

Intro

UwPE

4th H₂O

EMF

QFT

Conclusio

Why QFT matters!

Towards a Biophysical approach of
Health & Disease



**Introductory Lecture & Teaser
of Coherence in Biology**

Contributed by
Pierre MADL

for the Biophysics Seminar 2015



16-05-04

Madl

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URL: biophysics.scb.ac.at/talk/Why_QFT_matters.pdf

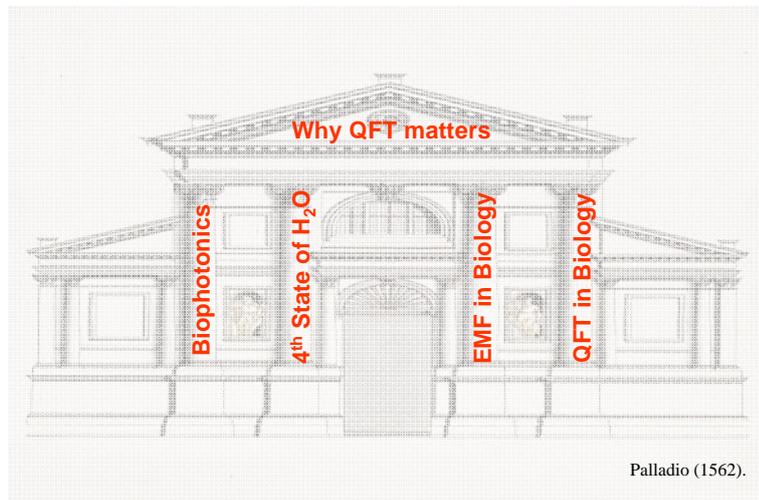
A Note to the reader

Brief intro for this lecture series:

Introductory module
(Why QFT matters)

The following deepening modules on issues raised herein are available as:

1. Biophotonics
2. 4th state of Water
3. EMF in Biology
4. QFT in Biology



Palladio (1562).

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A short note to the reader to facilitate readability and render the presented issues more digestible.

This lecture series consists of 4 (+1) modules. While each can be regarded as an independent entity, references therein (due to the multidisciplinary approach of the issues raised and because the issues are much better embedded therein) often refer to topics in one of the three other modules. Hence the five modules should be seen as a full package. Due to the sheer size, each module is offered individually (available from <http://biophysics.sbg.ac.at>).

The entire lectures series is headed by a relatively short overview and provides a quick “dive” into the main subjects and acts as a teaser for the actual modules. Thus, the introductory module entitled *Why QFT matters*, should be regarded as an enclosing envelop that tickles the reader by presenting unsolved riddles in biology that will be lifted once the reader dares to proceed further on to one or all the four modules.

In accordance with the that introductory module, the following four modules deepen the initially raised arguments and deals with the following topics:

1. **Biophotonics - The Light of Life**
2. **Liquid Crystalline State (or Fourth State) of Water**
3. **Role of Electromagnetic Fields in Biology**
4. **Quantum Field Theory in Biology**

Each of these four modules are in themselves split up into several sub-categories and typically cover a brief historical section, which are then deepened with related issues that build on the initially presented principles.

The author hopes that this brief introduction does not deter the reader from proceeding, but rather raises interest to such an extent as to become aware that there is a paradigm shift in biology and medicine that will turn upside down our current understanding of reality.

With these words, I wish you a pleasant read For comments and criticism, please do not hesitate to contact me at: [pierre.madl\(at\)sbg.ac.ac](mailto:pierre.madl(at)sbg.ac.ac)

Image: Alzado de la fachada de San Francesco della Vigna de Andrea Palladio (1508–1580)
<http://viajarconelarte.blogspot.co.at/2013/06/la-fachada-de-palladio-en-san-francesco.html>

Introduction



*.... some of many riddles that should make
one think*

Image: Pollack GH (2013) The Fourth Phase of Water: Beyond Solid, Liquid, and Vapor. Ebner & Sons (USA)

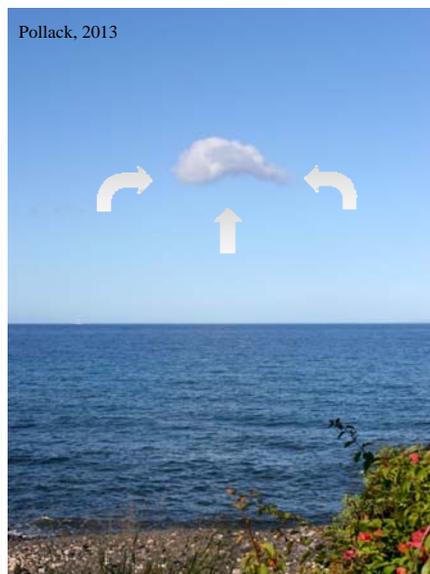
Introduction (1/10)

- i) Cloud: Isolated puffy white clusters.
 -) localized H₂O-droplet aggregates
 -) under stable conditions show no tendency of disintegration
 -) bear an intrinsic charge

.... so why does the cloud not fall apart?



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The Evaporative Event: Radiant energy builds vesicle EZs. If the EZ buildup adds interior protons, then mounting pressure may expand the vesicles, turning their liquid interiors to vapor. With that density reduction, the tubules may rise up into the air, creating the multi-tubular figures seen in the evaporating vapor. At first glance, density reduction would seem adequate to propel the rise: vapor-filled vesicles have lower density than liquid vesicles. However, interior density reduction cannot be the full story, for the vesicle also has a shell to consider. The shell consists of dense EZ material, denser even than liquid water. So vapor interior notwithstanding, mean vesicle density could easily remain higher than that of air. On the basis of density alone, then, the vesicles might not necessarily rise. Something more certain seems necessary for propelling the rise.

For a clue, think of those vesicles that rise high up to eventually form clouds. Cloud vesicles — often called aerosol droplets — are filled with water. Those clouds can be weighty Some alterable force keeps the elephants high in the sky to prevent them from falling. That same force might help lift the vesicles.

One could speculate that that lifting force may be electrostatic, i.e., charge based Negative charge by itself is not sufficient for explaining lift; however the earth bears negative charge as well. Those two negative charges create a repulsive force. In theory, this vertically oriented repulsive force could help propel the evaporative rise.

With this mechanism we can appreciate why the rise is practically explosive. The sun's radiant energy creates vesicles, which then self-assemble into mosaic tubes. The tubes bear net negative charge because constituent vesicles are negative. Protons lying between vesicles mitigate the negativity; however, those like-like attractors are merely spot welds contributing only modest amounts of positive charge. Net negativity remains. As tubules adsorb more and more vesicles the tubules' net negativity increases. When the internal charge exceeds a threshold, the tubule structure literally tears itself apart at the weakest point. The top section then rises upward — repelled from the negative residual structure below and also from the negative Earth.

Image: https://en.wikipedia.org/wiki/Niagara_Falls#/media/File:Niagara_Falls_at_night1.jpg

Isolated puffy white clouds. From vast uninterrupted reaches of the ocean's water, vapor rises toward the sky. The vapor is everywhere. Yet clouds will often form as localized entities, punctuating the otherwise clear sky. What force directs the rising water vapor towards those specific sites?

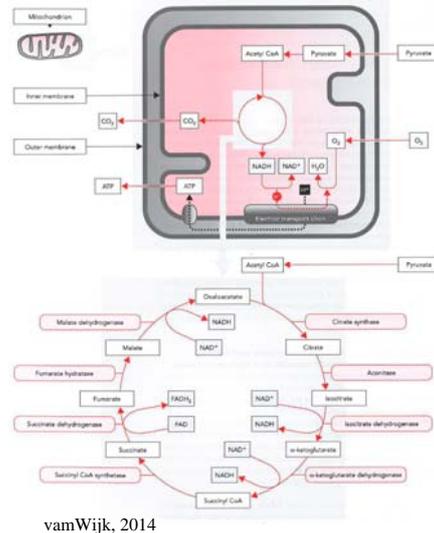
Source: Pollack GH (2013) *The Fourth Phase of Water: Beyond Solid, Liquid, and Vapor*. Ebner & Sons (USA)

Introduction (2/10)

- i) Cloud: Isolated puffy white clusters.
- ii) Egg: diffusion dilemma in a gel matrix
How can a complex reaction such as the CAC be maintained in such a "sticky" environment?



16-C



vamWijk, 2014

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The alternative places protein surfaces on center stage, ordering nearby water molecules into a "structured" state and providing adsorptive sites for charged solutes. The resulting protein-ion-water matrix has a gel-like character very different from the liquidity of an aqueous solution In considering the nature of the cytoplasm, think of the familiar egg. Certainly you have cracked open a raw egg—would you characterize it as an aqueous solution? Or, is fresh egg-white more gel-like? The raw egg did not mislead—the cytoplasm is not the aqueous solution it is cracked up to be. Although ordinary water freezes at 0°C, cell water does not. Even after accounting for freeze-temperature depression arising from the presence of dissolved particles, cell water should still freeze at just below 0°C, but far lower temperatures are required. The cytoplasm's water behaves anomalously—molecules are somehow kept from entering the ice phase. Something restrains them. (1)

Electron microscopic studies by George Palade and Fritjof Sjostrand revealed that mitochondria have two membrane systems, an outer membrane and an extensive highly folded inner membrane. A typical mitochondrion is about the size of a bacterial cell with a diameter of 0.2 to 0.8 μm and a length of 0.5 to 2 μm . The two membranes have markedly different properties. The outer mitochondrial membrane has few proteins, the major protein forms channels through this membrane allowing free diffusion of ions and small water soluble metabolites. The inner mitochondrial membrane is very rich in protein. This membrane is permeable to uncharged molecules such as water, O₂, and CO₂

The protein concentration in the matrix is so high that the matrix is somewhat like a gel. The reactions of the citric acid cycle take place in the matrix

Basically, the citric acid cycle is harvesting high-energy electrons from carbon fuels with two carbon atoms entering the cycle (as an acetyl unit) and two carbon atoms leaving the cycle as two molecules of carbon dioxide

The high-energy electrons and redox potentials are of fundamental importance in oxidative phosphorylation in which O₂ is the acceptor of these electrons.

