Biophotonics

PART 1: The Light of Life,

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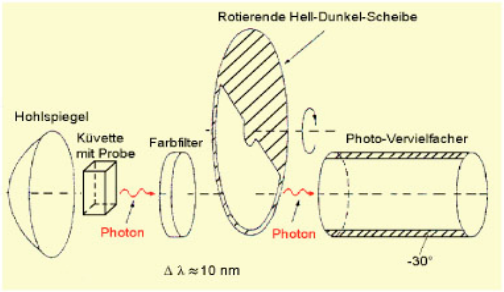
What are *Biophotons* ? (1/3)

Bios (Gk. life) +
Photon (quantum of EMR)
= ultraweak cell-radiation

Biophoton emission regard:

- **Life**: occurs in all living cells
- **Mechanism**: part of cell metabolism
- **Intensity**: low luminescence
- **Quantity**: appr. 100 photons·sec^{-1}·cm^{-2}
- **EMR-Range**: 200-800nm



i) **What are Biophotons**: Biophoton emission is a general phenomenon of living systems. It concerns low luminescence from a few up to some hundred photons per second, per cm^2 surface area, **at least** within the spectral region from 200 to 800 nm ()00000.

ii) **Measurement Technique**: Measuring principle is based on

- counting singl e photons
- uses the photo-electric effect
- employs a photomultiplier as a detecting device

Source: F.A. Popp, Die Botschaft der Nahrung, 2005.

The word „**biophotons**" has been chosen to express the fact that the phenomenon is characterized by measuring single photons, indicating that this phenomenon has to be considered as a subject of quantum optics rather than of "classical" physics.

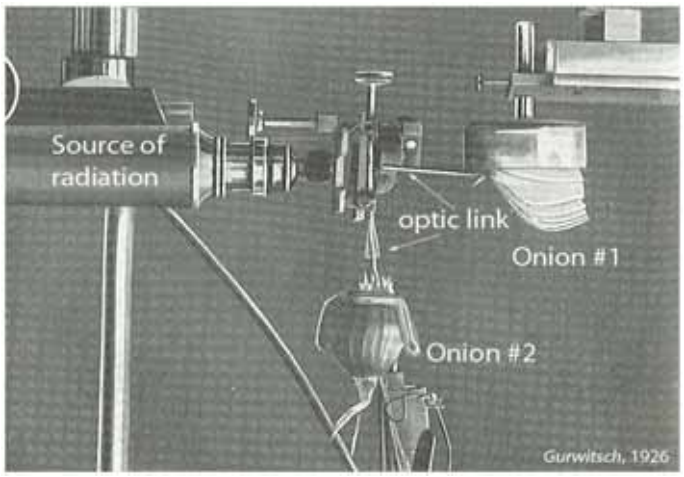
Source: Popp. F.A. online; About the Coherence of Biophotons; http://www.lifescientists.de/ib0204e_1.htm

It was concluded that the emission of photons by living systems may be considered as a kind of **chemiluminescence** due to the recombination of the free radicals which appear in a number of chemical reactions. In this paragraph we will consider primarily biochemical mechanisms by which living systems create electronic excited states and photons, and the link between them and physiological processes.

Source: VanWijk R., 2001; Bio-photons and Bio-communication; *Journal of Scientific Exploration*, Vol. 15, No. 2, pp. 183–197

What are *Biophotons* ? (2/3)

Pioneered by:
Alexander GURWITSCH
(1926)



i) Gurwitsch's famous Onion Experiment.

