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## **Biophotons in Diagnostics Progress and Expectations**

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The following article was prepared exclusively for Occidental Institute Research Foundation specifically for publication in a previous issue of "The Bridge". It provides an excellent introduction to the work of Prof. Dr. Van Wijk and to the more in depth presentation he will give to participants of our forthcoming **Biological Medicine Symposium 2012**.

### **Introduction**

The concept of the basic bioregulatory system (German: Das Grundsystem), enriched with system theory, has a long history. It has been developed alongside the cell pathology model and now becomes more and more a central theme within the scientific and medical communities of naturopaths, acupuncturists and neural therapists. This paper emphasizes that the bioregulatory concept is maturing into an accepted regulatory and

communicative body-wide system of connective tissue structures containing distinct electromagnetic and light communication properties. It may presently be included as the third body-wide system next to the blood and neural systems that facilitate the distribution of information that initiates systemic activity. Biophoton properties are presently studied for their diagnostic value based on the energy/information properties of connective tissue.

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## **A concise history of the Basic BioRegulatory System (BBRS)**

The concept of BBRS is rooted in fruitful European scientific endeavours of more than 200 years. Historic highlights and steps in research follow [1].

### *1767 Bordieu*

Postulates an organ that provides all tissues for their nutrition and is an intermediary for their collaboration. It is the most exploited organ of the body and extends to all parts. In this organ, the essentials of disease processes reside.

### *1845 Reichert*

Recognized the connective tissues as being of vital importance for the body. He emphasized that nowhere in the body is there a direct contact between (vegetative) nerve endings, capillaries and parenchymous cells. An interstitial substance always separates them. It functions as the intermediary for (vegetative) nerve action and nutritional trafficking.

### *1857 Bernard*

Appreciates the importance of the internal environment in the functioning of the organism: 'La fixité du milieu intérieur est la condition de la vie libre.' (the constancy of the internal environment is the condition for a free life).

### *1869 Von Rindfleisch*

Elaborates on Bernard's thoughts in his criticism of Virchow. His notion was that the area of local disturbances (Bernard's Terrain) encompasses three components: a.) the cell of the loose connective tissue, b.) the capillaries, and c.) the (vegetative) nerve endings. Later, he called these components cellular,

humoral, and neural components, respectively.

### *1910 Buttersack*

Proposes that the system formed by the loose connective tissue network not only functions as an intermediary between blood / lymph and parenchymous cells but that it has its own structure and physiology.

### *1921 Schadé*

Investigates the physical chemistry of the system. The collagen fibers that are present as a loosely knitted network during swelling, are able to absorb large amounts of acid. It is presently known that homeostasis of the acid/alkaline exchange primarily resides in the interstitial tissue.

### *1928 Standenath*

Reviews the qualities and functions of the system:

- 1.) it is an intermediary for metabolite and fluid flow between the capillary system and parenchymous cells;
- 2.) it governs metabolism by regulating levels of the mix of water, ions, and nutrition;
- 3.) it has storage capacities;
- 4.) it regulates tonus; and
- 5.) it has immune and defense functions.

### *1949 Eppinger*

Compiled the facts about the behavior of the system during illness. Under normal conditions, the system of pores and crevices that delineate the organs is hardly visible. Only after swelling, due to some pathology, can it easily be discerned. The volume of the extracellular fluid within the entire human system normally amounts to approximately 16 litres. All loose connective tissues amalgamate

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throughout the body. The extracellular fluid within it flows at a slow, but constant rate.

#### *1949-1975 Pischinger*

and his co-workers approached the system from the perspective of experimental histology. They were able to present a synthesis of most known facts leading to the concept of Das Grundsystem. Many cell types and structures such as the reticulo-histiocellular/macrophage system and vegetative nerve endings were identified. Particularly important is the notion that the system originates from the mesenchym. This foetal tissue, which is assembled from cells from within mesoderm (the second germ layer) and neural crest cells, is in fact the embryological counterpart of the basic bioregulatory system in the adult. It has very important developmental biological functions. It took to the 1960's to establish the characteristics of the neural component. It could only be accomplished by incorporating the clinical experience from neural therapeutics.

#### *1975 to now*

Virchow's inheritances boomeranged within the realm of Bernard's 'terrain' or Von Rindfleisch's 'confining physiological conditions'. Modern cell biological research leads to questions regarding interactions between cells and their direct environment as expressed in e.g., the developments in extracellular matrix biology, immunology and the puzzling mind-body interrelationships between present day neuropeptide research.

The relationship between the basic bioregulatory system and the extracellular matrix, which constitute the interstitium

of body cells, sculpts the field wherein modern academic research merges with the aforementioned classical concept.