Mitochondrion: Schematic overview of the mitochondrial structure and the citric acid cycle. The upper left panel presents the basic structure of a mitochondrion. The lower panel demonstrates the intermediates and enzymes of the citric acid cycle. The reaction of acetyl CoA with oxaloacetate starts the cycle by producing citrate. In each turn of the cycle, two molecules of CO₂ are produced, plus three molecules of NADH, and one molecule of FADH₂. (2)

Water, as we know, will self-organize around protein surfaces. The actin surface appears to be especially adept, for actin filaments gel practically at the snap of a finger, implying high water-adsorptive capacity. Even huge osmotic gradients cannot remove actin-gel water (Ito et al., 1992). Moreover, the actin-filament bundle is confirmed by microscopic observations to be jacketed by a clear zone extending out as far as 1,000 nm from the bundle's surface, devoid of any particulate matter (Kamitsubo, 1972). Exclusion of solutes again implies high water-structuring capacity.

Source: (1) Pollack GH (2001) Cells, Gels and the Engines of Life. Ebner & Sons (WA), USA

Ito T, Suzuki A, Stossel T P (1992). Regulation of water flow by actin-binding protein-induced actin gelation. Biophys.J. Vol.61: 1301-1305.

Kamitsubo E. (1972). Motile protoplasmic fibrils in cells of the Characeae. Protoplasma Vol.74: 53-70.

(2) vanWijk R (2014) Light in Shaping Life – Biophotons in Biology & Medicine. Meluna, Geldermalsen (NL), EU

Introduction (3/10)

- i) Cloud: Isolated puffy white clusters.
- ii) Egg: diffusion dilemma in a gel matrix
- iii) Medusa: How can 99% of water move in coordinative manner?

What role is assigned to bio-molecule associated water?



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Bulk water covers almost 71% of our planet Biological water constitutes about 79% of the newborn and 57% of the adult human body mass (in certain medusa's even up to 99%). A water molecule with its bent structure reveals peculiar properties as an energy transducer. Although water is able to absorb and re-emits most of it as heat, a substantial part of it is also present in a form that can be utilized for work. In a neg-entropic concept, this kind of work creates order and separates charges Hence, water – in particular, organismic water – is an energy transducer and does so via i) electromagnetical, ii) physico-chemical, iii) electrical and iv) mechanical pathways It needs to be highlighted, though, that this quite new approach is still highly debated. Thus we present the following issues only in view of the fascinating possibilities that may arise out of the ongoing discussions.

Just like jelly fish, gelatin desserts comprise 95% water. The question is why all that water doesn't just dribble out. In fact, there is no dribbling, even from gels whose water content is 99.9% That's practically all water, with only a bare trace of solids. Why doesn't all that water leak out?

Animation: giphy.com/gifs/psychadelic-jellyfish-pu0QEMzRJdVzq or giphy.com/gifs/jellyfish-GEsoqZDGVoisw

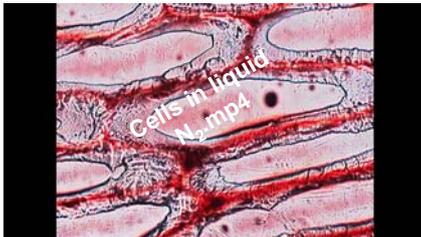
Source: Pollack GH (2013) *The Fourth Phase of Water: Beyond Solid, Liquid, and Vapor*. Ebner & Sons (USA)

Madl P, Lemaire SE (2015) The field and the photon from a physical point of view. In: Fels D, Cifra M, Scholkmann F (eds) *Fields of the Cell*. Editors. Research Signpost, Kerala IND.

Introduction (4/10)

- i) Cloud: Isolated puffy white clusters.
- ii) Egg: diffusion dilemma in a gel matrix
- iii) Medusa: 99% water in coordinated motion
- iv) How can cells survive in deep-freeze?
Certain substances interfere with ice-crystal formation
– how to these interact with the water matrix?

Cell culture
samples
survive -196°C
(DMSO-mediated)



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Cucujus clavipes
survives -100°C
(protein-mediated)

Upis ceramboides
survives -60°C
(sugar-mediated)



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Konventionsgemäss soll Wasser unter atmosphärischen Standarddruck bei 0°C frieren und bei 100°C kochen. Dies ist umso erstaunlicher wenn man sich vergegenwärtigt dass je kleiner die Moleküle desto niedriger liegt der Siedepunkt. Ein darauf basierender Vergleich von Wasser mit ähnlichen Substanzen würde somit ergeben dass Wasser bei -93°C sieden und nur wenige Grad darunter gefrieren sollte (Franks, 1981). Schon damit wird klar das Wasser und hier speziell die einzelnen Moleküle, etwas besonderes sind, zumal diese aufgrund ihrer gewinkelter Anordnung ein Dipolmoment ausbilden das in der Lage ist durch Wasserstoff-Brückenbildung seiner Umgebung (sofern geladen) in Interaktion zu treten (Chang, 1994). Aufgrund dieser Eigenschaft sind Wassermoleküle in der Lage bis zu vier Wasserstoff-Brücken zu bilden wodurch sich diese Moleküle gegenseitig dreidimensional vernetzen. Obwohl es eine schwache Bindung ist (ca. 5% der chemischen Bindungsstärke zwischen Sauerstoff und Wasserstoff) so reicht die aus um Wassermoleküle aneinander „kleben“ zu lassen – mit den für uns bekannten Siede- und Gefrierpunktwerten (Franks, 1981). Dass Wasser unter bestimmten Bedingungen aber auch weit unter diesem Gefrierpunkt fest, bzw. bei Temperaturen fern von 100°C verdampfen kann wurde erst kürzlich wieder von Chang (2011) bestätigt. Könnte darin Erklärungsmöglichkeiten zu finden sein wie es einigen Arthropoden (z.b. *Cucujus clavipes* in der Arktis) möglich ist Temperaturen von -100°C zu überleben ohne das Eiskristallbildung deren biologische Matrix irreparable perforiert? Hinweise dazu weisen auf spezielle Proteine und glycolytische Enzyme (Carrasco, et al., 2012). Ganz anders bei dem gefriertoleranten Käfer *Upis ceramboides*, der er schafft lediglich durch grosse Zuckermoleküle und Fettsäuren schafft in eine Kältestarre zu verfallen und -60°C schadlos zu überdauern (Walters et al., 2009). Bis zu einer gewissen Grösse lässt sich das auch ohne Hilfsstoffe erreichen, denn in fast jedem Labor werden Zellen bei -196°C lagert ohne dass diese merklich Schaden nehmen. Mehr noch, mindestens 20% des Zellwassers bleibt bei diesen Temperaturen flüssig (Franks, 1981). In allen Fällen ist Wasser im Spiel, doch welche Rolle spielt dabei dieses biologisch gebundene Wasser? Offensichtlich sind die Wassermoleküle in einer gewissen Zwangssituation die sie daran hindern ihre adäquaten Plätze in der Eiskristall-Konfiguration einzunehmen. Wir wissen noch viel zu wenig um die Verteilung von Wasser innerhalb der Zelle, und wie seine Funktion und wie sein Fluss in und aus der Zelle kontrolliert werden. Speziell wenn man sich vor Augen hält dass zelluläres Wasser überwiegend in einer gel-ähnlichen Matrix gebunden vorliegt (Pollack, 2001) und eine flüssigkristalline Eigenschaft annimmt (Ho, 2003).

Franks, F. (1981). Polywater. MIT Press, Massachusetts, USA.

Chang, R. (1994). Chemistry. 5th ed. McGraw-Hill., Princeton, USA.

Carrasco, M.A., Buechler, S.A., Arnold, R.J., Sformo, T., Barnes, B.M., Duman, J.G. (2012). Investigating the deep supercooling ability of an Alaskan beetle, *Cucujus clavipes puniceus*, via high throughput proteomics. *J Proteomics*. Vol. 75(4): 1220-1234.

Walters, K.R., Serianni, A.S., Sformo, T., Barnes, B.M., Duman, J.G. (2009). A nonprotein thermal hysteresis-producing xylomannan antifreeze in the freeze-tolerant Alaskan beetle *Upis ceramboides*. *Proc Natl Acad Sci*, Vol. 106(48): 20210–20215.