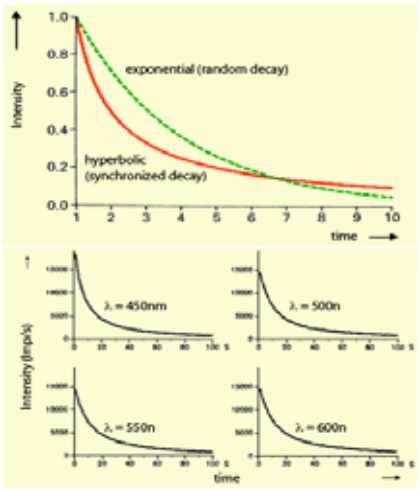
- The roots of two onions are positioned perpendicularly so that the tip of one root points to one side of the other root.
- Gurwitsch found that there was a **significant increase in cell divisions** on this side, compared to the opposite, "unirradiated" side.
- The **effect disappeared** when a thin piece of **window glass was placed between the two roots**, and reappeared when the ordinary glass (which is opaque for ultraviolet light) was replaced with quartz glass, which is transparent for ultraviolet light.

Source: Gurwitsch A.G.; 1926; Das Problem der Zellteilung;
Bischof M., 1995; Biophotonen, das Licht in unseren Zellen; p.89

What are *Biophotons* ? (3/3)

Biophoton characteristics:

broad photon storage capability:
due to many coupled resonators
follows **hyperbolic** decay pattern;
> decay time: range of minutes to hours,
and is independent of λ, i.e. extends
<200nm and >800nm;
> coherence-times: better than LASERs
(>1·E^{-2} s)



i) Popp & Li: Chlorophyll molecules in plants are coherent solar collector, which delay thermalization (i.e. conversion of EMR to heat, entropy), thereby enabling them to synthesize nucleic-acid polymers.

- Chlorophylls are resonators with a high Q-factor
- Schrödinger 1933: the grip to maintain an organisms stationary at such a high level of organisation relies in the fact that it continuously aspires order (neg-entropy) from its surrounding (environment);
- **Hyperbolic Decay pattern**: Incoherent systems (i.e. radioactive decay) follow an exponential pattern; whereas a reciprocally coupled (coherent) system reveals a **hyperbolic decay** pattern;

i) **Bose-Einstein Condensate** (BEC) is a phase of matter formed by bosons cooled to temperatures very near to absolute zero. Under such conditions, a large fraction of the atoms collapse into the lowest quantum state, at which point quantum effects become apparent on a macroscopic scale. In biophotonics, the BEC enables a coherent cell-biological state; i.e. Photons of same frequency and phase align to each other and become coherent; thereby, the range f interaction increases from the microscopic to include macroscopic entities (cells, organs, and entire organisms).

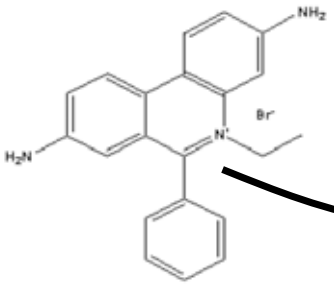
Source: Schrödinger E., 1926; Was ist Leben?
Bischof M., 1995; Biophotonen, das Licht in unseren Zellen; p.181-2,
http://www.colorado.edu/physics/2000/bec/what_is_it.html

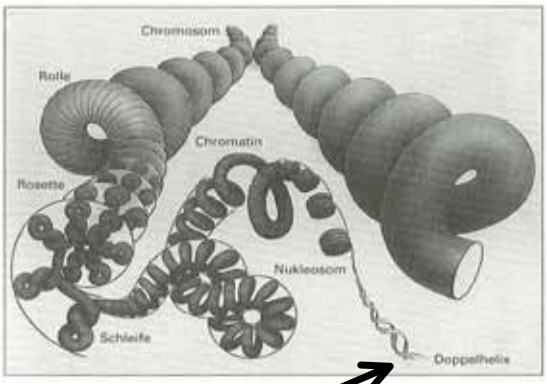
Biophotons and Communication (1/4)

Within DNA & Cell-Nucleus:

DNA: site of photon generation and storage

Ethidium-Bromide: used to monitor biophoton emission





i) **DNA**: A typical gene is composed of 600-1800 sequential base-pairs; at least **75% of biophotonic activity** originates from the DNA (Niggli, 1992), with the single DNA-strand (chromatid) being the main contributory of nuclear biophoton activity;

ii) however, **purified DNA is biophotonically inactive**, indicating that biophotons are a result of histone-DNA-interaction (Wijk, 1992)!

iii) proof of biophotonic activity by unwinding the DNA-molecule with **Ethidium-Bromode** (inert chemical that intercalates between base-pairs of DNA);

iv) Degree of coiling is proportional to the degree of biophotonic activity; **the more unfolded** (separated strands) **the more emission**, indicating the release of photons from the gene-sequence; (**DNA as the storage site for photons**); indeed, excitation energy is handed over from one base-pair to the next along each DNA-strand;

Source: Postlethwait, J.H., Hopson, J.L.,;1995; The Nature of Life. 3rd ed.; p.230

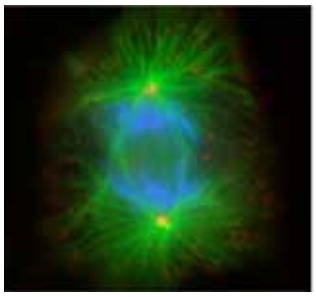
Bischof M., 1995; Biophotonen, das Licht in unseren Zellen; p.39, p.189-190;

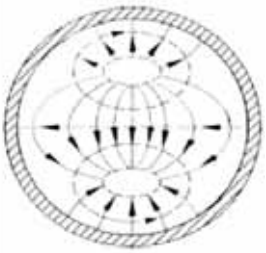
Biophotons and Communication (2/4)

Biophotons in cell physiology:

During phases of **Mitosis** (Soma cells): i.e Anaphase to early Telophase,

comparable to a cavity resonator





Mitosis: The process of nuclear division in which replicated chromosomes separate and form two daughter nuclei genetically identical to each other and the parent nucleus. Mitosis is usually accompanied by cytokinesis (division of the cytoplasm);

i) Agreement between structural pattern of spindle apparatus and electrical field lines.

ii) Inside the cell the spatial energy distribution in each moment controls the release of chemical reactions in a **well coordinated functional** sequence.

iii) The comparison between mitosis and the cavity resonator reveals that mitotic patterns are excellent examples of long-lasting photon storage units in biological systems. (??????? Explain cavity resonator ??????)

Source: http://www.imp.ac.at/events/ev_press_4_images.html

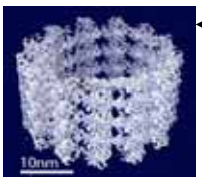
Dürr H.P., Popp F.A.; Schommers W. (eds); 2000; Elemente des Lebens;

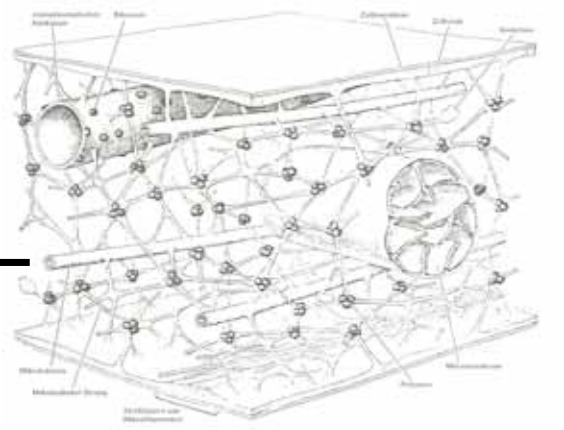
Bischof M.; 1995; Biophotonen, das Licht in unseren Zellen; p.39, p.269;

Biophotons and Communication (3/4)

Within Cell & Cytoskeleton:

Cytoskeleton: fibre-optic network links organelles with cell nucleus; here, the **microtubular** network (25-30nm) represents the primary photonic conductive pathway;





