BOOK REVIEW

PHOTOBIOLOGY

The Science of Life and Light.

Second Edition. Edited by Lars Olof Björn, Lund University, Lund, Sweden. Springer 2008.
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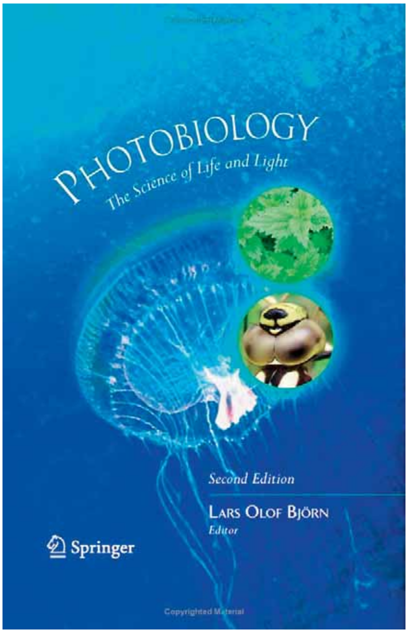

The book contains 25 chapters, written by 17 authors: Lars Olof Björn (*1*, *2*, *3*, *4*, *5*, *6*, *8*, *9*, *10*, *11*, *12*, *18*, *20*, *23*, *24*, *25*); Wolfgang Engelmann (*14*); Helen Ghiradella (*9*, *23*); Govindjee (*12*); Pirjo Huovinen (*18*); Anders Johnsson (*14*); Theresa Jurkowitsch (*22*); Richard E. Kendrick (*16*); Robert Knobler (*22*); Richard L. McKenzie (*18*); Curtis D. Mobley (*7*); Rachel Muheim (*17*); Mary Norval (*21*); David Saunders (*15*); Raymond C. Smith (*7*); Villy Sundström (*13*); James L. Weller (*16*).

Remark: The numbers in italics in parentheses refer to the number of the author's chapter; underlined when written with co-author*.

684 pages, 266 figs (+ 1 on p. *V*). With exhaustive lists of references (about 108 pages).

The book begins (*1*) with a physica1 background explaining the properties of light, the interactions between light and matter, the transfer of electron excitation energy between molecules, including the Förster mechanism, triplet states, and the photobiologically important properties of the dioxygen molecule. Some important concepts as (*2*) energy fluence, energy fluence rate, photon fluence, photon fluence rate as well as some obsolete and superfluous terms are explained and discussed. Various kinds of artificial light sources (*3*) which are of a special interest to photobiological research are also presented and well

* Chapter-Author(s): (*1-6*) Björn; (*7*) Smith – Mobley; (*8*) Björn; (*9*) Björn – Ghiradella; (*10*, *11*) Björn; (*12*) Björn – Govinjee; (*13*) Sundström; (*14*) Johnsson – Engelmann; (*15*) Saunders; (*16*) Weller – Kendrick; (*17*) Muheim; (*18*) Björn – Huovinen; (*19*) Björn – McKenzie; (*20*) Björn; (*21*) Norval; (*22*) Jurkowitsch – Knobler; (*23*) Björn – Ghiradella; (*24*, *25*) Björn

explained. Further (*4*), various thermal, electronic, and chemical devices for the measurement of light are described including the construction and calibration of a spectroradiometer, as well as the measurement of very weak light (e. g. the ultraweak luminescence from living cells). Various light tools (*5*) as optical tweezers, uses of lasers for ablation, desorption, ionisation and dissection, Abbe's diffraction limit to spatial resolution in microscopy, two photon excitation fluorescence microscopy etc. are described and represented as important devices for photobiological research.

The fluence rate (*6*), and the spectral and directional distributions of sunlight are, in all natural daytime light on the Earth's surface, modified by clouds, gases, aerosols and similar factors in the atmosphere, as well as by vegetation, snow and other ground cover of the Earth's surface. The UV-B daylight spectrum and its biological action are of particular interest.

During the passage of solar light through natural waters (underwater light) (*7*) many changes, depending on many variable factors in the atmosphere and in the water, occur.

As to the identification (*8*) of a light absorbing chromophore taking part in a photobiological or biochemical process (changes in DNA , plant light perception, protochlorophyllide photoreduction to chlorophyllide etc.) it can be determined spectrophotometrically by comparing the efficiency of the light of various wavelengths on the intensity of the photobiological or photochemical process.

Spectral Tuning (*9*) is defined as the principles for how the spectra of the pigments are adjusted to the needs of the organisms that produce them. In living organisms the spectral tuning plays an important and significant role in the processes of photosynthesis, vision, bioluminescence, and coloration (both for the needs of protection and signaling). It can be achieved both by chemical means (e.g. by the choice of the pigment) as well as by physical means (e.g. by changing the optical conditions).

In biological light perception (*10*) and regulation many photochemical reactions by light and ultraviolet radiation are based on cis-trans (and trans-cis) isomerisations. On the other hand the blue-light receptors, cryptochrome and phototropin, use other chemical mechanisms, so as the ultraviolet-B receptor, which enables plants to exhibit some regulatory effects and the insects to see, what our eyes cannot perceive.

The diversity of eye optics (*11*) is explained on the examples of the human eye (including the problems of the eye in water and the chromatic aberration), the problems and solutions for amphibian animals, feedback regulation during the eye development, compound eyes, nipple arrays on insect eyes, eyes with mirror optics, scanning eyes, and the evolution of eyes.

Photosynthesis (*12*), a very ancient process on our planet, has had an enormous impact on the biosphere, the chemica1 composition of Earth's surface, and the Earth's atmosphere including the radiation climate.

