Multi-author Reviews

Biophoton emission, stress and disease

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Introduction: Biophoton emission, stress and disease

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The emission of light by living organisms has always been a fascinating phenomenon. Two classes of light emission related to biological phenomena have been recognized; these show a large difference in intensity. In contrast to the well-known phenomenon of bioluminescence originating in luciferin-luciferase reactions, low intensity photon emission in the visible region of the electromagnetic spectrum has been found in almost every species studied so far. At present, the nomenclature of this latter field of photobiology has not crystallized and is referred to by a variety of names, such as 'dark luminescence', 'low-level luminescence', 'low-intensity luminescence', 'ultraweak luminescence' or 'ultraweak photon emission'.

The spontaneous endogenous emission of low intensity luminescence from a diversity of biological systems ranging from the basic biomolecules to man has been the central topic of a number of reviews [2,7,8,11,12] and conferences, for instance those on 'Electromagnetic Bio-Information' [9], 'Photon Emission from Biological Systems' [3], and 'Biological Luminescence' [4]. The experimental techniques and theoretical considerations that are being developed require an acquaintance with concepts and objects basic to physics, biology and chemistry. Interdisciplinary communication, which this type of review seeks to encourage, is indispensable for the understanding of the complex problem of photon emission. [The reader is referred to the companion review on 'Biophoton emission' published in Experientia in July 1988.]

The present multi-author review on 'Photon emission, stress and disease' of Experientia contains articles written by those interested in photon emission from perturbed systems. In a collection as short as this one, it has not been possible to cover this subject completely. Nevertheless, we have attempted to illustrate the integrative approach with a spectrum of articles. The first articles present a comparative overview of photon emission from perturbed systems. In his article, Tilbury reviews the use of microorganisms, including bacteria, yeast and amoeba, in the study of ultraweak photon emission. Slawinski and co-workers include additional information on yeast, and review studies on photon emission from perturbed plants and animals. Perturbations of these organisms were caused by mechanical, temperature, oxidative, chemical and photochemical stress.

In most instances the perturbation gives rise to an increase in photon emission. The question arises as to how perturbations of the homeostasis are related to parameters of photon emission. The identification of the chemical reactions which are responsible for increased photon emission after perturbation has been discussed to the extent that experimental data including spectral analyses were available. All the biological stressors, including those of chemical, physical, emotional (psychological) nature and infections can cause an increase in endogenous free radical production and can overwhelm the various antioxidant defences. They liberate enough energy to generate electronically excited states of carbonyls and singlet molecular oxygen.

Another question is how to evaluate the perturbation of homeostasis from the stress-induced luminescence response? In addition to Slawinski and co-workers' short description of the various possibilities, the contribution of Kochel goes into more detail with respect to the methodological approach employing the correlation analysis of time-resolved photocount series. The photon emission process occurring after perturbation consists of two stages following in succession: the ascending and descending stages. According to the model the ascending stage is described by the Autoregressive Integrated Moving Average Model (ARIMA model) and the descending stage by the IMA or ARIMA model. Experimental results are increasingly giving evidence that biophoton emission cannot be decoupled from biological process; it is really both a product of physiological processes and their actual regulator.

This more fundamental basis for understanding of the photonic response from stress-perturbed bio-systems is given by Popp and co-workers. The model [5,6] suggests that there is a negative feedback loop in living cells which couples together states of a coherent ultra-weak photon field and the conformational state of the cellular DNA. The authors assume photon transfer or radiation-less chemical pumping from the cytoplasmic metabolism which results in changes of the DNA conformation via exciplex/excimer formation. Since the conformation of the DNA molecule is believed to be of importance for the regulation of the nuclear information transfer, such processes in turn influence the metabolic activity of a cell, thus closing the feedback loop. Their hypothesis suggests that biophotons originate from a delocalized coherent field within living matter. When a bioregulatory system is stressed, this is equivalent to a partially disintegrated system with a malfunctioning negative feedback. Gu and Popp review the theoretical research on the non-linear response of photon emission to external perturbation.

The last part of this multi-author review deals with photon emission in relation to disease. Phagocytes (macrophages and polymorphonuclear leucocytes) take an essential part in the defensive attempts of the host. In their article, Lilius and Marnila review the phagocyte activities from individuals under stress or disease. They conclude that photon emission capacity of phagocytes reflects remarkably well the pathophysiological state of the host. But what defence costs has the host to pay? Producing oxygen radicals is dangerous. Cells are unable to completely prevent these compounds from escaping their membranous compartments. Then the question arises as to how, in the diseased state, the chronically adapted cells behave with respect to photon emission. An interesting example is the photon emission of tumors and tumor cells. In the final contribution van Wijk and van Aken review the publications on photon emission in the field of tumor biology.

The assembly of the six contributions in this review offers the reader for the first time a more complete impression of photon emission in the field of stress. In the last decennium the study of stress has moved to center stage in cell and molecular biology. In the past few years HSP's have been the focus of investigations in many areas of cell biology. Several experimental data indicate that the increased production of oxygen-derived free radicals and other active oxygen species are directly or indirectly involved in the regulation of the expression of genes coding for stress proteins [1, 10].

We are beginning to discern the richness of information which can be retrieved from measurements of photon emission. This review on photon emission may offer new insights into the areas of stress and disease.

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The effect of stress factors on the spontaneous photon emission from microorganisms

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Abstract. The results of recent work on the photon emission from three yeasts and a bacterium is presented. Both visible region and ultraviolet photon emission is observed; however, no luminescence is observed in the absence of oxygen. The visible region emission is attributed to excited carbonyl groups and excited singlet oxygen dimers formed during the decomposition of lipid hydroperoxides. Possible sources of the ultraviolet photon emission are also examined. The use of microorganisms in the study of ultraweak photon emission and its relation to oxidative, temperature and chemical stress is reviewed and the applications and (or) functions of this photon emission are also discussed.

Key words. Ultraweak luminescence; photon emission; biophoton emission; mitogenetic radiation; lipid peroxidation; yeast; bacteria.