Superposition of different modes in the short wave (optical range) yields a spatially fine resolved intensity-pattern of STANDING WAVES. The spatially distributed electric field serves as guiding force for molecules. They are moved precisely positioned and get also excited. The guiding forces accurately trigger more than $100 \cdot E^3$ chemical reactions per second. These regulative task cannot be done by thermal photons.

i) **Cytoplasm**: the hypothesis that cytoplasm is responsible for biophoton activity is no longer valid (Wijk, 1992);

ii) **Cytoskeleton**: Cytoplasm of the cell provides only a fraction of the biophotonic activity (less than 25% - Wijk, 1992) - see previous slide;

iii) However, the **microtubules** of the cytoplasm plays a vital role in the propagation of the biophotonic emissions originating from the cell nucleus.

iv) Tight-, **adhering-**, and communications junctions conduct biophotonic pulses to neighbouring cells and to the **extra-cellular matrix**!

Adhesive forces between cells connect them to functional units and thus form a resonator system also for long-wave photons. When a cell of the unit dies, the resonance-situation is disturbed and some photons are emitted: THEY INITIATE THE PROCESS OF CELL DIVISION (MITOSIS).

Source: Postlethwait, J.H., Hopson, J.L.;1995; The Nature of Life. 3rd ed.; p.92;

Bischof M.; 1995; Biophotonen, das Licht in unseren Zellen; p.34;

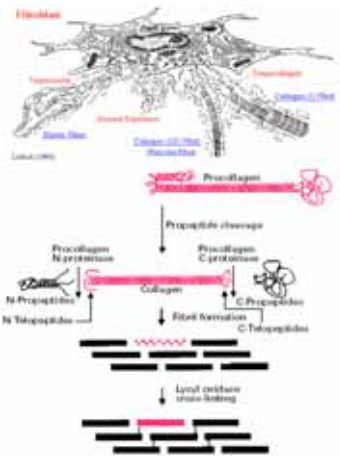
Biophotons and Communication (4/4)

Within Extra-cellular Matrix:

Connective Tissues (CT): light-conducting, extracellular matrix, of which the

Loose CT: (collagen& elastic fibers, fibroblast, matrix) is the most important conductive pathway;

other CT's include Adipose CT (fat), Fibrous CT (fibroblasts collagen & elastic fibers) and the Cartilagenous CT (chondro-cytes, matrix),



Outside the Cell: the purpose and the function of biophotonic processes regard the superposition of field contributions from cells generates an interference pattern; i.e. cell-membranes are positioned in the nodal planes of interference patterns (disease or even cell death disturbs this resonance-pattern - see previous slide).

Outside the cell the spatial energy distribution serves as a communication means and at the same time realizes the formation of functional-specific cell units.

The functions inside and outside the cells interact and form a regulatory process within a cell-unit as can be observed in the cell-cycle.

i) Connective Tissues: Connective Tissue binds other tissues and supports flexible body parts. It lies just under the basement membrane to which epithelial cells are attached, and it produces extra-cellular material that forms a matrix, or a framework, for other structures. This matrix includes:

* collagens: (fibrous proteins - see below), widespread: provides tensile strength; pro-collagen molecules secreted from cell. Self assemble in matrix to form fibres (Type I = thick fibres, II = thin), 67nm bands in EM, may have crimp in light microscopy, reticular fibres (Type IV) - very fine;

Collagen Fiber Types (different modifications, composed of collagen molecules): Type I: most ubiquitous / Type II: in hyaline and in elastic cartilage (its index of refraction is very similar to that of the ground substance) / Type III: reticular fibers for stabilization in reticular connective tissue, in fat cells and in the end-pieces of secretory glands / Type IV: "amorphous Collagen" without a fiber structure, synthesized by epithelia and/or endothelia cells

* elastin: (fibrous protein), fibrous protein forms elastic mesh and imparts yellow colour eg skin, aorta

* proteoglycans: (protein-polysaccharide), protein core+glycosaminoglycan side-chains which bind water: give "turgor"; aggregate with HA, tangle with collagen;