This very complicated process, using two photosystems in series, to be able of oxidizing water to molecular oxygen and reducing carbon dioxide to organic molecules became the main and dominating process of primary production of organic matter on the Earth through its history during about 3×10^9 years (~3 Ga) till today.

Photosynthetic production of molecular oxygen first appeared in ancestors of recent cyanobacteria about from 3.7 to 2.7×10^9 years (3.7 – 2.7 Ga) ago. The process of carbon dioxide assimilation, today occuring in connection with photosynthesis, is even older than photosynthesis itself. About 1~2 × 10^9 years (1~2 Ga) ago cyanobacteria entered into close association with other organisms and chloroplasts in green algae and green plants as well as those in algae on the red line of evolution (red algae, cryptophytes, diatoms, brown algae, yellow green algae, and others) stem from a single event of uptake of a cyanobacterium into a heterotrophic organism.

If we consider the enormous impact of photosynthesis on the biosphere, the composition of the Earth's surface, the Earth's atmosphere, the climate and radiation climate, there is no doubt that without photosynthesis, especially its oxygenic variant, the Earth would not at all be alike to the Earth on which we are living nowadays.

By the process of photosynthesis solar energy is used to produce biomass (*13*) at an overall efficiency of about 1 %. This process starts with high quality energy, and electron transfer processes transforming the energy of light to excited states and trans-membrane potentials. Energy rich carbohydrates are then produced through a series of dark (i.e. light independent) reactions.

The occurence of circadian rhythmus in almost all organisms (*14*), and the similarities and differences in the effects of light as well as the mechanisms of the circadian clocks used by them are presented and explained using the examples of *Synechococcus* and *Synechocystis* (Cyanobacteria), *Lingulodinium* (Dinoflagellate), *Arabidopsis* (plant), *Neurospora* (Fungi), *Drosophila* (Insecta) as well as rodents and humans (Mammalia).

Many species of animals, especially those living at higher latitude, regulate their behavioural and developmental strategies (*15*) by using informatiom from the length of the day (or night). In insects these include the onset of overwintering diapause, in other animals the seasonal breeding strategies. The role of light in this processes is well explained and discussed.

In plants there are several types of photoreceptor (*16*) which collectively enable them to detect variation in light spectral composition, irradiance direction and daily duration. Recent molecular genetic analysis in *Arabidopsis thaliana* has brought rapid progress in our understanding of the molecular nature and ecologic significance of plant responses to light.

Some animals are able to perceive various parameters of the geomagnetic field (*17*). There exist two principal independent mechanisms of magnetoreception: a) a light dependent mechanism which detects the axial course and the inclination angle of the geomagnetic field lines, and b) a magnetic-mediated mechanism, providing magnetic information (map sense). In vertebrates (birds and newts) the light dependent magnetic compass orientation is dependent on both light wavelength and intensity. There is some experimental indication that magnetic compass information is perceived by magneto-sensitive photoreceptors, containing cryptochromes, probably in the retina or the pineal.

When a substance becomes toxic only under the action of light we speak of phototoxicity (*18*).

Plants and some fungi produce phototoxins which may be harmful to humans, but on the other hand may be of use for medical purposes. Polycyclic hydrocarbons (widespread contaminants) are potential phototoxic substances. Factors that may affect contact of organisms with phototoxic substances and with UV, and interactions between multiple enviromental and stressing factors present in nature make assessing risk for phototoxicity highly complicated.

During the last decades stratospheric ozone depletion has taken place, causing various effects (*19*) of ultraviolet radiation on microorganisms, plants, animals, and humans. Therefore the role of the ozone layer has been a subject of very intensive scientific investigations.

Recent knowledge about the occurence and functions of vitamin D (*20*) in animals and plants, its biogeographical aspects and its non-photochemical production are overviewed and discussed.

In human skin (*21*) solar UV radiation can cause pigmentation, photoageing, skin cancer (squamous and basal cell) and the less frequent but very dangerous malignant melanoma. Solar UV radiation causes suppression of cell-mediated immune responses. The implication of this downregulation affects the control of skin tumors and infectious diseases. Photodermatoses (a diverse group of abnormal skin responses to UV and/or visible radiation) are also briefly described.

In the last century the beneficial effects of light, known already since ancient times, have been studied (*22*) from the scientific point of view as well as from that of medical application. The use of light is now widespread in medicine, especially in dermatology. Such ways of using light in medicine as phototherapy (use of UV-A and UV-B radiation without added photosensitizers), photochemotherapy, extracorporeal photochemotherapy (both of which combine photosensitizers and UV), and photodynamic therapy (using sensitizers activated by red and blue light) are presented and discussed.

Three kinds of light emission from living organisms (*23*) are described and explained: 1. Bioluminescence (in the narrowest sense) from some species of animals: Protozoa (9 species), Porifera (1), Cnidaria (65), Ctenophora (15), Nematoda (1); Mollusca (74), Annelida (40), Arthropoda (207); Bryozoa (1), Echinodermata (47), Chordata (208); 2. Delayed light emission from photosynthetic cells, and 3. Ultraweak light emission from all kinds of living cells.

At the end of the book directions are given for teaching and demonstrations relating to the topics of the book (*24*) and for the construction and performarce of a spectrophotometer (*25*) self made from a DVD, a digital camera, a lamp and some cardboard, wood and sheet metal.

The editor was aware that in the given conditions it was not possible to cover all aspects of photobiology in one volume, but felt that it would be promising to present a fair and well balanced cross section.

The reader may judge himself how far and much the editor succeeded to realize his idea. There is, however, no doubt that this book will be indispensable for all who are working with or interested in organisms living under light conditions. In short: The book is of great interest for biologists, biochemists, biophysicists, biotechnologists etc, and finally to all friends of nature.

Zvonimir Devidé