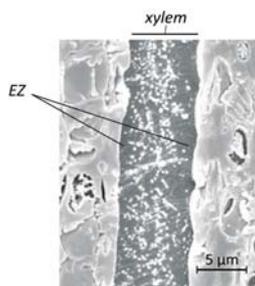
Mirabet V, Carda C, Solves P, Novella-Maestre E, Carbonell-Uberos F, Caffarena JM, Hornero F, Montero JA, Roig RJ. (2008) Long-term storage in liquid nitrogen does not affect cell viability in cardiac valve allografts. *Cryobiology*. Vol.57(2):113-121.

http://www.researchgate.net/post/How_are_cells_able_to_survive_at_80_degree_Celsius_as_all_the_water_80_of_total_volume_will_freeze_and_volume_will_increase_leading_to_lysis

Introduction (5/10)

- i) Cloud: Isolated puffy white clusters.
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- iv) How can cells survive in deep-freeze?
- v) How can a redwood pump water 100 high?

Capillary force and osmosis are just one side of the medal, what is the other?



Wegner & Zimmermann, 2004



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Rising water. Drawn from the tree's roots, water flows upward through narrow channels. It quenches the leaves' thirst. To draw the water upward, the top of the column supposedly exerts an upward force. But the column of water can be pretty heavy, especially those of 100-meter-tall Redwood trees. The columns should therefore break, like strings carrying too-heavy weights. That's a problem: once a column breaks it can no longer draw from the roots. How does nature avert this debacle?

Water Transport in Tall Trees: Capillary action is not restricted to quartz tubes and paper napkins alone; it occurs throughout nature. It is especially prominent in plants and trees, where water may rise even to the tops of 100-meter Redwood trees. Inside such trees, narrow xylem vessels run from roots to leaves, transporting the water ever upward First, the "hanging column" is too heavy to be lifted more than about 10 meters; and second, the air pockets commonly found within xylem tubes should thwart the drawing process as they do in straws. Scientists struggle with those issues A key issue is whether xylem tubes contain exclusion zones, and the answer appears to be yes He infused small ink particles into xylem tubes, quickly froze the specimens, and examined the frozen samples in an electron microscope. The results were positive Annular EZs in Nafion tubes generate steady flow Standard textbooks confirm the sap's low pH value, and modern methods narrow down those pH values. In maize seedlings for example, xylem pH ranges between 4 and 5, depending on conditions (Wegner and Zimmermann, 2004). Hence, the xylem fluid contains the required protons.

For plants, the main issue is replacing the water lost through evaporation. Water evaporates from the leaves. As it does, the xylem may become transiently dry near the top, except for a few residual EZ layers. Those EZ layers would then be the responsible protagonists; they must draw the water upward from below. They may do so by the same mechanism that draws water upward in the narrow quartz capillary tubes. That's all that's necessary for keeping the leaves hydrated The upper vessels of trees are of micrometer scale. The tubes farther down are wider, but still much narrower than standard quartz capillary tubes. Further, those tubes are commonly invested with meshes of hydrophilic polymer strands, which effectively narrow the tubes. EZs cling to all of these many surfaces; and positively charged bulk water clings to those EZs.

The energetics seem worthy of comment. The upward flow requires energy, just as pumping water to an elevated storage tank requires energy. The source is familiar: incident radiant energy. In the same way that radiant energy fuels the flow of water inside hydrophilic tubes, the same radiant energy should also fuel the flow through xylem tubes.

Given the rather direct contribution of radiant energy, you can understand why xylem flow might be seasonal. Flow begins as spring approaches — just when ambient radiant energy begins picking up. The flow increases as summer approaches, slows down in autumn, and shuts off in winter.

Source: Wegner LH and Zimmermann U (2004): Bicarbonate-Induced Alkalinization of the Xylem Sap in Intact Maize Seedlings as Measured in Situ with a Novel Xylem pH Probe. *Plant Physiol.* 136(3): 3469–3477.

Introduction (6/10)

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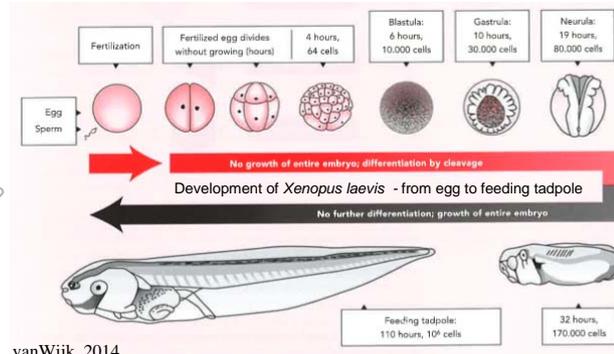
-) several organizational levels

(cells, tissues & other ordered domains), vanWijk, 2014

-) time ordering (sequentially ordered chains of chemical reactions),

-) functional organization (functional differentiation among different parts and compartments, hierarchical & temporal sequences of functions).

What is the coordinating entity behind these processes?



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Moving from such a hope Fröhlich observed that, although great energy and many valuable efforts have been put into play in biochemistry, nevertheless the question still remains open of how order and efficiency arise in living systems, and then coexist with random fluctuations in biochemical processes. **Living matter presents several levels of spatial organization (cells, tissues and other ordered domains), time ordering (sequentially ordered chains of chemical reactions), functional organization (functional differentiation among different parts and compartments, hierarchical and temporal sequences of functions).** Thus, from one side, there is the high level of space and time ordering, and the high and stable functional efficiency; on the other side, there is the randomness of kinematics which rules any chemical reaction. As a matter of fact, the question of how order, efficiency and functional stability arise in living systems also was a motivation for Erwin Schrodinger (Schrodinger 1944).

In the developing embryo, the movement of most cells are often extensive and dramatic. During the period of cleavage, the frog embryo becomes transformed from a solid sphere of cells into a hollow ball, a fluid filled cavity surrounded by cells. The embryo is then labelled as a *blastula*. Soon after this, the coordinated movements of gastrulation begin. This process transforms the hollow ball of cells into a multilayered structure with a central gut tube and bilateral symmetry. Many of the cells on the out-side of the embryo are moved inside. Subsequent development depends on the interactions of the inner, outer, and middle layers of cells thus formed. *Ectoderm* is the precursor of the epidermis and of the nervous system. A part of this sheet becomes tucked into the interior to form the *endodermis*, the precursor of the gut and its appendages such as the lung and liver. Another group of cells move into the space between ectoderm and endoderm, forming the *mesoderm*: the precursors of muscles, connective tissues, and various other components. From these three germ layers, the tissues of the adult vertebrate body will be generated preserving the basic body plan established through gastrulation. In the process, the three principle axes of the body are established: antero-posterior from head to tail; dorso-ventral from back to belly; and medio-lateral from the midline outwards to the left or to the right.

Source: Schrödinger E (1944) What is Life? The Physical Aspect of the Living Cell, Cambridge University Press, Cambridge, UK

<http://www.ib.bioninja.com.au/standard-level/topic-2-cells/21-cell-theory.html>

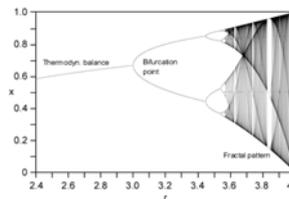
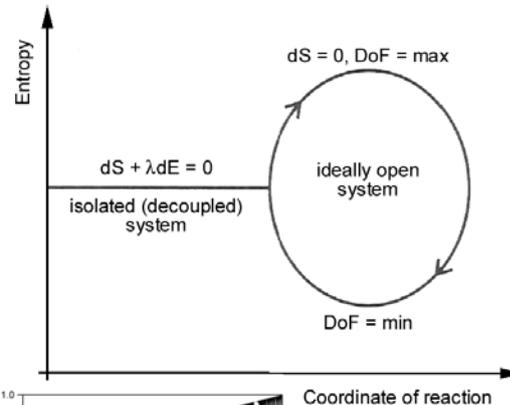
vanWijk R (2014) Light in Shaping Life – Biophotons in Biology & Medicine. Meluna, Geldermalsen (NL), EU

Introduction (7/10)

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- vi) Form & shape in phylo-ontogenetic development (out of 1D-DNA?)
- vii) Epigenomic modulation & Thermodynamics

Why can living things maintain such a high degree of neg-Entropy?

Why living entities seem to defy the 2nd LoTD?



Rossi et al., 2014

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Epigenetics: It is the study of reversible heritable changes in gene function that occur without a change in the sequence of nuclear DNA. It is also the study of the processes involved in the unfolding development of an organism. In both cases, the object of study includes how gene regulatory information that is not expressed in DNA sequences is transmitted from one generation (of cells or organisms) to the next - that is **'in addition to'** the genetic information encoded in the DNA.

Waddington's "**Epigenetic Landscape**":

- **Vertical axis:** the distribution is shown in the vertical direction; we have the points on the orbit for a certain value of x . This orbit is chaotic, but if we look at the distribution, it is definitively not fractal. It approximately looks like a U-shaped pattern (higher probabilities at the edges, lower at the center).

- **Depth axis:** the path followed by the ball, as it rolls down, corresponds to the developmental history of a particular organ. There is first an alternative, towards the right or the left. Along the former path, a second alternative is offered; however, it can only be reached over a threshold.

- **Bottom:** interacting network of signal transduction pathways. The pegs in the ground represent genes; the strings leading from them represent the pathways initiated by gene expression. The slope of the epigenetic landscape is controlled by the pull of these numerous pathways which are ultimately anchored to the genes.

