BEYOND MOLECULAR BIOLOGY

The Biophoton Revolution

by Jonathan Tennenbaum

Over the last 20 years, blacked-out from the pages of standard textbooks, and only seldom represented in the leading professional journals, a new, revolutionary field of biological research has emerged: the investigation of the spontaneous photon radiation emitted from living cells, as a "window" onto the most fundamental life processes. At present, experimental investigations related to this "biophoton" emission are being carried out in about a dozen laboratories and institutes, including in Germany, Italy, Switzerland, the Netherlands, Poland, Russia, China, India, and Japan.

A number of these research groups have joined forces to create an International Institute of Biophysics (IIB), which is now coordinating much of the research in this area. Over the last several years, this author has had the privilege of participating in several of the yearly symposia of the IIB, held in Hombroich, Germany.

The fact, that practically all living processes are light emitters—albeit usually at an extremely low level—was first discovered by the great Russian biologist Alexander Gurwitsch in the 1920s. Gurwitsch demonstrated in 1923, that when two onion roots are situated in a common plane, in such a way that the growing tip (meristem) of the first root points toward a point *X* along the axis of the second root, at a distance of several millimeters, then the frequency of cell division (mitosis) was *increased* in the region of *X*, compared to the opposite side of the second root.

This "mitogenetic effect" (as Gurwitsch called it) was not affected when a transparent quartz window was placed between the two roots, but it disappeared when he replaced the quartz window by ordinary glass or opaque materials. By a variety of further experiments, Gurwitsch was able to establish that the *physical agent* of this stimulation of the rate of mitosis in the second root (the mitogenetic effect), was a very weak, ultraviolet light radiation emitted from the meristem of the first root. He called this "mitogenetic radiation."

Soon, Gurwitsch and his co-workers were able to demonstrate that countless other biological objects, including animal tissue, cultures of microorganisms, and even some biological materials such as blood, emit mitogenetic radiation. Gurwitsch found that specially prepared cultures of yeast cells, grown on agar blocks, made the most convenient and reliable detectors for the study of mitogenetic emission. Typically, the yeast culture blocks were divided into adjacent pairs; one side was briefly exposed to an experimental object as "source," while the other was optically shielded as a control. Subsequently, both cultures were incubated for a certain time; then the cells were fixed and the number of mitoses (seen as "buds" on the yeast cells) were counted under a microscope for the exposed culture and for the control.

The presence (and to a lesser extent, the strength) of the mitogenetic radiation revealed itself in a significantly positive difference in the exposed cells relative to the controls. Gurwitsch and his co-workers developed this technique to the point, that they could even obtain *spectra* of the mitogenetic radiation, by interpolating a diffraction apparatus between the source and detector.

A Science of Theoretical Biology

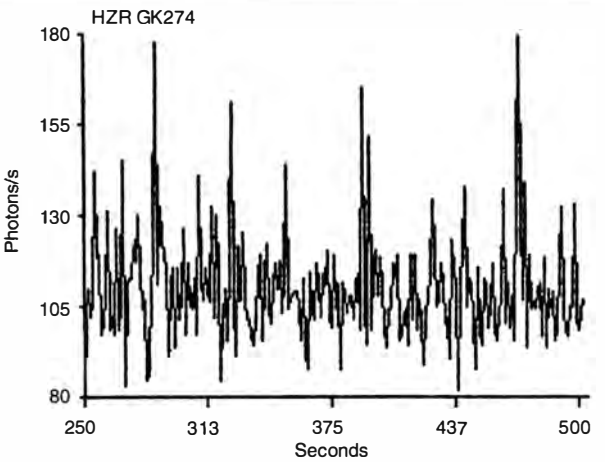
Fortunately, Gurwitsch was no mere experimenter, but one of the greatest *theoreticians* of biology in this century. In fact, it was his conception of the biological field, developed in connection with countless experimental studies of embryology, morphogenesis, and histology, which originally led him to *hypothesize* the existence of some sort of distant, radiative interaction between cells. The experimental demonstration of the mitogenetic effect by the famous "onion root" experiment—hailed at the time as one of the most important experimental discoveries of the century—by no means distracted Gurwitsch from his main goal, namely the creation of a comprehensive Science of Theoretical Biology.