#### **The extracellular matrix (ECM)**

The first major component of the ECM consists of different glycosaminoglycan (GAG) or mucopolysaccharide species. They are long rigid macromolecules composed of repetitive disaccharide units including at least one amino-sugar moiety. They derive their high cation / water-binding capacities from the high density of negative charges on their surface. This, together with their rigidity, presents in a very voluminous manner (a 1% GAG solution already forms a hydrated gel). Within the basic bioregulatory system their presence enforces turgor maintenance. Turgor is largely dependent on the pH of the system and hence the acid/alkaline balance of the body. An acid pH (high concentration of cationic  $H^+$ ) shields the negative charges on the surface of the GAG's and depresses their water binding capacity. This results in low turgor. The reverse happens at a more alkaline pH.

Proteins form the second major component of the ECM. Collagens are the major proteins of the extracellular matrix [2]. Collagens are a family of fibrous proteins. Their behaviour with respect to pH resembles that of GAG's. A low pH diminishes their mutual attraction. Consequently, bundles of tendons and/or networks of loose connective tissue swell. The reverse happens at a pH >7.

The special connective tissue structural features are best appreciated by comparing epithelium and connective tissue

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with respect to the relative contribution of cells and extracellular matrix. Cells in connective tissue are plentiful but sparsely distributed within the extracellular matrix. Direct attachments between one cell and another are relatively rare which is in contrast to epithelial tissues. The large extracellular space is, generally, composed of a variety of proteins and polysaccharides that are locally secreted and assembled into an organized network (matrix). The variations in the relative amounts of these macro-molecules and the way in which they are organized gives rise to a diversity of forms, each adapted to the functional requirements of the particular tissue. The matrix can become calcified to form hard structures of bone or teeth as well as the transparent matrix of the cornea. The matrix can also evolve into a ropelike organization that gives tendons their tensile strength.

Collagens have special electrical and electromagnetic properties. The ordered network of water molecules connected by hydrogen bonds and interspersed within the protein fibrillar matrix of the collagens is especially significant. Such a network may support rapid jump conduction of protons. Proton jump-conduction is a form of semi-conduction in condensed matter. This has been confirmed by dielectric measurements demonstrating that the conductivity of collagen is a function of the collagen fibrillar structure and, in addition, increases significantly with the amount of water absorbed. Conductivity along the length of a fiber is at least one-hundred times more than crossing the diameter of a fiber [3,4]. Dielectric and electrical conductivity properties in the connective tissue facilitate greater sensitivity to mechanical pressures, pH and ionic compo-

sition [5, 6]. Therefore, weak signals of mechanical pressure, heat or electricity may be readily amplified and propagated by a modulation of proton currents or coherent polarization waves [7].

The special electromagnetic properties of connective tissue have led to speculation that this tissue, in its highly structured form, has similar collective properties of photon emission dynamics. Evidence of such came from photo-induced delayed luminescence characteristics of bovine Achilles' tendon [8]. The tendon is a quasi-unidimensional, hierarchically ordered tissue containing aggregates of the collagen triple helix. The delayed reflecting luminescence of tendon is dependent on the order parameters of the system. For a description of the delayed luminescence, it is necessary to consider the existence of collective electronic states [9,10]. Special photon transparency properties have also been observed by using collagen gels and collagen fibrils extirpated from rat tails. Research concluded that the collagen structures both conduct and modify photon pulses coming from biological sources [11].

Additional arguments for special optical properties of particular forms of connective tissue originate from recent studies on primo-vessels. In the early 1960's, Bong-Han Kim claimed that he discovered such vessels which he presumed to exist as a novel circulatory system throughout a living being [12]. The vessels are specially characterized by their high, in vivo affinity to staining which discriminates them from background tissue such as dermis, muscles, and similarly appearing lymphatic vessels [13].

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The intense infiltration of stain is histologically understood to be due to its multi-lumen structure of loose collagenous openings and pores at the outer boundary. These primo-vessels have been studied for their optical properties compared to those of the surrounding tissue (dermis and muscles). The primo-vessel contains lower absorption and scattering coefficients. It appears more transparent than its surrounding dermis and muscle [14,15], suggesting that it can transport light with high efficiency and act as an optical channel [16]. A recent, interesting development is the study of light transparency of artificially prepared collagen gels (particularly for ultra-weak photon emission). Preliminary research was performed regarding the transparency of collagen gels for enzyme-dependent ultra weak photon emission produced by the Xanthine oxidase – Xanthine enzyme system in combination with the enhancer Methylated Cypridina Luciferina Analog (MCLA). Preliminary data demonstrated that collagen gels increase photon emission, suggesting that the collagen fibril in the macro structure of connective tissue may play a role in light-piping within connective tissue [17].