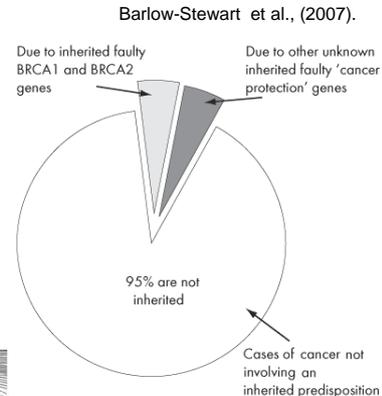
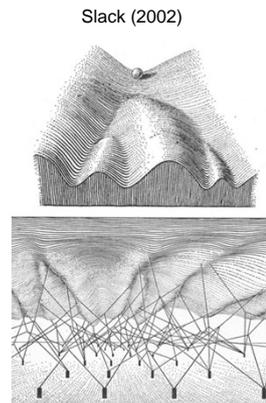
Bifurcation Pattern: In case of brief disturbances, homeostasis is restored sooner or later as the disturbance passes. On the other hand, if the disturbance or is significantly long, a series of irreversible events bring the organism to a new 'steady state'. Chronic disturbances favour development or differentiation of "new" tissues (cancer as a result of prolonged and repetitive events of distress?). The **tumour cell as such does not exist** (the bad cell, the bad virus = HN15N, the bad bacteria = *Mycobacterium tuberculosis*, the bad plant = *Caulerpa taxifolia*, the bad animal = *Canis lupus*, the bad individual = *Homo sapiens sapiens*, the bad group of people = Bush's axis of evil, etc.). **It just depends on the interaction with its surroundings** (the relation is much more important than the entities themselves). Here the disease itself becomes a messenger, the vehicle that tries to communicate to the outside world / brain (i.e. to the westener that sees the body as something separate from the mind).

- Accordingly, **the segmental structure of the fruitfly *Drosophila* is not predetermined (preformed) in the egg, but evolves rather from a step-by-step (epigenetic) process** that controls the spatial distribution of regulatory proteins that in turn de/activate the corresponding genes sequences – a result of the MGF.

Source: Rossi C, Madl P, Foletti A, Mocenni C, (2015) Chapter 4 - Energy flow and dissipative structures. In: Fels D, Cifra M, Scholkmann F (eds), Field of the Cells, Vol. 1, Research Signpost (IND).

Introduction (8/10)

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- iv) How can a redwood pump water 100 high?
- v) Form & shape in phylo-ontogenetic development (out of 1D-DNA?)
- vi) Epigenomic modulation & Thermodynamics
- vii) Extremely low mutation rate adult human body:
 -) body: roughly $37.2 \cdot E^{12}$ cells
 -) w/ approx. $350 \cdot E^9$ mitotic events/day
 -) <95% of tumors w/ epigenetic origin



What assures such a **low rate** of mutation?

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Judah Folkman (1974) estimated that as many as 350 billion mitosis occur in the human body every day. With each cell division comes the chance that the resulting cells will be malignant. Indeed, Folkman and his colleagues have shown by autopsy that every person over 50 years old has microscopic tumors in their thyroid glands (although less than 1 in 1000 persons have thyroid cancer). They suggested that cells capable of forming tumors develop at a certain frequency. However, most never form observable tumors. The reason is that a solid tumor (like any other rapidly dividing tissue) needs oxygen and nutrients to survive. Without a blood supply, potential tumors either die or remain dormant. Such "microtumors" remain (under low oxygen conditions) as a stable cell population wherein dying cells are replaced by new cells. The critical point at which a node of cancerous cells becomes a rapidly growing tumor occurs when it becomes vascularised. A microtumor can expand to 16000 times its original volume in the 2 weeks after vascularization.

Source: Gimbrone MA, Cotran RS, Folkman J (1974). Tumor growth and neovascularization: an experimental model using rabbit cornea. *J. Natl. Cancer Inst.* Vol.52: 413-427.

Bianconi et al. (2013). An estimation of the number of cells in the human body. *Annals of Human Biology*, 1-11

Specialized DNA polymerases (DNA pols) are required for lesion bypass in human cells¹. Auxiliary factors have an important, but so far poorly understood, role. Here we analyse the effects of human proliferating cell nuclear antigen (PCNA) and replication protein A (RP-A) on six different human DNA pols—belonging to the B, Y and X classes—during in vitro bypass of different lesions. The mutagenic lesion 8-oxo-guanine (8-oxo-G) has high miscoding potential. A major and specific effect was found for 8-oxo-G bypass with DNA pols I and g. PCNA and RP-A allowed correct incorporation of dCTP opposite a 8-oxo-G template 1,200-fold more efficiently than the incorrect dATP by DNA pol I, and 68- fold by DNA pol g, respectively. Experiments with DNA-pol-I- null cell extracts suggested an important role for DNA pol I. On the other hand, DNA pol i, together with DNA pols a, d and b, showed a much lower correct bypass efficiency. Our findings show the existence of an accurate mechanism to reduce the deleterious consequences of oxidative damage and, in addition, point to an important role for PCNA and RP-A in determining a functional hierarchy among different DNA pols in lesion bypass.

Numerous investigations of the epidemiology of cancer reveal that only 5 to 10% of breast, prostate or bowel cancer and 1-2% of melanoma cases are attributable to genetic mutations, while the large bulk does not involve an inherited predisposition at all. [2,3]

Image: Proportion of cases of breast cancer that involve an inherited predisposition (susceptibility).

Slack JMW (2002). Conrad Hal Waddington: the last Renaissance biologist? *Nature Reviews Genetics*; Vol.3: 889-895;

Source: <http://www.genetics.edu.au/Publications-and-Resources/Genetics-Fact-Sheets/FactSheet48BreastandOvarianCancerandInheritedPredisposition.pdf>

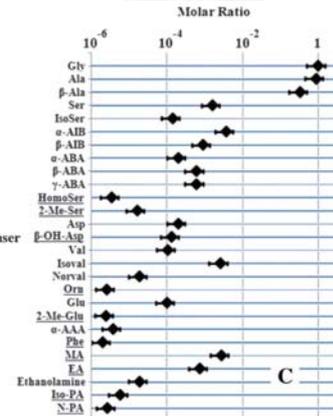
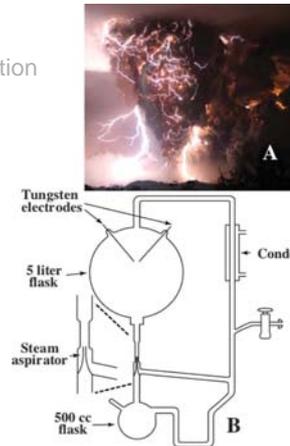
[1] Maga G, Villani G, Crespan E, Wimmer U, Ferrari E, Bertocci B, Hübscher U. (2007) 8-oxo-guanine bypass by human DNA polymerases in the presence of auxiliary proteins. *Nature* 447, 606-608.

[2] Willett W.C. (2002). Balancing Life-Style and Genomics Research for Disease Prevention. *Science*, Vol.296(5568): 695-698.

[3] Barlow-Stewart K., Dunlop K., Reid V., Saleh M. (2007). The Australian Genetics Resource Book. Centre for Genetics Education. Fact Sheet No. 48, 49, 50, 51; available online: www.genetics.edu.au/factsheet

Introduction (9/10)

- i) Cloud: Isolated puffy white clusters.
- ii) Egg: diffusion dilemma in a gel matrix
- iii) Medusa: 99% water in coordinated motion
- iv) How can cells survive in deep-freeze?
- v) How can a redwood pump water 100 high?
- vi) Form & shape in phylo-ontogenetic development (out of 1D-DNA?)
- vii) Epigenomic modulation & Thermodynamics
- viii) Extremely low mutation rate
- ix) The Primordial soup Hypothesis
 -) why would this approach not work?



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EDG_E

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In this apparatus an attempt was made to duplicate a primitive atmosphere of the earth, and not to obtain the optimum conditions for the formation of amino acids. Although in this case the total yield was small for the energy expended, it is possible that, with more efficient apparatus (such as mixing of the free radicals in a flow system, use of higher hydrocarbons from natural gas or petroleum, carbon dioxide, etc., and optimum ratios of gases), this type of process would be a way of commercially producing amino acids.(1) Geoscientists today doubt that the primitive atmosphere had the highly reducing composition Miller used.(2)

-) gas-mix in atmosphere was different to that what Miller assumed;

-) released organelles of cells wouldn't evolve to fresh cells;

Figure: (A) Lightning associated with the 3 May 2008 eruption of the Chaiten volcano, Chile. (B) The volcanic spark discharge apparatus used by Miller (3). Gas quantities added were 200 torr of CH₄, 200 torr of NH₃, and 100 torr of H₂ [these would have dissolved in the water according to their solubilities (2)]. Water was added to the 500-cm³ flask and boiled, and the apparatus sparked with a Tesla coil for 1 week; (C) Moles (relative to glycine=1) of the various amino acids detected in the volcanic apparatus vials [see (2) and table S1 for abbreviations]. Amino acids underlined have not been previously reported in spark discharge experiments. Values for amines are minimum values because of loss due to their volatility during workup.

Source: (1) Miller SL (1953) A Production of Amino Acids Under Possible Primitive Earth Conditions. Science, Vol.117:528-529.