In the subsequent period, Gurwitsch and his growing school of students and collaborators, transformed mitogenetic radiation into a powerful experimental technique for fundamental biological research. Mitogenetic radiation attracted worldwide scientific interest and became, in the course of the 1930s, one of the main areas of biological research in the Soviet Union. An enormous number of interesting and important results were published in nearly every major domain of biology, including also neurophysiology and cancer research.

Unfortunately, for reasons I indicate elsewhere (see box, p. 30), Gurwitsch's work on mitogenetic radiation came under heavy attack in the 1930s—not accidentally at the same time as funds began to be poured into molecular genetics and molecular biology, which were built up to take the dominant position in biological research in the postwar period. After World War II, the whole subject of mitogenetic radiation nearly disappeared from view, at least in the West; while in the Soviet Union, a few groups—centered on students of Gurwitsch—continued active experimental work in the directions he had initiated.

The main attack on Gurwitsch consisted in the claim, that all the thousands of experiments by Gurwitsch's and other groups (including in France and Germany), demonstrating the mitogenetic effect, were "wrong," and that Gurwitsch's mitogenetic radiation simply "does not exist." To bolster this assertion—hardly credible to anyone familiar with the quality of the scientists involved, and their painstaking methods of work—it was pointed out, that Gurwitsch's experiments were exclusively based on the use of *biological objects as detectors;* whereas attempts to detect the radiation by technical means (photodetectors) had failed or yielded ambiguous results. The argument was also raised, that a light radiation, so weak that it could not be detected by technical devices—not to speak of by the human eye itself—could hardly be expected to have any noticeable effect on biological objects.

In fact, as we know today, the spontaneous photon radiation of living organisms is indeed too weak—given the problems of sensitivity and background noise—to have been reliably measured by the kinds of photodetector apparatus that were available in the 1930s and 1940s. In 1954, however, a group of Italian astronomers who had been working on the development of supersensitive light detectors, discovered that sprouts of wheat, corn, beans, and other plants constantly radiate light at an intensity of the order of 10 to 100 photons per second per square centimeter of living tissue. These results were first looked on as a curiosity in the West, but they gave a considerable boost to the work of Gurwitsch's followers in the Soviet Union.



LOW LEVEL LUMINESCENCE OF CUCUMBER SEEDLINGS

Photons per second observed between 250 and 500 seconds in the course of time. The dark-count rate is of the order of 10 photons. The figure is from Fritz Popp's experimentation, as he reported in "Principles of Quantum Biology As Demonstrated by Ultraweak Photon Emission from Living Cells," International Journal of Fusion Energy, *Vol. 3, No. 4, Oct. 1985.*

Fritz Popp's Experiments

In 1973, some of the newer Soviet results caught the attention of the German biophysicist Fritz Popp and his collaborators. At that time, Popp was working in cancer research; he and a group of graduate students were trying to find an explanation for the extremely powerful carcinogenic action of the substance 3,4-benzpyrine, compared to the very similar, but essentially harmless 1,2-benzpyrine. Popp's hypothesis was, that the anomalously strong carcinogenic action of the former molecule was somehow related to a known, peculiar feature of its absorption and emission spectra in the ultraviolet range. The idea, that the carcinogenic action of 3,4-benzpyrine might be caused *directly* by its *optical* characteristics—and not necessarily mediated through its chemical reactivities—went directly against the prevailing, molecular-biological mindset of most cancer researchers.

But to put the matter rather simplistically: How could the posited *optical* action be accounted for, unless there were a source of light in the cell? And unless very small photon "signals" could trigger gross changes in the behavior of cells? The Soviet work on "ultraweak" photon radiation of cells seemed to provide the missing link.

In order to learn more about this photon radiation, Popp and co-workers developed and perfected over many years, a photo multiplier-based experimental apparatus with a high sensitivity and high signal/noise ratio, specially suited to the measurement of "ultraweak" photon emission of biological objects. With the help of this greatly improved "biophoton" detector, Popp and his collaborators have been able to discover a number of remarkable and highly *anomalous* characteristics of the biophoton radiation. Indeed, taken together, the results of Popp and his growing circle of international collaborators, demonstrate the existence of principles of organization of living processes, which are entirely incompatible with the basic assumptions of molecular biology.

Biophoton Radiation in Brief

We cannot go into the matter in depth here, but the following brief summary should give the thoughtful reader a sense of the fundamental importance and anomalous character of biophoton radiation. This should wet the reader's appetite for more in-depth discussions of these matters in coming issues of *21st Century*.

