Natural Light From Organisms:

What, If Anything, Can It Tell Us?

by **Beverly Rubik**

NOETIC SCIENCES REVIEW # 26, PAGE 10
SUMMER 1993
from Noetic Website

A scientist reports that ultraweak light emitted from virtually all organisms is enough to spotlight the difference between two worldviews: the mechanical and the organic.

Virtually all organisms give off **light**, say scientific frontier researchers. Is this light merely an insignificant waste product? Or does it mean the existence of what ancient philosophies called "subtle life energies" or a "vital force"—an organizing energy field which communicates within whole organisms?

Increased recognition and respect of this subtle energy, variously called "**the life force**", "**prana**", "**qi**", or "**life energy**", is a common thread among the medical practices of what is today called energy medicine.

A larger paradigm than mechanical reductionism, one that may involve a new or at least modified concept of life, is needed to accommodate the increasing number of biological and medical phenomena that challenge the paradigm.

- For example, some experimental findings show beneficial effects of healers laying hands on sick organisms or patients. But how is the healer-healee interaction mediated?
- There are profound psychophysiological changes reported from the effect called Kundalini-awakening in certain mystical experiences. Are they due to the release of a subtle life energy?
- Then there is the mystery of homeopathy, an alternative medical modality in which there are infinitesimal dilutions of substances, in some cases without measurable numbers of active molecules present. Do they act "energetically" or "informationally" on the body-mind to promote healing?

Dozens of laboratories around the world have studied a wide variety of species of **plants** and **animals**, of tissues, and of single cells and have collected a substantial amount of experimental evidence that all these emit **a weak biological light.** Among the best studied are yeast, plant seedlings, and blood. They've found that a beating heart isolated from a frog continues to produce light. Even human breath has proved to emit light. Particularly well studied is the development of the larch tree, in which changes in the light emitted correlates with various developmental stages.

This ties in with investigations of tumor tissues which show a different light emission than normal tissue.

Further research (see below) shows results that cannot be explained in terms of properties of single cells, but in terms of whole tissues, suggesting a new communication mechanism within the organism.

The Importance of Coherence

In the **biophoton theory** of **Popp** et al.[4], it is critical that the postulated bioelectromagnetic field within the cell be coherent, a special condition in which the waves are in phase like a laser beam. One reason is that coherent light sources have some remarkable properties and must be regarded as integral wholes. By contrast, incoherent light may be regarded as being produced by a collection of independent emitters.

Another reason is that **coherent light** is capable of carrying more information than incoherent light. The more coherent the interaction is between the emitter and the

receiver, the less energy is needed for resonance, and hence for communication to occur. Accordingly, the ultraweak biological light should display at least some degree of coherence. Thus, experimental verification of the biophysical hypothesis must demonstrate this **coherence**.

Ideally, one would measure the coherence directly using the classical interferometer, but here the light intensities are too low and of too many wavelengths. Because the biological light emission is ultraweak, a **quantum physical theory** of coherence must be invoked. There are ways of ascertaining the coherence indirectly from the kinetics of the luminescence decay, but questions remain, as this is on the frontier of quantum optics. In fact, this area of research has attracted some of those interested in the frontiers of communication and quantum optics due to the apparently unusual properties of the biologically produced light.

Physical theory predicts that under certain conditions an incoherent light source, upon excitation by external light, would show a different decay response than a coherent source. Whereas an incoherent source relaxes according to an exponential relationship between light intensity and time of measurement, a coherent emission decays according to a hyperbolic relationship. **Popp** et al. and others have done considerable research to measure the kinetics of the decay of biological light emission from many organisms, with the result that almost all of the decay curves show a hyperbolic relationship.

Although hyperbolic decay might also be observed for systems with a large number of independent emitters, **Popp** and Li [10] maintain that under the particular conditions in which they have measured hyperbolic decay for light from organisms, the long-lasting hyperbolic decay observed for induced light emission is a sufficient condition for coherence.

Coherent: Two sinusoidal oscillations of the same frequency are said to be mutually coherent if they exhibit a constant phase relationship during the course of time. For example, a laser is coherent, and sunlight is partially coherent.	**Incoherent:** All other oscillations that do not exhibit a constant phase relationship during the course of time. This includes, for example, all ordinary incandescent light and fluorescent light sources.
Examples:	**Examples:**
	

Two Types of Light

Light emitted from organisms is of **two types:**

- a relatively strong bioluminescence peculiar to a few species such as fireflies and "flashlight" fish
- the invisible ultraweak light emission that appears to be associated with all lifeforms

The detection of this **ultraweak biological light** requires sensitive photoelectric devices available since about 1950. The intensities of this weak light range from a few to several thousand photons per second per cm^2 * However, it is sensitively dependent on a variety of factors such as temperature, carbon dioxide, oxygen, freshness, integrity, etc. The spectrum is broad over the full optical range, from the ultraviolet to the infrared.