* hyaluronic acid: (long polysaccharide), lubricant, binds matrix, vit.hum of eye;

* water! (large effect on properties); N.B. bones also contain hydroxyapatite;

Source: http://www.tiho-hannover.de/einricht/anat/lit/mwenth/conntis/kol_bdgw.htm http://www.biochemj.org/bj/316/0001/bj3160001.htm

http://137.222.110.150/calnet/cellbio/image/fibroblasts%2520%26%2520fibrocytes-micrograph.jpg&imgrefurl=http://137.222.110.150/calnet/cellbio/page9.htm&h=592&w=491&sz=24&tbnid=LKQudOJn7NoPTM:&tbnh=133&tbnw=110&hl=de&start=23&prev=/images%3Fq%3Dcollagen%2Bmicrograph%26start%3D20%26svnum%3D10%26hl%3Dde%26lr%3D%26sa%3DN

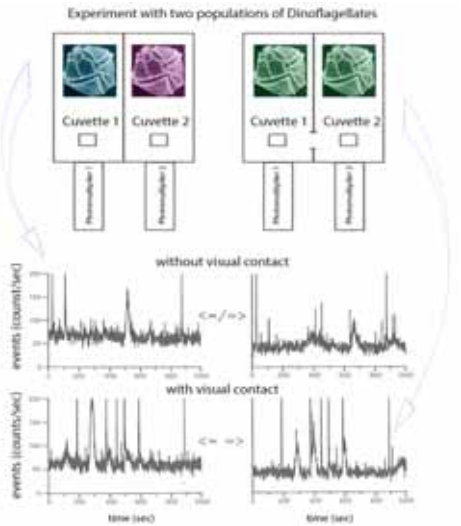
Postlethwait J.H., Hopson j.L.,; 1995; The Nature of Life. 3rd ed.; p.91;

Ho M.W.; 2003; The Rainbow and the Worm: The Physics of Organisms; 2nd ed.;

Biophotons and Semiosis (1/4)

Biophotons are used among:

- **Cells**: communication and synchronization patterns
- **Organs**: to coordinate organ functio
- **Organisms**: to obtain coherent state
- **Inter-/intra organismic** (society): to coordinate "global" response pattern



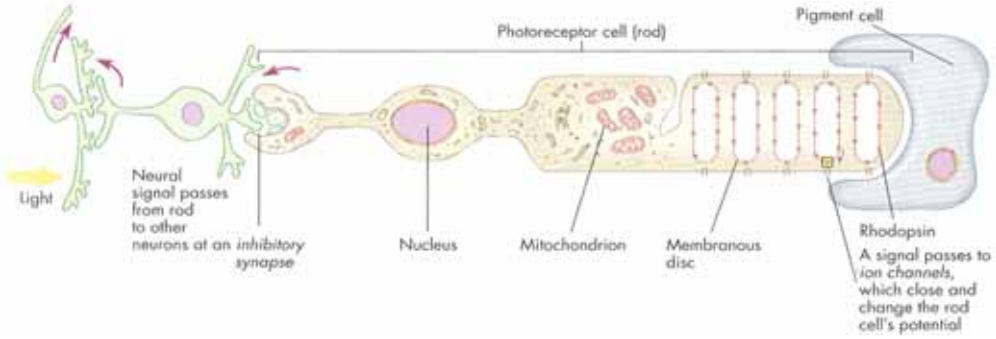
I) Emissions patterns of two biological samples. The two populations of the tiny dinoflagellate *Gonyaulax polyedra* under optically separated (left) and optically connected conditions (right). The top part of the graph shows the pattern of emissions with the shutter closed; the bottom graph shows the experiment with the shutter opened. The random events on the top, become a coordinated, tuned process of increased intensity, with simultaneous spikes of photon emissions.