### **The anatomy of (human) ultra-weak photon emission**

During the last several years, considerable research has been done with the objective to collect knowledge about the anatomic pattern of human photon emission. A study regarding spontaneous human ultra-weak photon emission began with a systematic multi-site recording utilizing 29 anatomic sites. This selection was made in order to obtain the

quantitative UPE distribution for a.) right-left symmetry, b.) dorsal-ventral symmetry, c.) the ratio between the central anatomic location and extremities and d.) flat versus highly structured anatomy. The recordings were accomplished with a photomultiplier highly sensitive in the visible regions (300-650nm). Data demonstrated that variation in photon count over the body depended on the subject and on the time of day. Studying emissions in the morning and in the afternoon demonstrated that the increase of emission confirmed different patterns. In many cases, a location with high-emission in the morning migrated to a further increase in the afternoon. Although the body emission pattern was highly idiosyncratic, the patterns shared some general features: Emission from the hands and head were commonly higher than from other body locations. Higher values were also recorded for elbows, knee and feet. If large fluctuations occurred, right-left symmetry remained, but dorsal-ventral symmetry could not be observed. Body parts that were more shaped and structured emitted more than the relatively unstructured (flat body parts). The authors made the suggestion that there might be a correlation with lack of homogeneity of the electrical field of the body surface (spike effect) [18, 19].

Another system utilized to characterize anatomic distribution of spontaneous human photon emission was the two-dimensional imaging technology using a cryogenically cooled CCD camera system. It was used in various studies to measure photon emission from the upper frontal torso, head, neck and upper extremities of subjects [20-23]. The

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emission intensity around the face and neck was highest and gradually decreased first over the torso and subsequently over the abdomen. Photon emission intensity from the face was higher than from the body. Moreover, photon emission intensity from the face was not homogeneous: only the central areas around the mouth, cheeks, and probably teeth were relatively high. Although the hands (both dorsal and ventral) demonstrated relatively high emissions, the nails produced higher emissions than the anterior-ventral (fingerprint) sides.

Subjects differed in overall emission intensities. Photon counts of subjects ranged between a factor of 4 to 5. The etiology of a.) the “common” pattern of emission, b.) the differences in overall emission intensities *between* subjects, and c.) the diurnal and annual fluctuations *within* a subject are presently under investigation. It is interesting to distinguish two major lines of research: a.) the relation to ROS and b.) the mechanical origin of photon emission. Following early research in Eastern Europe, many scientists have used photomultipliers to measure the light emitted by ROS-generating systems in vitro. These studies have been extended to tissue and whole organisms. The ultra-weak photon emission (UPE) is related to direct utilization of molecular oxygen and the production of electronically-excited states in biological systems (in particular, the oxygen dependent chain reactions involving biological lipids) [24,25]. In mitochondrial and microsomal fractions, singlet molecular oxygen appears mainly responsible for the observed UPE. Both the differences in overall intensities *be-*

*tween* subjects and the diurnal and annual fluctuations *within* subjects may be traced back to physiologic conditions.

One such situation is the effect of ischemia – reperfusion of ROS. Cell functioning is dependent on the availability of oxygen and the functioning of the respiration process. Respiration is, in principle, a cell-based process in which mitochondrial proteins play an energy formation role in the formation of ATP. Since the respiration enzyme processes are not perfectly tuned, a small percentage of oxygen in this process will end up in the form of reactive oxygen species. However, it can be considerably increased when tuning between metabolic reactions becomes less. Tissues that become hypoxic or ischemic survive for a variable time depending on the tissue. They respond to ischemia in a number of ways. If the period of ischemia is *insufficiently* long to damage the tissue irreversibly, much of it can be salvaged by reperfusion of the tissue with blood and re-introducing O<sub>2</sub> and nutrients. However, it was demonstrated in the early 1980’s that re-introduction of O<sub>2</sub> to an ischemic or hypoxic tissue could cause additional insult to the tissue (reoxygenation injury) that is, in part, mediated by ROS. The relative importance of reoxygenation (often called reperfusion) injury depends on the time of ischemia / hypoxia. If the reactive oxygen is able to react, it does so with many types of molecules, including DNA, lipids and proteins. Free radicals and other ‘reactive species’ play important roles in living systems and have been implicated in the pathology of many human diseases [25].