By a method pioneered in Japan, one can actually make images of certain living tissues such as plant roots by means of their own natural light emission by placing them in a darkroom on a photographic plate **. These two-dimensional photon-images of plant seedlings show localized light emission in areas of active cell division or injury. There is also some indication that seedlings may serve as "light pipes", transporting light from localized regions throughout the organism.

Alternatively, one can make time measurements of the light intensity to study dynamic processes in living systems. This offers a way to study the dynamics of a whole living system non-invasively. Phenomena such as circadian rhythms or the effects of stressors such as chemicals or electromagnetic fields are readily seen. Whereas research on this topic has been ongoing in Eastern Europe and Russia since the 1920s, it was only in the late 1960s that ongoing scientific inquiry began in the West, with most of the present work being done in Europe and Japan ***.

In the 1920s, the pioneering Russian biologist **Alexander Gurvich** 1 discovered that onions kept close together stimulate growth of each others' roots. He separated the roots by encasing them in different materials and showed that this was not simply a *chemical influence*. One important finding he made was that the roots are stimulated when separated by quartz but not by glass. He therefore hypothesized that a radiation, possibly ultraviolet light emitted by one onion and absorbed by another, stimulates root cell division. This has been called the Gurvich effect, and the radiation originally called mitogenetic rays.

Today modern research has confirmed many of the early phenomena observed by **Gurvich**. For example, what he called the "pre-mitotic flare", a burst of light emitted just before cell division, has been demonstrated in synchronized yeast cultures. In general, growing cell cultures radiate more light than those in which growth has ceased. "Degradation radiation", the intense burst of light emitted from damaged or dying cells, has also been confirmed, regardless of the cause of death. The kinetics of the decay of the light emission provides information about whether these agents destroy or merely disturb life processes.

Ultraweak biological light emission has been implicated in connection with other biological phenomena as well. For example, there are Eastern European reports by **Kaznacheev** and others 2 on the alleged transfer of "pathological information" by means of this light.

What is known as the "cytotoxic effect" involves two cell cultures separated by at least a few centimeters and by means of a quartz or glass window. Under certain conditions, a poisoned, dying culture apparently communicates a long-range electromagnetic signal that initiates pathological changes and even death of the second culture.

Similar to Gurvich's original experiments with onion roots, positive results have been obtained using a **quartz barrier**, but not glass, supporting the notion that the signal is ultraviolet radiation. This research has not yet been replicated in the West.

> We are chinks in the lantern through which the One Great Light shines.
> —**Sufi saying**

"Biochemical" Versus "Biophysical"

There are **two schools** of interpretation of the phenomenon.

- The "biochemical school" maintains that the ultraweak biological light is an insignificant waste product of certain biochemical reactions.
- Alternatively, the "biophysical school", which sometimes refers to the light as "**biophoton emission**" ****, maintains that it is indicative of an endogenous, innate, electromagnetic field pervading the entire organism, which may act as both sender and receiver of the **biophotons** that are "electromagnetic bio-information" used in regulating life processes.

According to many in the biochemical school, the extremely low intensities and the broad spectral range of the light are considered as evidence that the phenomenon is biologically insignificant. These researchers maintain that the light emission is due to heterogeneous, localized phenomena in various parts of the cell with different sources of emission from unrelated processes.

For example, **Zhuravlev** 3 maintains that the light emission is *accidental "leakage"* from various metabolic

reactions, a spontaneous transformation of chemical energy into light.

From in vitro biochemical studies it is known that chemical reactions involving strong electronic excitations of free radical species, such as peroxides, may emit light. From this perspective, ultraweak biological light emission is considered to be *chemiluminescence*—physiologically insignificant, *waste energy.* Considerable experimental support from biochemical evidence abounds. Because the biochemical view is also consistent with the dominant biological paradigm of molecular reductionism, it has been widely accepted.

The competing viewpoint, the biophysical interpretation, maintains that the ultraweak biological light arises globally from within the whole organism or cell. Experiments show that interfering with a living system increases the intensity of the light emitted. Actually, this observation may support either interpretation, but the drastic and similar changes in light intensity under the influence of virtually all external agents could indicate that the light emitted is a centrally regulated response of the whole.

Cooperative interactions between molecules or regions within the cell might be involved at the very least. It has been demonstrated that the spectral distribution or color of the light is independent of the type of external perturbation. This observation supports the biophysical viewpoint, because *chemiluminescence* should lead to spectral changes depending on the perturbation. For example, the intensity of the biological light emitted may be greatly enhanced for a small increase in concentration of a toxic agent, contrary to standard chemiluminescence theory that predicts a linear relationship between them.