Source: Bischof M.; 1995; Biophotonen, das Licht in unseren Zellen; p.231;

Biophotons and Semiosis (2/4)

Biophotonic processes are involved in:

Photo-Sensitive Pigments (Rhodopsin)



Molecular cascades are common to all processes involved in signal transduction, and it is generally through that one of their main functions is to amplify the signal - **examples 1:**

i) **Eye**: The visual cascade …. The nervous system has time constants that are too large to account for the rapidity of visual perception - which is in the order of $10 \cdot E^{-2}$sec. Thus it takes about 10msec to activate one molecule of phospho-diesterase after photon absorption. Much of the amplification is actually in the initial step, where the single-photon-excited rhodopsin passes on the excitation to at least 500 molecules of transducin within 1ms! - How that is achieved is still a mystery - but it is assumed that biophotonic processes are key players.

In addition, it was shown that signal transduction via the synaptic cleft occurs not exclusively via neurotransmitter (ACh), but also by biophotones (optic communication)!

i) Photosynthesis …. A similar process is responsible for the highly efficient energy conversion from solar energy into chemical energy (sugar molecules).

Source: Postlethwait J.H., Hopson J.L.; 1995; The Nature of Life; 3rd ed.; p.729;

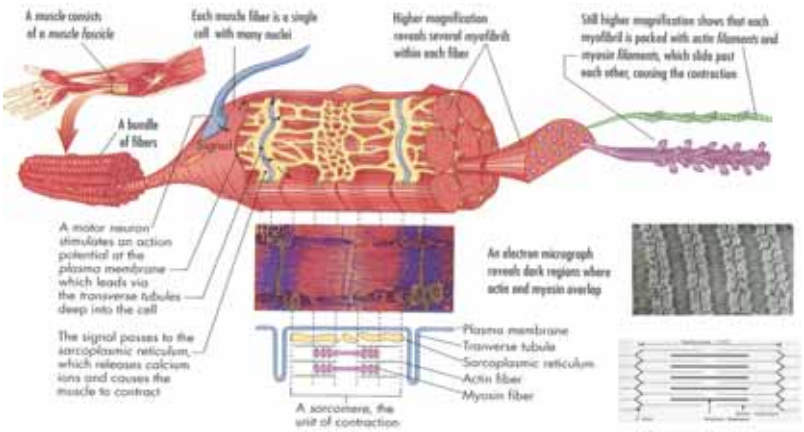
Ho M.W.; 2003; The Rainbow and the Worm: The Physics of Organisms; 2nd ed.; p7-8;

Bischof M.; 1995; Biophotonen, das Licht in unseren Zellen; p.277;

Biophotons and Semiosis (3/4)

Biophotonic processes are involved in:

Muscle Tissues



Muscle fiber - **examples 2:**

i) **Muscle tissue**: The biological processes of molecular energy machines reveal a fundamental quantum nature. The energy stored in a single molecule is released in a specific molecular form and then converted into another specific form so quickly that it never has time to become heat. Macroscopic action is produced by the sum of all the individual molecules involved. Muscle contraction is the most obvious example. Electron tunneling (going under an energy barrier) ….. is already known to be involved in the separation of charges and electron transport across the biological membranes of the chloroplasts …. Indeed, such fluctuational changes in conformation occur within **nanoseconds**, and they have been observed in a large number of proteins. But, in order to do useful work, the fluctuations have to be coordinated. Otherwise there will be equal probability for the reaction to go forwards as backwards and cancel out – as with incoherent energy, precisely as predicted in statistical mechanics. Thus stored energy, being capable of doing work, must be **coherent energy**.

ii) Muscle contraction occurs in definite **quantal steps**, which must be synchronous, at least, over the entire muscle fibers. The contraction is essentially flucutationless - a characteristic of a coherent quantum field!