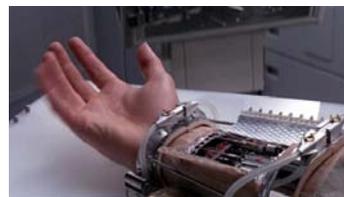
(2) Johnson AP, Cleaves HJ, Dworkin JP, Glavin DP, Lazcano AL, Bada JL (2008) The Miller Volcanic Spark Discharge Experiment. Science, Vol. 322: 404

Gishlick AD (2005) The Miller-Urey Experiment. Icons of Evolution? Why Much of What Jonathan Wells Writes about Evolution is Wrong. National Center for Science Education.

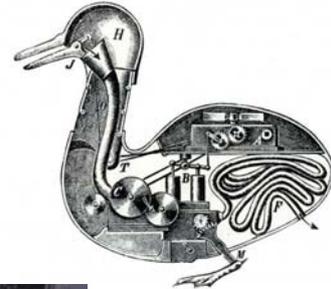
Introduction (10/10)

- i) Cloud: Isolated puffy white clusters.
- ii) Egg: diffusion dilemma in a gel matrix
- iii) Medusa: 99% water in coordinated motion
- iv) How can cells survive in deep-freeze?
- v) How can a redwood pump water 100 high?
- vi) Form & shape in phylo-ontogenetic development (out of 1D-DNA?)
- vii) Epigenomic modulation & Thermodynamics
- viii) Extremely low mutation rate
- ix) The Primordial soup Hypothesis
- x) Difference b/w a healthy, a diseased and a dead organism?
-) Classical Physico-Chemical science still does not know the differences!

Artificial hand (Pare', 1564)



mechanized "Digesting Duck"
(Vaucanson, 1739)



The differences among these states can't be elaborated if looked at from a mechanistic point of view.

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Left: French surgeon Ambroise Paré designed mechanical hands to replace those amputated on the battlefields of sixteenth century France. His 1564 manual, *Instrumental Chirurgiae et Icones Anatomicae*, was displayed close to Touch Bionics' new "", a highly sensitive powered prosthetic hand, often worn by veterans who have fought in Afghanistan and Iraq. [2]

Right: A nineteenth-century inventor's illustration of his own imagined version of a mechanical digesting duck. An arrow helpfully indicates where the main action takes place.[1]

French inventor Jacques de Vaucanson's mechanized "Digesting Duck" from 1739. NYPL, General Research Division.

Prosthetic electrodes will return amputees' sense of touch

http://www.engadget.com/2015/05/14/prosthetic-electrodes-will-return-amputees-sense-of-touch/?utm_source=Feed_Classic_Full&utm_medium=feed&utm_campaign=Engadget&?ncid=rss_full

Source: [1] Riskin J (2003) The Defecating Duck, or, the Ambiguous Origins of Artificial Life. *Chigago Journals*, Vol.29(4): 599-633.

Artificial hand described in *Dix Livres de la Chirurgie*, Ambroise Paré', 1564. Major 428.

www.kumc.edu/dc/rm/16_71p.jpg

[2] <http://faktografia.com/2012/12/28/living-design/>

Klima H (2000) Wasserstrukturen in dissipativen Systemen. In *Wasser – Polaritätsphänomen, Informationsträger & Lebensheilmittel*. Engler I. (ed.). Ch. 30: 238-266. Dt. Spurbuchverlag (FRG)

Ultra-weak Photon-Flux Emission

*.... and how to measure in real-time cells
under stress*

The Roots (1/2)

i) Cell-to-cell cross-communication

Setup:

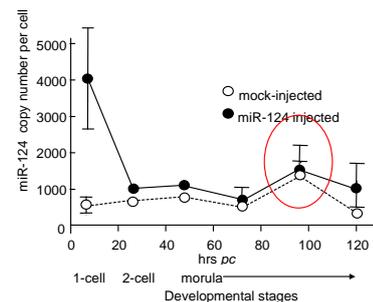
- Effects of paramutation studied using miR-124 injections into fertilized eggs
- Stapling of in-vitro cell cultures of treated and control samples and subsequent incubation

Results:

During ontogenesis from the fertilized cell-stage to multi-cell-stage (morula), a boost in miR-124 concentration was observed even in the control (mock injected).

.... **how is this possible?**

Rassoulzadegan, 2014



16-05-04

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Initiation of paramutation in embryonic cells: RNA-mediated heritable controls of transcriptional activity. After the first experimental models of epigenetic inheritance, starting with the plant paramutation, and now characterized as 'heritable gene silencing', *Rassoulzadegan* reported in the recent period three examples of RNA-mediated epigenetic heritable variations corresponding to modulation in transcriptional activity. Their analysis led us to conclude that non-coding RNA molecules carried by the gametes, sperm RNA in the case of paternal transmission, may act as transgenerational determinants of epigenetic states. These three mouse paramutations (epigenetic variation inherited in a non-Mendelian manner) are studied at the following loci: *KIT* (fur color, tumoral development, diabetes), *Cdk9** (via miR-1: cardiac hypertrophy), *Sox9** (via miR-124: gigantism & gemellity). The latter in particular is evident by accelerated embryonic and post-natal growth. It can be induced by microinjection in fertilized eggs of *Sox9*-specific microRNA (miR-124) and reveals itself by transcriptional activity of *Sox9* expression in E2.5-4.5 embryonic stem cells. The effect is persistent over 2-3 generations.[2]

As can be seen in the above sketch an increase in miR-124 count was observed even in the control (mock) samples. Contamination via molecular diffusion can be excluded when operating under sterile conditions – so how can this happen?[1]

Source: [1] Mino Rassoulzadegan (2014) RNA-mediated heredity of paramutation and acquired phenotype in the mouse. Conference on: DNA Habitat and its RNA Inhabitants, Salzburg (AUT)

[2] Grandjean V, Gounon P, Wagner N, Martin L, Wagner KD, Bernex F, Cuzin F, Rassoulzadegan M (2009) The miR-124-*Sox9* paramutation - RNA-mediated epigenetic control of embryonic and adult growth. *Development*, Vol.136: 3647-3655.

The Roots (2/2)

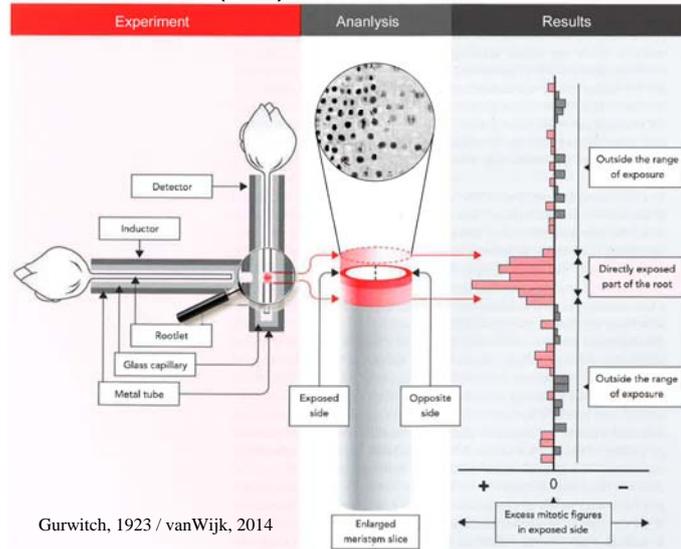
- i) Cell-to-cell cross-communication
- ii) Onion-root experiment

Setup:

Inducer and detector roots separated by a glass or quartz window.

Results:

Increase in mitotic events in detector root – photons stimulate cell divisions



Gurwitsch, 1923 / vanWijk, 2014

16-05-04

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EDG&E

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A tip of an onion root (the inducer) was directed at the wall of another onion root (the detector). After they had been kept for some time in this con-figuration, the number of mitoses at the detector side facing the tip of the inducer root as well as at the opposite side of the detector were carefully counted. Amazingly, during that first "mitogenetic" experiment (in which a horizontally oriented inducer-root was positioned at a distance of 1.5-2 mm from the medial surface of the meristem of the vertically oriented detector-root) positive results were documented within 1.5-2.0 h from the beginning of the recording. The number of mitoses at the medial zone of the "radiated" side became 20-25% higher than over the other parts of the meristem If a glass plate was introduced between the inducer and the detector, there was no stimulation of mitotic activity. In contrast, a quartz plate shielding the tip of the inducer root did not interfere with its action. If the tip of the inducer was aimed at the metal mirror in such a way that its reflection fell onto the wall of the detector, stimulatory action again was observed. These results could neither be explained chemically or mechani-cally. The most plausible explanation followed. A living organism can emit photons that stimulate cell divisions. That is why photon emission from a tip of the root stimulating mitosis in another root was named "mitogenetic radiation".

Besides onion root cells, many other biological systems could serve as de-tectors. After comparing many systems, it turned out that an ordinary yeast culture was the most convenient *detector* testsystem.

Image: Each root is fixed in a capillary glass tube that is enclosed by a metal tube The inducer and the detector roots are separated by a glass or quartz window. The middle panel ("Analysis") shows enlarged the slice of a detector root with its "exposed" and "opposite" side The number of mitotic figures in successive 10 um thick cross sections is counted for the exposed side and opposite sides.