In addition, the complexity of the temperature dependence of the light emission cannot be understood within the framework of the classical biochemical model based on individual reactions.

These observations, among others, suggest central control within the living state that is nonlocal and possibly electromagnetic in nature. Many significant correlations between features of **the weak biological light** and a number of fundamental biological processes, such as cell division, death, and major shifts in metabolism, exist. These correlations may indicate that the light is a sensitive, global expression of biological regulatory processes.

One frequent argument against the biophysical hypothesis is that cells are optically opaque and therefore cannot use light for intercellular communication. However, experiments testing the tissue transparency show that this objection does not hold. The transparency of tissues to the light from organisms is at least two orders of magnitude higher than that of comparable artificial light of higher intensity.

The high transparency may reflect the high degree of coherence of biophotons. Furthermore, in certain media the coherence of incident light actually increases with the distance traveled, due to multiple propagation and diffraction. **Biophoton theory** even predicted these optical characteristics of living tissues. Moreover, it is well known that certain deeply situated organs such as the pineal gland and the brain are light sensitive. All of this would allow for a rapid, extensive biocommunication network in the body through light.

DNA may be involved in biological light emission. Changes in DNA conformation, that is, molecular shape changes, are known to occur when certain chemicals such as ethidium bromide are added to cells, and the light emitted from them changes in a direct, quantitative fashion. Cell fractionation studies show that most of the light comes from isolated cell nuclei. Moreover, **isolated chromatin**—the thread of DNA as it exists in resting cells which consists of a complex of nucleic acids and proteins—**emits more intense light than cell nuclei.**

A well-developed biophysical hypothesis for the ultraweak biological light is that of **Popp** et al.[4] who propose that the biophotons are released from a **coherent electromagnetic field** within the organism that serves as a basis of communication in living tissues.

In this model, the **biophoton** is trapped and reemitted by DNA, which undergoes physical resonance, resulting in light emission with at least some coherence, in which the light waves dance together in synchrony like a corps de ballet. Cellular biochemistry is thus conceptualized as a highly dynamic, space-time structure with long-range order. Biochemical processes may be integrated by the endogenous bioelectromagnetic field that has a primary organizational and informational role. Conformational states of DNA may serve as the photon storage of the coherent modes of the electromagnetic field within the cell.

A detailed model has been proposed by **Nagl** and **Popp** [5] in which cellular DNA is considered as a high energy, electronically excited molecular complex that both chemically and energetically regulates all nuclear information transfer in the cell. In this model the biophoton emission from the DNA is **energy emitted from the cell** that contains information about the state of the whole cell. Furthermore, emission and absorption of biophotons by DNA regulates the energy state of both DNA and the whole cell.

Similar models of life involving endogenous physical fields have been advanced by others. For example, **Burr** and **Northrup**'s [6] model is that of a complex electrodynamic field that is in part determined by its atomic components, and which in part determines the behavior and orientation of those components. The concept of the morphogenetic field, conceived independently by **Gurvich** [7] in 1922 and **Weiss** [8] in 1926, was believed to orchestrate embryonic development. Of course, the concept of an organizing field in biology evokes shades of vitalism.

In 1839 **Claude Bernard** [9] wrote,

> "The vital force directs phenomena that it does not produce; the physical agents produce phenomena that they do not direct."

Vitalism was cast out long ago when modern biologists adopted mechanical reductionism, and any suggestion of a regulatory field governing life challenges this paradigm.

Nonetheless, a growing body of experimental evidence supports the biophysical hypothesis. This includes research on "photochemistry without light", whereby certain electronically excited chemical species promote energy transfer without any energy loss whatsoever and without any absorption of external light. Conversely, any light emitted from such excited states indicates a loss of energy efficiency. However, it is speculated that the "**biophotons**" released are absorbed by other cells where they are used to promote biochemical reactions, thereby forming the basis of "electromagnetic bio-information".

From another physical perspective, the spectral distribution of the ultraweak biological light indicates that the living state is far from equilibrium. Thus, the rate of biochemical reactions in the organism should be much faster than in vitro. Indeed, this rate discrepancy has been observed and remained enigmatic in the conventional biochemical view of life. This evidence indirectly supports a view whereby the organizing field within cells supplies energy for metabolism and its regulation.

Studies in this area of **biocommunication** are extremely difficult to perform, and direct evidence is lacking. However, indirect evidence comes from a large number of observations that living systems respond to extremely weak electromagnetic fields, which is enigmatic in the conventional biochemical view (see footnote* below). In addition, there is evidence that threshold values for biological responses to light have been found to be much lower than those previously reported.

