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EDITORIAL NOTES

Preface to the Special Issue “New Advances in Photobiochemistry and Photobiophysics”

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The special issue of Biochemistry entitled “New Advances in Photobiochemistry and Photobiophysics” is devoted to current research on the interaction of light with living organisms and, in particular, to the elucidation of the biophysical and biochemical mechanisms underlying biological responses to illumination. It brings together contributions from scientists who presented their findings at the 1st Regional Meeting of the Russian Society for Photobiology and the All-Russian Conference with International Participation “Current Problems of Photobiology and Biophotonics”, held in Nizhny Novgorod on October 14-19, 2024 and hosted by N. I. Lobachevsky State University of Nizhny Novgorod.

Light is recognized as a key environmental factor for photosynthesizing organisms of all kinds, exerting both beneficial and deleterious effects. In photosynthesis, it serves primarily as the energy source that drives electron transport in the thylakoid membranes of plant chloroplasts, cyanobacteria, and photosynthetic bacteria. Excess illumination, however, can inflict photodamage on pigment–protein complexes. This dual energetic and destructive character of light necessitates a suite of light-dependent regulatory mechanisms, including non-photochemical quenching, the activation of alternative electron-transfer pathways (such as electron flow to molecular oxygen and cyclic electron flow around Photosystem I), and other protective responses. Consequently, photobiophysical and photobiochemical studies of photosynthesis focus mainly on the primary events of solar energy conversion, the operation of the thylakoid electron-transport chain, and the strategies that regulate and safeguard the photosynthetic apparatus under fluctuating environmental conditions.

A further, predominantly applied, branch of photobiochemistry and photobiophysics involves developing methods to modify photosynthetic organisms – mostly algae and bacteria – for “green” energy applications and designing hybrid energy devices that incorporate components of the photosynthetic electron-transport chain.

Another important area concerns the mechanisms of photoreception, encompassing both the primary light-sensing targets and the ensuing signaling cascades that shape physiological responses. Because photoreception is widespread – rhodopsin- and iodopsin-based in animals, phytochrome-, cryptochrome-, and phototropin-based in plants – its study holds great fundamental and practical significance.

Investigations of protein fluorescence mechanisms, together with the development of new research tools such as green fluorescent proteins expressed in model transgenic organisms, likewise fall within photobiochemistry and photobiophysics and are expanding rapidly.

Finally, photobiochemistry and photobiophysics play a pivotal role in biomedical research. Photodynamic therapy of cancer, which relies on selective photodamage to malignant cells, is one prominent example, yet the medical relevance of photobiological processes extends far beyond this application.

In sum, photobiochemistry and photobiophysics are dynamic, fast-evolving disciplines that span a broad spectrum of biological and medical research. The present special issue offers the latest experimental and theoretical contributions that advance these fields.

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