Source: Gurwitsch AG (1923). Die Natur des spezifischen Erregers der Zellteilung. *Arch. EntwMech. Org.* 100: 11-40.

vanWijk R (2014) Light in Shaping Life – Biophotons in Biology & Medicine. Meluna, Geldermalsen (NL), EU

The Roots (2/2)

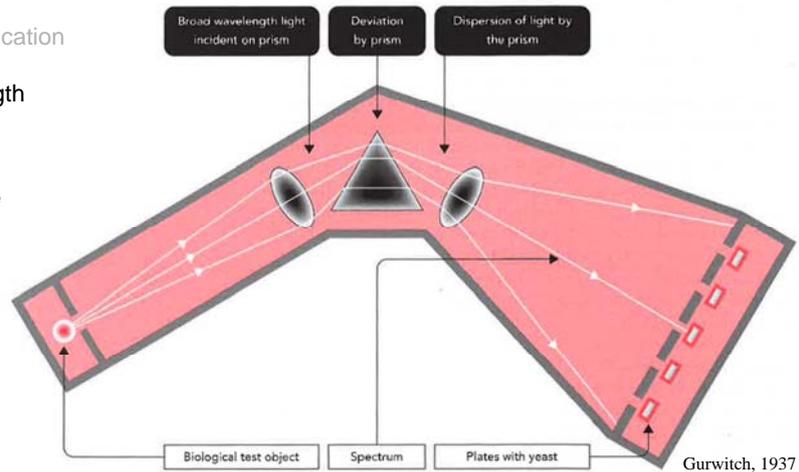
- i) Cell-to-cell cross-communication
- ii) Onion-root experiment
- iii) Yeast sample on wavelength

Setup:

Quartz-prism to determine spectral analysis of UwPE-emissions

Results:

the biological detector (yeast) responds at 190-250 nm.



16-05-04

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EDG

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In the following years, the *radiation spectrum* was studied in great detail. From this, it followed that mitogenetic radiation emerged as a consequence of high metabolic activity and that the radiation in its turn induced metabolic processes.

This work started around 1931 and was carried out for 6 years. Eleven collaborators as well as laboratory guests took part in the work. The analysis of the data was published in the monograph entitled *Mitogenetic Analysis of the Excitation of the Nervous System* (1937). However, at that time, the results did not fit into the limits of the doctrines of the classical physiology of the nervous system and, therefore, were not accepted. The monograph was, according to Gurwitsch, the result of more than 5000 experiments. The research methodology utilized yeast cultures.

The yeast method is based on the principle of a "mitogenetic effect", [i.e. regarding the stimulating action of the ultraviolet rays (within limits approximately between 190-250 nm) on cell multiplication] The source of radiation (in this case it was the nerve preparation) was placed as near to the slit of the collimator as possible, generally using a slit of nearly 1 mm. The detector (i.e., the yeast culture) was placed exactly in front of the monochromatic slit.

Source: Gurwitsch AG (1937). *Mitogenetic Analysis of the Excitation of the Nervous System*. Noord-Hollandse Uitgeversmaatschappij, Amsterdam

vanWijk R (2014) *Light in Shaping Life – Biophotons in Biology & Medicine*. Meluna, Geldermalsen (NL), EU

Recent observations (1/3)

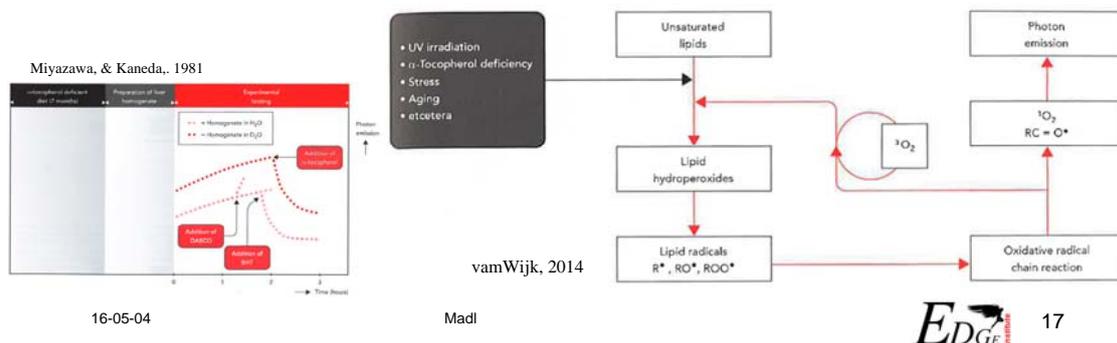
- i) Cell-to-cell cross-communication
- ii) Onion-root experiment
- iii) Yeast sample on wavelength
- iv) O₂, UwPE emission (ROS) and

Setup:

stressing cells w/ various stimuli

Results:

BP-emissions related lipid peroxidation, UV, etc.



Ultra-weak photon emission from liver homogenates prepared from rats that were fed a α -tocopherol-deficient diet for 7 months.(2) The liver homogenate was prepared in physiological saline or in 0.9% NaCl - D₂O rats. D₂O possesses an elongation effect on the lifetime of singlet oxygen (¹O₂) molecules. Tocopherol is supposed to quench ¹O₂ and free radicals. In the same studies the stimulating effect of DABCO (1,4-diazabicyclo[2,2,2] octane) was tested. The compound is known as a stimulant for the generation of singlet oxygen molecules. Also, the effect of BHT (butyl hydroxytoluene) was investigated. It acts as a free radical scavenger.

Another interesting contribution addressed the role of α -tocopherol deficiency in rat tissue lipid peroxidation. The rats were divided into two groups. They were fed either an α -tocopherol containing diet (normal diet) or an α -tocopherol-deficient diet (which consisted of components similar to those of the normal diet). After 7 months of feeding, the α -tocopherol-deficient liver had a markedly enhanced photon emission compared to that of a normal diet.

This confirmed that α -tocopherol quenches free oxygen radicals. To further elucidate the chemistry involved in such emission, the effect of α -tocopherol was combined with substances known as stimulants in order to generate singlet oxygen (¹O₂). Hence, the data verified the involvement of excited (¹O₂) molecules and free radicals in the production of ultra-weak photon emission.

Lipid peroxidation refers to the oxidative degradation of lipids. It is the process in which free radicals "steal" electrons from the lipids in cell membranes, resulting in cell damage. This process proceeds by a free radical chain reaction mechanism. It most often affects polyunsaturated fatty acids, because they contain multiple double bonds in between which lie methylene bridges (-CH₂-) that possess especially reactive hydrogens. As with any radical reaction, the reaction consists of three major steps: initiation, propagation, and termination.(1)

Source: (1) http://en.wikipedia.org/wiki/Lipid_peroxidation

(2) Miyazawa T, & Kaneda T. 1981. Extra-weak chemiluminescence of organ homogenate and blood in tocopherol-deficient rats. *J.Nutr. Sci. Vitaminol.* Vol. 24: 415-423.

vanWijk R (2014) *Light in Shaping Life – Biophotons in Biology & Medicine.* Meluna, Geldermalsen (NL), EU

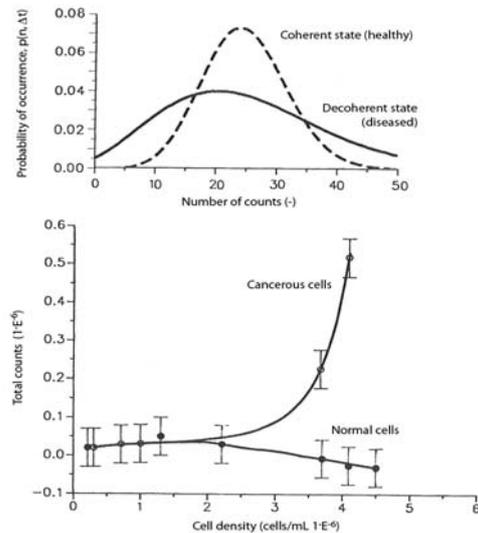
Recent observations (2/3)

- i) Cell-to-cell cross-communication
- ii) Onion-root experiment
- iii) Yeast sample on wavelength
- iv) O₂, UwPE emission (ROS) and
Cancer

Healthy state: coordination of cell functions easily achieved (coherent state);

Diseased state: erratic perception of syntactic, semantic, pragmatic codes (incoherent state);

Tumor: diminished capacity to inter-communicate with surrounding tissue (accelerated decoherence – high UwPE-emissions)



Schamhart & VanWijk, 1987.

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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, whereas a sick organism is out of tune. A diseased organ, organism is no longer capable to “learn” (adapt to new situations), and can be interpreted as a DEVOLUTION in progress.

•**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! Certain parameters in the hyperbolic decay function can be taken as a measure of incoherence, as it is directly correlated with the inability of the system to re-absorb emitted energy coherently. Such parameters are shown to increase with increasing cell density in the malignant cells, and to decrease with increasing cell density in the malignant cells, and to decrease with increasing cell density in normal cells. These results are consistent with the suggestion that **tumor cells have a diminished capacity for intercommunication.**

Source: Schamhart DHJ, & VanWijk R. (1987). Photon emission and the degree of differentiation. In: Jezowska-Trzebiatowska B, Kochel B, Slawinski J, & Strek W. (Eds.), *Photon Emission From Biological Systems* (pp. 137–152). Singapore: World Scientific.