Applications

The measurement of biophoton emission looks promising as a valuable complement to other analytical biological methods, because it is one of very few noninvasive techniques that may permit a holistic approach to the dynamics of the organism.

A number of analytical and diagnostic applications measuring the ultraweak biological light emission are emerging in various industrial sectors of Europe and Japan, but most are so far experimental. These include measurements of plant seed viability, food quality and freshness, and the innocuity of cosmetic ingredients on test organisms.

Measurements of the light emitted from barley-hops fermentation mixtures in beer-making are being used to diagnose any early bacterial contamination of the brew. New tests on biopsied tissue to determine the degree of malignancy of tumors by physical features of the emitted light are also being made, as well as their energetic response to potential remedies.

Interesting experimental results show differences in the light emitted from cancer compared to normal tissue. The decay rate of **ultraweak biological light** is more rapid in malignant than normal cells, which implies that cancer cells have a poorer photon storage capacity. Photon intensity of normal cells decreases nonlinearly with increasing cell density, and for cancer cells increases with increasing cell density. This suggests evidence for mutual long-range interactions between cells in a population, which are fundamentally different for normal and cancer cells. It could also be interpreted as indicating a loss of coherence with increasing tumor size, compared to greater coherence in normal tissue.

Furthermore, this relationship between light intensity and cell density dependence, always the opposite for normal and malignant cell populations, shows that the results cannot be explained in terms of properties of

single cells, but in terms of whole tissues, again suggesting a novel communication mechanism within the organism.

Conclusion

The biophysical hypothesis and biophoton communication theory remain controversial. Presently, it is very difficult to come to any conclusions about the presence or absence of coherence in the cell solely by examining the ultraweak biological light. On the other hand, there is a separate line of evidence from other biological research that indicates that, if not coherent, at least collective, nonlinear dynamics are involved in the mechanisms by which weak physical and chemical stimuli elicit biological responses.

Novel biological experimentation done in tandem with physical studies on the biological light emission are needed to fully examine the biophysical hypothesis, and this has not yet been done. At the least this hypothesis has had heuristic value and opens new horizons in the holistic interpretation of the **ultraweak light phenomenon** and its role. In my opinion, the prejudices on both sides need to be set aside to move forward with a new interpretation, a synthesis that encompasses all of the biochemical and biophysical evidence.

If the **biophysical hypothesis** does prove to be scientifically valid, one may see the whole biosphere as a large network of electromagnetic communication. With that, perhaps scientists weren't the first to invent such long-range global communication systems.

Nonetheless, if the biophysical hypothesis proves to be invalid, and the ultraweak biological light is **not coherent**, the general concept of coherence may provide a new conceptual tool for a more adequate understanding of the living state. Considered as a unifying principle in which the components of life exhibit a dynamic relationship interconnected through space-time, it may be the beginning of a new epistemology for biology.

The debate between the two schools of interpretation recapitulates the tension that has existed throughout much of Western history between two worldviews—one that can be labeled mechanical and the other organic. At present, there is still little consensus on where to draw the line between inanimate and animate systems, that is, between chemical systems and whole organisms, leading some to conclude that there is no such line. This is the worldview that predominates today in modern biology, with its focus on molecular genetics.

On the other hand, it may be that conventional science has investigated only those features of life to which its particular method of abstraction applies, and that the subtler levels of life—**qi**, **prana**, etc.—have escaped detection. The experimental data clearly show the presence of a ubiquitous, ultraweak biological light.

Although evidence is accumulating that would support the biophysical view of a deeper organizing field within the organism, further research is needed to substantiate this concept.

Beverly Rubik has conducted research on healing and other frontier topics. As Director of the *Center for 'Frontier Sciences'* at Temple University, she is involved in research projects and networking with scientists worldwide. She is the editor of a new book, The Interrelationship Between Mind and Matter.

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* "**Photon**" is the word used in conventional physics to mean a quantum packet of light energy, expressing the particle view of the duality of light, the **wave-particle.**

** This method is not to be confused with Kirlian photography. **Ultraweak biological light** is emitted from organisms in their normal, natural state, or under stress. By contrast, the Kirlian aura is a corona discharge that may be quite intense, which is produced by an organism in contact with one pole of a high frequency electrical generator of the order of 10,000 volts or more (a large voltage, hence a large electrical energy input to the organism).

*** The highly specialized literature on ultraweak biological light has not yet had impact on biology as a whole, but a comprehensive technical review is in preparation: **B. Rubik** and **M. Bischof**, The Question of Ultraweak Light Emission from Organisms: "Superfluous" Light or Electromagnetic Bio-Information?: Institute of Noetic Sciences (in production).

**** "**Biophoton**", coined by the biophysical school of interpretation, simply means a photon emitted by an organism, although the word carries the implicit connotation that there is something special about light emitted from organisms.

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