PREFACE

Photosynthesis is a metabolic pathway that converts light energy into chemical energy. Its initial substrates are carbon dioxide and water; the energy source is sunlight (electromagnetic radiation); and the end-products are oxygen and (energy-containing) carbohydrates, such as sucrose, glucose or starch. This process is one of the most important biochemical pathways, since nearly all life on Earth either directly or indirectly depends on it as a source of energy. It is a complex process occurring in plants, algae, as well as bacteria such as cyanobacteria. This new book presents the latest research in the field with special emphasis on energy, biotechnology and nanotechnology.

Chapter 1 - Material design of artificial light-harvesting nano- and biomaterials mimicking for biological photosynthesis systems is one of the key issues in future applications of nano- and biotechnologies. To realize ideal photosynthetic materials having highly efficient light-harvesting and rapid energy transfer functions artificially, not only methodology of new material design and synthetic procedure but also development of new laser spectroscopic tools to visualize the excited-state dynamics and energy transfer process of materials is highly desired.

In this chapter, first, the authors will demonstrate new material design and synthestic approach for the artificial organic molecules in nanometers scale having highly efficient light-harvesting and energy transfer functions: π-conjugated light-harvesting small dendrimers. In these materials, both the electronic states and molecular structure play an important role for the light-harvesting and energy transfer functions – for example, how π-conjugation between the core and antenna molecules is maintained and whether the molecular structure is planer or not. In the second part of this chapter, the authors will show you the mechanism of the rapid energy transfer in light-harvesting small dendrimers, from temperature-dependent and time-resolved photoluminescence measurements.

To reveal rapid energy transfer processes in light-harvesting nano- and biomaterials, femtosecond pump-probe transient absorption spectroscopy is generally utilized. However, the conventional pump-probe measurements are not feasible for theses materials, where large sample quantities are not readily available and the samples are easily photodegraded after many irradiation of intense laser pulses. In the last part of this chapter, the authors will demonstrate a new scheme for the pump-probe measurements which overcome the above limitation: *femtosecond time-frequency two-dimensional (2D) imaging spectroscopy*. Using this new imaging spectroscopy, the authors can successfully map time-frequency 2D transient absorption signals of the light-harvesting nano- and biomaterials – *β*-carotene in solid films

eventually trapped and results in electron translocation (current). Such an efficiency is unmatched by any other biological or chemical system, thus plant PSI, which is at the top of the evolutionary tree of this kind of complexes, has evolved to operate as the most efficient sunlight capture and conversion device.

Recently the molecular and structural basis of PSI sunlight capture and conversion was determined by the X-ray crystallography [Jordan *et al.*, *Nature*, 2001; Ben Shem *et al.*, *Nature* 2003; Amunts *et al.*, *Nature*, 2007]. This chapter describes a glimpse at the architecture of this most efficient bio-solar energy nano-converter at almost atomic level. In this context, the authors discuss PSI based, future nano-scale sustainable technological solutions and possible applications for hydrogen production utilizing the plant PSI mechanism.

Chapter 9 - Cyanobacterial NADPH dehydrogenase (NDH-1) was identified more than 16 years ago. This enzyme is confined to the thylakoid membrane, and it accepts electrons from NADPH and contains at least 15 subunits. Recently, studies using reverse genetics, proteomics, and activity staining have shown the presence of functionally distinct multiple NDH-1 complexes in cyanobacterial cells. In this mini-review, these cyanobacterial NDH-1 complexes will be described with emphasis placed on their multiplicity and assembly. (1) Firstly, reverse genetic studies proposed the presence of 2 functionally distinct NDH-1 complexes in cyanobacteria; (2) subsequently, proteomic studies revealed the presence of multiple functionally distinct NDH-1 complexes in the cyanobacterial thylakoid membrane, including NDH-1L (large size; 460 kDa), NDH-1M (middle size; 330 kDa) and NDH-1S (small size; 190 kDa). However, none of these NDH-1 complexes showed NADPH dehydrogenase activity. (3) Recently, activity staining studies identified 2 active NDH-1 complexes in a unicellular cyanobacterium. Based on the size, the 2 active NDH-1 complexes were called Act-NDH-1Sup (*act*ive *sup*ercomplex; approximately 1,000 kDa) and Act-NDH-1M (*act*ive *m*ediumcomplex; approximately 380 kDa). Act-NDH-1Sup is a newly identified complex, and its protein activity is much higher than that of Act-NDH-1M. It is also more than twice the size of NDH-1L, while Act-NDH-1M is similar in size to NDH-1M. In addition, both Act-NDH-1Sup and NDH-1L participate in cellular respiration, while both Act-NDH-1M and NDH-1M are involved in CO_2 uptake. Thus, from the analysis of the sizes and physiological functions of these 4 cyanobacterial NDH-1 complexes, it is speculated that Act-NDH-1Sup is an NDH-1L dimer with still unknown activity subunit(s), and that Act-NDH-1M is an active NDH-1M analog. However, the active component(s) and the electron input device of these cyanobacterial NDH-1 complexes has remained undocumented.

Short Communication - Cyanobacteria have been recognized as a source of numerous natural products which are structurally interesting bioactive compounds, including toxins, antibiotics, and siderophores. The authors attend that cyanobacteria potentially hold gene clusters for the biosynthesis of natural products. These genes are distributed in marine and freshwater cyanobacterial genomes. Here, the authors summarize the pathways by which cyanobacterial products are synthesized by huge multienyzme complexes called nonribosomal peptide synthetases (NRPSs). The authors also discuss cutting-edge bioengineering technology in which antibiotics or biochemical matters are artificially created as products, based on good use of the mechanism generating secondary metabolites.