Recent observations (3/3)

- i) Cell-to-cell cross-communication
- ii) Onion-root experiment
- iii) Yeast sample on wavelength
- iv) O₂, UwPE emission (ROS) and
- v) cancer
- vi) **Bone & UwPE-emission**

Setup:

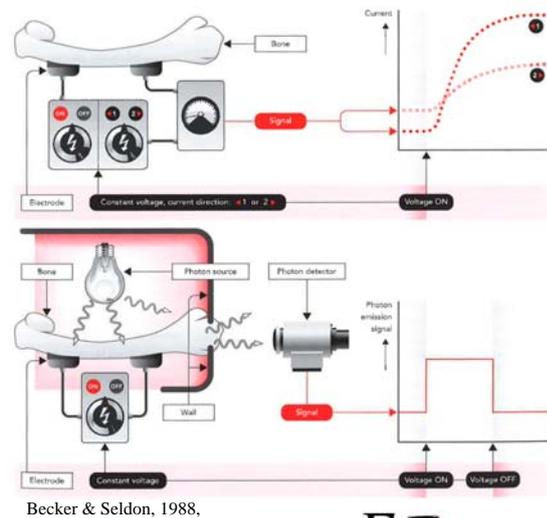
Human bones conductivity

Results:

- i) current flows better in forward than in reverse;
- i) semiconductor-like behavior (PN)
- i) bone has LED-properties
- i) Bio-Communication !

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Becker & Seldon, 1988,

EDG

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It appeared that the amount of current they could put through the bone samples from a battery of constant voltage was much greater in one direction than in the other

Many semiconductors absorb energy from light

Becker and colleagues found that bone was a light emitting diode (LED) The light emitted is consistently an infrared frequency. It was known that some semi-conductors fluoresced. That is, they absorbed ultraviolet light and emitted part of it as a lower frequency of visible light. Bone fluoresced a bluish ivory color. However, collagen yielded an intense blue and apatite a dull brick-red color

It was already known that cer-tain trace metals such as copper, lead, silver, and beryllium bind readily to bone. The metal responsible for the observed effect in bone was copper The electrical forces of this copper bond held the crystals and fibers together. The electrical nature of the hole sug-gested a PN junction at the atomic level.

Conclusio

By the early 1970's, Becker and colleagues had solid proof for nearly every detail of the control system within fracture healing in frogs (and by ex-tension, probably in mammals as well). Like all other injuries, a fracture produces a current that originates from the nerves in and around the pe-riosteum. At the fracture site, the bone generates its own current piezoelec-trically due to the residual stress in the mangled collagen-apatite matrix. Such electrical signals combine to stimulate the cells that form new bone.

Unfortunately, the scientific community was not ready for biological semi-conduction and the notion of diodes in living tissue seemed ridiculously far fetched to most of the people. In the mid-1960's, solid-state devices were only beginning to enter the market. Nowadays, various kinds of PN junctions (such as LEDs) are everywhere as digital readouts in watches and calculators. However, at that time, they were just laboratory curiosities.

Source: Becker R, Seldon G (1988). The Body Electric: Electromagnetism And The Foundation Of Life. William Morrow Paperbacks (USA)

vanWijk R (2014) Light in Shaping Life – Biophotons in Biology & Medicine. Meluna, Geldermalsen (NL), EU

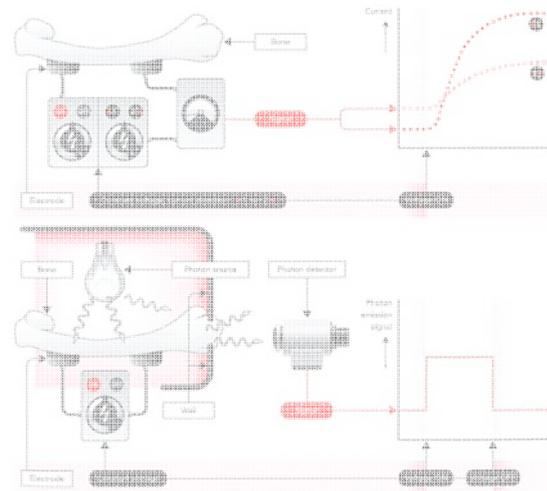
Recent observations (3/3)

- i) Cell-to-cell cross-communication
- ii) Onion-root experiment
- iii) Yeast sample on wavelength
- iv) O₂, UwPE emission (ROS) and
- v) cancer
- vi) Bone & UwPE-emission



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Becker & Seldon, 1988.

EDG

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For an in-depth presentation on issues of Biophotonics and Ultraweak Photon Emission, see Module-I (The Light of Life)

The 4th state of Water

*(Liquid-Crystalline-
or
Biological Water)*

.... and its marvellous properties

4th State of Water (1/5)

i) Exclusion Zone & Interfaces

Setup:

Gel-surface immersed in Microsphere-resolution

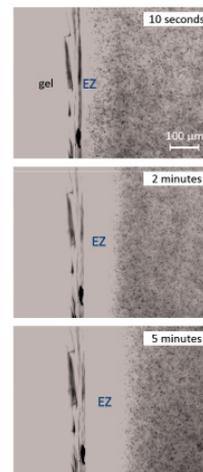
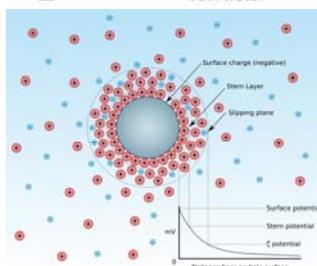
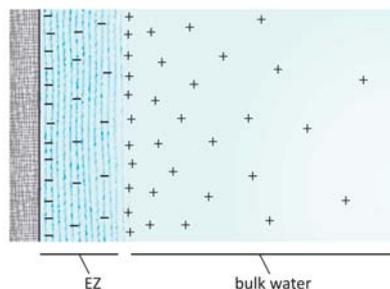
Results:

exclusion zone (EZ) next to the gel surface far more macroscopic than Stern-layer & Zeta-potential



16-05-04

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Zheng et.al. 2006

EDG

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More conclusive were results obtained by switching the charge of the excluding surface. For these experiments we used gel beads, whose spherical surfaces create shell-like zones of exclusion Negatively charged microspheres were consistently excluded whether the beads' surface contained positively or negatively charged polymers (Zheng et al., 2006). Hence, exclusion zones cannot arise from simple electrostatic repulsion, even allowing for repulsive forces extending far beyond conventional expectation. Nor could electrostatic repulsion conceivably create meter-long exclusion zones.

Water stores Energy: Water's fourth phase stores energy in two modes: order and charge separation. Order constitutes configurational potential energy, deliverable as the order gives way to disorder. For the working cell, this order-to-disorder transition constitutes a central energy delivery mechanism.¹ Charge separation, the second mode, entails electrons carrying the EZ's usual negative charge, while hydronium ions bear the corresponding positive charge. Those separated charges resemble a battery — a local repository of potential energy.

Albert Szent-Gyorgyi, the father of modern biochemistry, famously opined that the work of biology could be understood as the exploitation of electron energy. The EZ offers a ready source of electrons that could drive any of numerous biological reactions. The complementary hydronium ions may play an equally vital role. Positive ion concentrations build pressure, which can drive flows. Flows exist practically every-where: in primitive and developed cells; in our circulatory systems; and in the vessels of short plants and tall trees. Hydronium ions could drive many of those flows.

Source: Zheng JM, Chin WC, Khijniak E, Khijniak E, Pollack GH (2006). Surfaces and Interfacial Water: Evidence that hydrophilic surfaces have long-range impact. *Adv. Colloid Interface Sci.* Vol.127: 19-27.

Pollack GH (2013) *The Fourth Phase of Water: Beyond Solid, Liquid, and Vapor.* Ebner & Sons (USA)

Hunter RJ () *Zeta Potential in Colloid Science – Principles & Applications.* Academic Press, London (UK)

<http://de.wikipedia.org/wiki/Zeta-Potential>

4th State of Water (2/5)

- i) Exclusion Zone & Interfaces
- ii) Water-motion driven by IR

Setup:

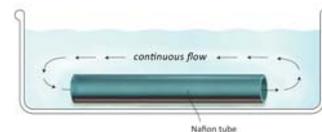
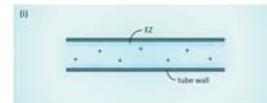
Nafion-tube immersed in Microsphere suspension

Results:

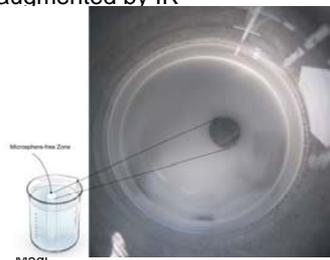
Directed flow through the tube – augmented by IR-exposure.



16-05-04



Ovchinnikova & Pollack, 2009



MAZI

EDG

23

Water gets Energy from Light: The sun's electromagnetic energy builds potential energy in water. Photons recharge the EZ by building order and separating charge. They do this by splitting water molecules, ordering the EZ, and thereby setting up one charge polarity in the ordered zone and the opposite polarity in the bulk water zone beyond. The transduction concept may seem less exotic once you realize that plants do the same. Plants absorb radiant energy from the environment and use it for doing work. Plants, of course, comprise mostly water; therefore, it should hardly surprise that the glass of water sitting beside your potted plant may transduce incident photonic energy much like the plant does. At any rate, *electromagnetic energy builds potential energy in water*, which then becomes an energy repository. That energy can radiate back toward the source from which it came, and/or it can be harvested for doing work. The energy is a gift from the environment; it is genuinely *free* energy, which we can perhaps exploit for resolving today's energy crisis.