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It was evident from the research data that body parts shaped and highly structured (and/or mineralized) emitted more than the relatively unstructured, flat body parts. Such data suggest a special role of the highly structured (and mineralized) connective tissues in the ultra weak photon emission. In a few studies, attention has been paid to the photon emission of mineralized connective tissues, particularly in human bone, dentine and enamel. Bone is a specialized connective tissue composed of an organic matrix of type I collagen that is eventually mineralized with an inorganic phase of calcium hydroxyapatite-like crystals. Main components of teeth include the enamel, dentin, pulp and the periodontal ligaments. The enamel is highly mineralized to provide the strength to withstand the force of mastication and to protect the dentin. The dentin consists of mostly collagen and forms a structure called a dentinal tubule that radiates from the pulp to the enamel and cementum. The mineralized tissues display the property of phosphorescence, a long-term luminescence, at a relatively high intensity. Photon emission has been specifically related to the semi-conductor properties of these tissues.

The phosphorescence of calcified tissues arises principally from the organic moiety [26]. Collagen may exert this control over apatite structure through surface contact. The separation of collagen and apatite revealed that both the decollagenation and demineralization initiated a reduction in fluorescence compared with the original whole bone. This would be compatible with the knowledge of the semiconducting properties of bone. Nails are another example of a highly structured hard tissue.

Keratin is the major protein in nails. The mechanical strength of keratin is determined, in part, by the content of the sulphur containing amino acids that form disulphide linkages within its tertiary structure [27]. Phosphorescence studies on nails, however, have not been found. However, it is evident, that the relationship of human “common” pattern of ultra weak photon emission to bone, tooth and nail phosphorescence (specifically in relationship to flexibility and concomitant changes in the structure of the organic matrix and semi-conductor properties of the tissues) requires further research. This research may further confirm the complexity of connective tissue resulting in both its light-piping properties and light storage capacity discussed above.

#### **Functional integrity of physiologic systems in relation to balanced corticoneuromusculoskeletal activities**

The discussions regarding a.) connective tissues and their regulatory properties relative to oxygen and nutrient supplies, b.) photon emission and photon storage capacities of different types of connective tissues, and c.) ultra weak photon emission and bone (i.e., skeletal dynamics) offer intriguing perspectives for developing a more holistic approach to health and disease vis-à-vis photon emission. It is based on the integrity of the body vis-à-vis the musculoskeletal system in health and disease. Body functions are not dependent on sharply compartmentalized anatomic or self-limiting physiologic systems. Instead, the body functions as an integrated unit. The

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functional unity of the body cannot be understood without the musculoskeletal system (which comprises 60 percent of the body mass).

As one considers the organism in its entire dynamic functioning, one must appreciate the coordinated distribution of force exerted by muscle activity upon the skeletal (bony) structures and controlled by sympathetic nerves. The major challenge of such dynamic muscle activity demands a rapid adaptation and redistribution of its available oxygen and nutrient supplies for that activity. The cerebral cortex might assist with the challenge by coordinating the muscle movements with visual and other sensory information. Such a joint effort requires a rapid, efficient systemic coherence. This motor system as a whole from intention to behaviour has often been called the corticoneuromuscular network. The documentation of these highly interrelated physiologic activities include synchronization or cross coherence [28].

### **Discussion and Conclusion**

This review addressed scientific evidence for an energy/information system in the body that is associated with a.) properties of connective tissue and also b.) contains distinct electromagnetic and light communication properties. Is biophoton emission an effective biomarker that can be utilized scientifically to quantify the existence of energy distribution balances?

The paper describes the two origins of photon emission related to energy shifting in disease. The first is triboluminescence, particularly of bone tissue (skeletal structures). This mechanically-

induced luminescence may explain the initiation of the previously documented anatomical pattern of emission (including left-right (im)balance/(a-)symmetry) in disease states. The second is enhanced photon emission under conditions of local (organ) ischemic-reperfusion fluctuations when the tuning in the corticoneuromusculoskeletal unity is disturbed. Considering the organism in its entire functioning, the most dynamic and remarkable feature is its rapid local flexibility. Such is based on highly organized systemic and/or local biochemical and physiologic shifts within the muscles of arms, legs, hands or fingers. Such flexibility always challenge the local supply of oxygen and nutrients.

The basic bioregulatory role of connective tissue then becomes more evident. The connective tissue forms a structural, functional and communication, initiating energetic continuum extending into every nook and cranny of the body vis-à-vis oxygen and nutritional regulation by the autonomic system, arterioles, and very fine capillaries that penetrate as close as to every tissue cell. This line of thinking brings the classic anatomic and cellular physiologic data of the basic bioregulatory system into concordance with the photon communicative and photon storage properties of the differentiated parts of the connective tissue.

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