iii) The actin and myosin molecules are packed and arranged very precisely, approaching the regularity of crystals (PIEZO crystal - thus even muscles are biophoton emitters). In a typical muscle contraction all cells in the muscle - billions of them at the very least - are executing the same molecular threadmilling in concert (coherence); a series of action coordinated instantaneously over a scale of distances spanning NINE ORDERS of magnitude from $1 \cdot E^{-9}$m (1nm). Skeletal muscles consist of bundles of long, thin muscle fibers, that are several cm in length, each of which is actually a giant cell formed by the fusion of many separate cells. The same instantaneous coordination over macroscopic distances involving astronomical numbers of molecules and is sustained over a long period without break. Here energy is available to us at will in the amount we need and is supplied at close to 100% efficiency!

iv) Muscle tonus: in a healthy system both protagonistic and antagonistic muscles oscillate in harmony (muscular micro-vibrations) enabling muscular contraction at will.

Source: Postlethwait J.H.; Hopson J.L.; 1995; The Nature of Life. 3rd ed.; p.743;

Ho M.W.; 2003; The Rainbow and the Worm: The Physics of Orgs; 2nd ed; p.10, 34;

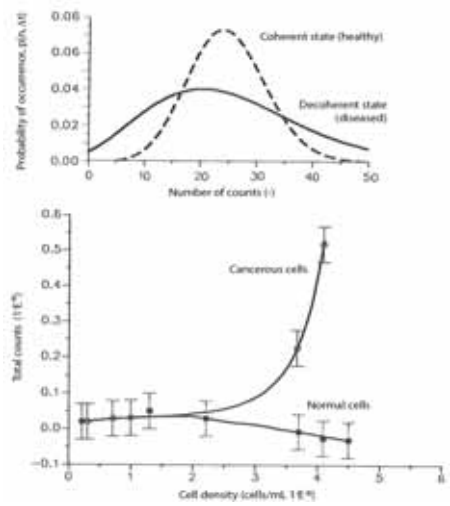
Bischof M.; 1995; Biophotonen, das Licht in unseren Zellen; p.275;

Biophotons and Semiosis (4/4)

Biophotons in healthy and diseased tissues:

Stress: erratic perception of syntactic, semantic, pragmatic codes

Disease: to coordinate organ function



Disease must be considered as a decoupling process - healthy cells resonate unisono, i.e. they are coupled systems of specific tissues, organs, including even the entire organism. Thus such systems should be regarded as huge resonators, while a sick organism is out of tune and no longer able to oscillate in harmony. A diseased organ, organism is no longer capable to "learn" (adapt to new situations), and can be interpreted as a DEVOLUTION in progress.

Even an improper mental reflex (accord. To Bohm, thinking pattern) that may trigger situations of tension or conflict - and in case of prolonged action to chronic stress; if no bio-energeetic regulation does take place psychological and or physical disturbances may result; i.e. sleeping disorders, stomach cramps, that may pave the way for pre-cancerogenic stages.

The entire body - inn particular when talking about proteo-glycans (sugary proteins) can be considered as a huge liquid-crystalline makromolecule, that is according to its dissipative nature subject able to flip-flop from one state to the other (to flip over from a healty state to a sick state).

- Above: A coherent field displays always a Poissonian distribution while a decoherent field is always chaotic.
- Below: Photon counts of normal liver cells (lower curve) have a relatively stable or even falling level of photon counts at increasing cell density, while cancer cells of the same cell type show an increasing photon count at higher cell densities. Populations of cancer cells have lost the harmony (coherence) that is typical for healthy tissue. A tumor is just a symptom resulting from the loss of negative feedback cycles between chaos and order of the entire organism hence. Cutting out the tumor is not equivalent with healing!