(1) It is well established that spontaneous, ultraweak photon emission is a ubiquitous phenomenon throughout nature. This ultraweak emission is completely different in nature from the familiar, much more specialized phenomenon of "bioluminescence," typified by fireflies for example, and whose intensity is many orders of magnitude larger. The intensity of ultraweak emission differs very greatly between cell types—undisturbed animal cells having generally the lowest rate of emission—but also varies greatly from moment to moment for any given culture or organism studied. The emission often contains "trains" of very short (sub-millisecond) "photon bursts" with a tendency toward recurrence, but with constantly shifting periodicities.

(2) Judging from experiments with interference-filters, the typical wavelength spectrum is spread over a broad band, from the near-infrared into the ultraviolet; the intensity distribution varies with time and the biological object studied. Bursts in the ultraviolet range tend to be found in tissue or cultures undergoing rapid cell divisions, in agreement with Gurwitsch. However, the exact relationship between Gurwitsch's mitogenetic radiation and the general phenomenon of ultraweak photon emission, as detected with the apparatus of Popp, has not been clarified.

(3) The intensity of biophoton emission is extremely sensitive to virtually any disturbance or other change in the biological system. For example, the introduction of toxic substances in extremely small concentrations—concentrations lower than those required to cause noticeable effects on metabolism or morphology—are typically followed by a sharp burst of biophoton emission.

(4) In spite of the obviously intimate relationship between biophoton emission and the biological state of a given object, it has proven impossible to discover any strict, mechanical correlation between variations in photon intensity, on the one hand, and any *specific* known set or type of biomolecular events on the other.

(5) On the contrary, the evidence of many biophoton experiments points to the existence and involvement of a *correlation among a large "continuum" of events* occurring virtually simultaneously, not only within a given cell, but between large numbers of cells in a tissue or population of microorganisms—events which could not *possibly* be correlated, within the extremely short times involved, by "chemical messengers" or similar mechanisms of molecular biology.

(6) One of the clearest demonstrations of the above-mentioned fact is the dramatic change in the photon emission behavior of two biological objects, when they are placed into optical communication with each other.

For example, in experiments conducted by Popp and others at the IIB laboratory in Hombroich, Germany, two cuvettes containing *Gonyaulax polyedra* were mounted in adjacent dark chambers and the real-time spontaneous photon emission of each was measured by a separate photo multiplier detector, the axes of the two detectors being parallel. When a shutter was opened, allowing the two cuvettes to "see each other" along an axis perpendicular to the axes of the photomultipliers, then the emission of both cultures changed markedly: The emissions became closely correlated, with a strong tendency toward simultaneous, short bursts, as well as a general increase in emission activity.

(7) Another, somewhat different demonstration of the same principle is provided by studies of the strongly nonlinear character of the biophoton emission of suspension cultures of cells or microscopic animals as a function of their *density*.

In the case of suspensions of *Daphnia magna* at the same development stage, for example, the curve of the average total photon intensity as a function of the number of organisms in a fixed-volume cuvette, displays a succession of several maxima and minima, which is hardly understandable if we assume a simple additivity of the emission from the individual organisms, together with the effects of absorption and opacity as the density changes. Close study rules out the possibility of chemical communication or "collision" models as an explanation of this phenomenon, and strongly points to a biologically significant resonance-interference effect: The total intensity has a pronounced *minimum* at a density corresponding to the "natural" distance between adjacent animals when populations of them are living in natural conditions, but has pronounced *maxima* in the regions where the density is 50 percent and 150 percent of the "natural" density.

(8) Although much more extensive studies need to be done, it has been found that the cells of at least some cancer types (for example, hepatocytes vs. HTC cells) distinguish themselves relative to the corresponding healthy cell types by a striking difference in the curve of emission as a function of cell density—the former showing monotonically *increasing* emission with density, and the latter displaying a nonlinear density dependency with decrease toward a minimum.

This is interpreted, roughly, to indicate that the processes in the population of cancer cells are no longer correlated in the strongly harmonic, coherent manner characteristic of healthy tissue.

(9) Finally, the photon emission from a given living system (organism or culture) displays characteristics of optical coherence, particular *temporal* coherence, indicating that the sources of emission—to the extent they can be localized within the system at all—are not independent, but are strongly correlated with each other in the manner suggested by the image of a *multimode, multifrequency* laser.

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