Artificial Photosynthesis: Energy of the Future

Speaker: Prof Bruno Robert (Institute of Biology Technologies, CEA-Saclay, France)

What we call artificial photosynthesis is the attempt to mimic the natural process of photosynthesis and split water into hydrogen with the help of energy from the sun. Why is this idea so appealing? It is because this would give an energy resource that would hold until the sun stops shining. It would also be a clean energy resource that would have very little impact on the environment. There are several different approaches to create artificial photosynthesis, but most of the methods share the same ideas as those used in natural photosynthesis. Most systems have an antenna for harvesting light, a reaction centre for charge separation, catalysis and a membrane to separate the generated products. The reaction is very similar to natural photosynthesis but some reactants must be changed.

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