Source: Klimek W., Biophotonics - A Rieview, 2005

Bischof M.; 1995; Biophotonen, das Licht in unseren Zellen; p.291, 298, 301, 303;

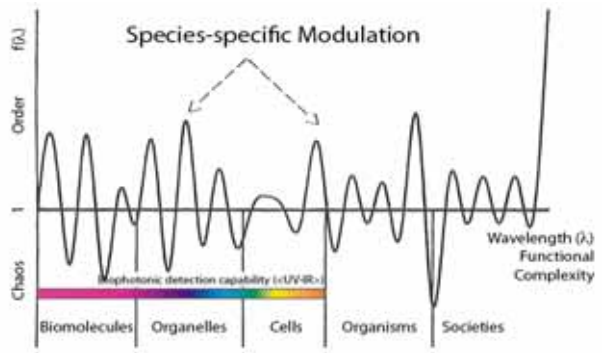
Ho M.W.; 2003; The Rainbow and the Worm: The Physics of Orgs.; 2nd ed; p.115

Bohm D.; 19xx; Thought as a System; p.???

Biophotons on a larger Scale (1/1)

Biophotons on a larger scale:

- **Biomolecules**: DNA, RNA,
- **Organelles**: ribosomes, mitochondria, centrioles, etc.
- **Cells**: of all biota (Archaea, Eubacteria, Protista, Eukaryota)
- **Organism**: Multicellular living beings;
- **Society**: group of single species (population) that can also share common cultural rules (*Homo sapiens*)**;**



i) Abscissa: "1" represents the Balance of Operation (Homeostasis) - from left to right: Functional Complexity

ii) Holographic organism: Although biophotonic processes are predominantly associated to the DNA, they propagate via the microtubular network of the cytoskeleton to the extracellular matrix, thereby involving the entire organism. It is even assumed that any organism (incl. Humans act as a holographic biocomputer). A common hypothesis claims that information in the brain is not stored in localized areas of the brain but rather smeared like a hologram over the entire brain. Thereby, information is retrieved via a built-in Fourier transformation and converted to distinct action potentials.

iii) Living systems are neither mere subjects, nor objects, but subjects and objects at the same time. In contrast to the Neo-Darwinistic point of view the capacity of evolutionary development does not originally depend on the rivalry and power in the fight for existence, rather, it depends mainly on the capacity of communication; they can be looked upon at as expanding antennae systems.

iv) Not only tissues and organs are tied together to form an organism, also members of a group, of a culture, a society. Symbolically, the immune system and a society perform similar tasks – it protects the group from potentially dangerous influences. Pandemics or even epidemics are challenges to the entire social 'immune system'. If the feeling of being 'crippled' is evident within a society, its members to a large extent reflect this attitude (see F.D.Roosevelt's election, 1933: a handicaped president for a crippled nation trying to escape the great depression). Most members are victims of the tribal culture.

Source: Popp F.A., et al.; 1992; Recent Advances in Biophoton Research;

Bischof M.; 1995; Biophotonen, das Licht in unseren Zellen; p.276;

Myss C.; 2000; Anatomy of Spirit; (DE ed.); p.144-149;

Conclusion

Living systems are dynamic, multimode storage structures.

Biophotons coordinate regulatory processes:
- the spatially inhomogeneous energy distribution structures biological matter;
- biological matter changes the spatial distribution of energy;
- this feedback loop yields a self-organizing control of the regulation process;
- this regulation process enables growth in stability and leads to an increase in functional complexity;

Danke für Eure Aufmerksamkeit - Thanks for your attention

i) Conclusion: Coherence is the capability of each unit to interact with all the other parts that constitute a living system. It is possible to show evidence of an extraordinary high degree of coherence of biophotons. The conclusion follows that this universal phenomenon of biological systems is responsible for the information transfer within and between cells. This responsive patterns is crucial for intra- and extracellular biocommunication, including the regulation of the metabolic activities of cells as well as of growth and differentiation and even of evolutionary development.

ii) Not only cellular compounds and population of species but also growth, embryogenesis, morphogenisis, biological rhythms, metamorphosis, differentiation of tissues, as well as communication and social forms, patterns and behaviors of individuals and populations are organized and regulated by coherent photons.

Source: Bischof M.; 1995; Biophotonen, das Licht in unseren Zellen; p.273;