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Biophoton emission

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Introduction

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It is well known that manifold chemical messenger molecules like m-RNA and hormones play an important role in intracellular and intercellular communication, respectively. For a long time, however, it has been disregarded that *beside*, or even *below*, this biochemical level of control *electromagnetic* interactions play a fundamental role for the living state.
After the remarkable work of Galvani and Pasteur in the 18th and 19th centuries, which was continued in the early decades of this century by H. S. Burr [2], A. G. Gurwitsch [6], and G. Lakhovsky [8], the impressive progress of chemistry displaced attention from electromagnetic interactions in living tissues in favor of a well-elaborated biochemistry that has now climbed up to the modern stage of genetic engineering.
The up-to-date phase of research on bio-electromagnetism started with A. S. Presman's 'Electromagnetic Field and Life' [12] in which a variety of careful experiments demonstrated resonance-like reactions of biological systems after exposure to radio waves of different frequencies. In view of the low quantum energy of the radio waves causing the effect, which is much lower than the mean thermal energy, Presman pointed out that these interactions could be better understood in terms of bio-*information* than in those of bio-*energetics*.
In 1968 H. Fröhlich [4] introduced the concept of coherence into this research on bio-electromagnetism. He claimed that coherent long-range interactions in living tissues provide a basis of spatial and temporal order in biological systems. In particular, optical phonons of about 500 Giga-Hertz should be selectively excited by fluctuations of the membrane potential. Fröhlich's hypothesis can be considered as an electromagnetic paradigm of I. Prigogine's dissipative structures [10], since it represents a non-equilibrium phase transition based on Bose-condensation-like electromagnetic couplings far away from thermal equilibrium. However, the obtaining of experimental evidence for Fröhlich's concept turned out to involve crucial experimental problems which are still unsolved [5].
Besides these developments in studies of the microwave range and others [5, 11], the study of photons in the IR- to the UV-range opens a window on to a new, most promising area of electromagnetic bio-information due to 1) the relatively high quantum energies (providing a high signal/noise ratio) and the variety of significant effects of photo-biology. It may also be effective in clarifying questions in relation to Presman's, Fröhlich's and Prigogine's work.
The origin of this particular field of photo-biology can be traced back to Alexander G. Gurwitsch, who more than fifty years ago emphasized that the most fundamental biological function, namely cell division, is triggered by a very weak ultraviolet photocurrent originating from the cells themselves. Despite its serious experimental and theoretical basis, this postulate of 'mitogenetic radiation' appears to a number of scientists to be pure speculation, and even today provokes contempt rather than carefully-considered objections, or at least a careful analysis of the experimental background.
However, with improved techniques it became more and more evident that actually *all* living tissues exhibit a very weak photon emission. A decisive step forward was the paper of L. Colli and U. Facchini et al., which appeared in 1955 in Experientia [3]. In this paper evidence of the existence of a very weak photon emission from different grain seedlings was obtained for the first time by the use of the photomultiplier technique, including the measurement of the spectral distribution of photons.
At present, research groups in most parts of the world have become familiar with 'low-level luminescence' or 'biophotons' by analyzing this weak photocurrent and discussing its biochemical and/or biological significance. This development can be recognized by the increasing literature in this field, and by the holding of conferences, for instance the 1st International Symposium on Photon

Emission from Biological Systems (PEBS), held in Wroclaw in 1986[7].

It is clear to any scientist working in this field that the pioneering work of Alexander Gurwitsch has more than historical importance. One must not confine his results to a narrow range of weak UV-emission from onion or yeast cells. The roots of his work extend in fact to important questions of modern science, including the gestalt-problem in biology, phase transition phenomena and dissipative structures, and the link between biochemistry and biophysics. At the present time, there is nobody better fitted to introduce these aspects than Alexander Gurwitsch's daughter, Professor Anna Gurwitsch, who is still working on the problem of 'mitogenetic radiation'.

The progress in biophoton research has always been mainly a question of the availability of technical devices for registering very weak photocurrents of a few photons per second and per square centimeter of surface area. This corresponds to the light intensity of a candle at a distance of some kilometers. Consequently, after the introduction by A. Gurwitsch, we at first turn to the problem of instrumentation. Professor Inaba has enjoyed a worldwide reputation as the expert in this field for many years. He will give the basic technical introduction to this review.

'Low-level luminescence' has been looked upon so far mainly as a new discipline of photobiochemistry. Consequently, a number of possible reactions and biochemical pathways have been suggested and investigated in order to find the source(s) responsible for this phenomenon. The more carefully the experiments have been performed, the more reactions have been the subject of further proposals and research. Therefore, a review on the question of possible biochemical sources, including the position within the framework of 'bioluminescence', is a logical step towards obtaining further information on the latter phenomenon. Professor Slawinski, who has been working on this field for many years and is the author of one of the most recent reviews[13], presents this valuable contribution.

In order to reach a complete understanding of radiation from (and within) biological matter, consideration of distances equal and higher than the wavelengths under investigation is important. As a consequence, long-range interactions and dissipation come into view. The gap between these modern aspects and the localized biochemical viewpoint has been most elegantly bridged by Professor Cilento's work 'Photobiochemistry Without Light'[1]. In his present contribution he will demonstrate again that in biological systems excited molecules can transfer their excitation energy to other biomolecules, and thereby trigger amplification mechanisms and/or promote photochemical processes in the dark.

In its deepest consequence, this coherent transfer of photon energy – together with the questions already investigated by Gurwitsch – focus on the problem whether 'low-level luminescence' originates from spontaneous chemiluminescence, or from a coherent electromagnetic field within the cell population. This alternative is discussed by taking account of recent experimental results in a paper, presented by the writer, together with Mei Wei-Ping and Professor Li, who is fundamentally engaged in basic research on the physics of open systems[9].

From an empirical point of view the most decisive result will be the finding of correlations between 'biophoton emission' and biological functions. These 'regulatory' aspects have been investigated very carefully during the last years by Drs van Wijk and Schamhart, who deliver their contribution more from a biochemical point of view, and by a research group consisting of a biologist (W. B. Chwirot) and two physicists (R. Dygdala and S. Chwirot). Dr. W. B. Chwirot likes to deal with the more biological and biophysical aspects of photonic regulation.

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