Do Particles Really Move Toward Light: A third example: Do you remember the microsphere-free cylinder running vertically down the middle of the beaker? That was one of the Chapter-1 anomalies we sought to resolve. The microspheres were initially distributed uniformly. After some time they moved toward the beaker's periphery, leaving a vertically oriented cylinder devoid of microspheres We found that the light impinging on the beaker from all around drew the microspheres toward the beaker's periphery. The microspheres moved toward the light. Once the cylinder formed, then shining additional light from one side drew the microspheres rapidly toward that side. The accumulation displaced the cylinder progressively toward the darker side of the beaker, where it ultimately collapsed into nothingness. All of this happened within a minute or so (Ovchinnikova and Pollack, 2009).

Source: Ovchinnikova, K., Pollack, G.H. 2009 Cylindrical phase separation in colloidal suspensions. *Phys Rev E* 79(3): 036117.

4th State of Water (3/5)

- i) Exclusion Zone & Interfaces
- ii) Water-motion driven by IR
- iii) Water battery

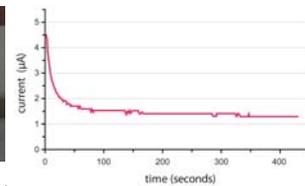
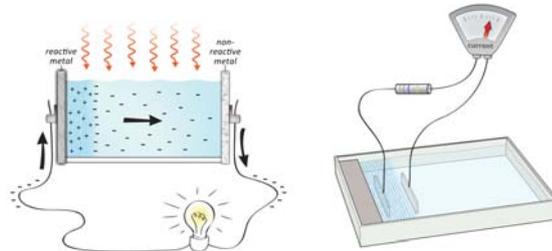
Setup:

Two electrodes inserted into EZ-water

Results:

Current flows immediately after immersing electrodes & maintains a non-zero plateau value for an extended period of time.

IR-exposure boosts efficiency of battery!



Kung, 2014

16-05-04

Madl

EDG_E

24

Like-Charged Entities Can attract One Another: Perhaps the least obvious principle is the like-likes-like attraction. The idea that like charges can attract one another seems counterintuitive until you recognize that it requires no violation of physical principles. The like charges themselves don't attract; the attraction is mediated by the unlike charges that gather in between. Those unlikes draw the like charges toward one another, until like-like repulsion balances the attraction.

Another example can be found in atmospheric clouds. Clouds are built of charged aerosol droplets. By conventional thinking, such droplets should repel and disperse; however, the like-like-likes mechanism explains why those droplets can actually coalesce into the entities that we recognize as clouds. The sun provides the energy, and the opposite charges provide the force.

Sources: Kung K (2014) The effect of Ionized air on the interfacial water's electrical properties. Conference on the Physics, Chemistry and Biology on Water, (BG)

Pollack GH (2013) The Fourth Phase of Water: Beyond Solid, Liquid, and Vapor. Ebner & Sons (USA)

4th State of Water (4/5)

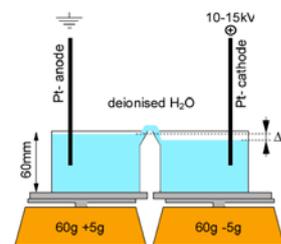
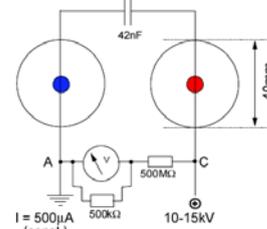
- i) Exclusion Zone & Interfaces
- ii) Water-motion driven by IR
- iii) Water battery
- iv) 4th state of Water (forcefully induced)
(cell: approx. 100mV/5nm = 20MV/m)

Setup:

Two Pt-electrodes inserted into bidest-water & 15kV
(= approx. 300kV/m)

Results:

Separated beakers hold thread of water (>5cm)
Opposite effect: Lord Kelvin's water dropper
"solid" water @ room-temperature!



Fuchs, 2010

16-05-31

Madl

EDG

25

Like-Charged Entities Can attract One Another: Perhaps the least obvious principle is the like-likes-like attraction. The idea that like charges can attract one another seems counterintuitive until you recognize that it requires no violation of physical principles. The like charges themselves don't attract; the attraction is mediated by the unlike charges that gather in between. Those unlikes draw the like charges toward one another, until like-like repulsion balances the attraction.

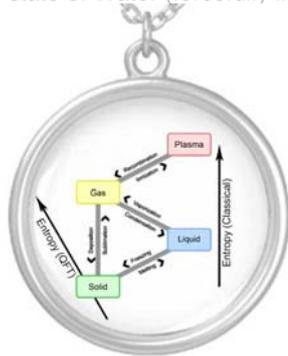
Another example can be found in atmospheric clouds. Clouds are built of charged aerosol droplets. By conventional thinking, such droplets should repel and disperse; however, the like-like-likes mechanism explains why those droplets can actually coalesce into the entities that we recognize as clouds. The sun provides the energy, and the opposite charges provide the force.

Kelvin Water Dropper: Apart from the impressive zap, a subtle sideshow is the droplets' dynamic behavior. The descending droplets sense the charge on the buckets below. As bucket charge increases, the falling droplets begin deflecting away and even upward, often missing the target bucket altogether. In other words, the charge effect is anything but feeble; from the Kelvin demonstration it's clear that *charge effects can be strong enough to defy gravity.*

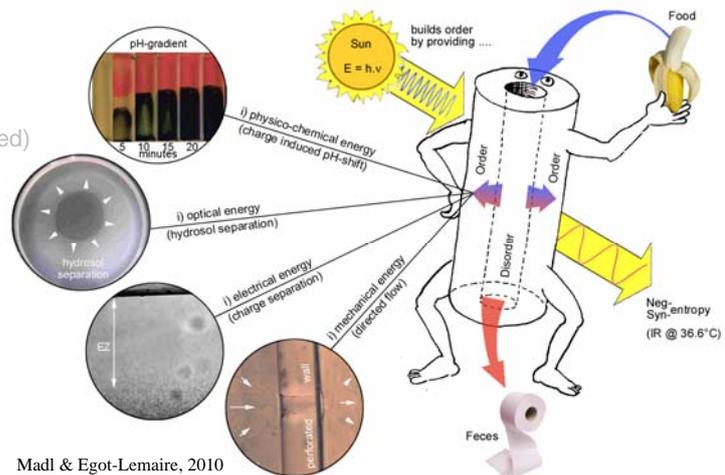
Source: Fuchs E.C. (2010). Can a Century Old Experiment Reveal Hidden Properties of Water? *Water*, 2, 381-410; p.390

4th State of Water (5a/5)

- i) Exclusion Zone & Interfaces
- ii) Water-motion driven by IR
- iii) Water battery
- iv) 4th state of Water (forcefully induced)



16-05-04



Madl & Egot-Lemaire, 2010

Madl

EDG

26

Water has four Phases: The second part of the journey began in the early 1900's vis-a-vis a better understanding of a biological organism as a system. This perspective accepted a field of organization with properties specific to the totality of the form, not solely about the particles that make up the form. In search-ing for a non-mechanical/non-particle regulatory principle, an alternative principle developed: a morphogenetic field based on radiation. Although this part of the journey offers many fascinating scientific explorations, it took a long time and many developments in physics before biology definitively and internationally, in the 1970's, accepted the existence of universal ultra-weak biological radiation. At that time, one could finally begin to document the richness of information from measurements of biological photon emission. The new photovoltaic and multiplier technologies connected photon emission with the biochemistry of oxygen and oxygen reactions.

Image: The transducing effects of aqueous systems when exposed to EMR. Only a fraction of the potential energy delivered by EMR to an aqueous is available to do work. The huge bulk of absorbed energy is re-emitted – particularly as infrared radiation (refer to text for further explanation). In this regard, food likewise contributes to increased ordering but at the same time provides the material precursors needed for biomolecular synthesis.

Water - in particular, organismic water - is an energy transducer for the following pathways.

Optical: water samples that are stored in dark-rooms absorb and store IR or microwave radiation (Ochinnikova & Pollack, 2009b), which becomes re-emitted as visible light that can be detected by PMTs. Exposure of saltwater to radio-frequency leads to the emission of visible light and heat and creates the impression of burning water (NGN, 2007).

Physico-chemical: Absorption of IR using a suspension of microspheres in a beaker of water for several hours not only yields a uniformly cloudy suspension but also leads to phase-separation. Directed migration of this particle-free zone can be augmented by unilaterally shining light on it (Ovchinnikova & Pollack, 2009a, Chai et al., 2009). Is of vital importance for metabolic activity for shifting molecular species.

Electrical: A hydrophilic membrane in a water-bath forms an exclusion zone, which is dominated by an excess of negative charges (Guckenberger et al., 2004). By shining extra light onto the membrane, the width of the zone, and thus its charge accumulation can be increased further (Ovchinnikova & Pollack, 2009b). EZs become automatically established, thereby providing energy to the cell.

Mechanical: Immersing a hydrophilic membrane arranged in tubular form into water reveals a directed spontaneous flow through the tube (O'Rourke et al., 2011). Light augments this effect. Essential for water transport from root to canopy via xylem – see redwoods that can grow up to 100 m in height (Pollack, 2001)

Source: National Geographic News: Salt Water can Burn (accessed 25th April, 2012):

<http://news.nationalgeographic.com/news/pf/92354998.html>

Chai, B. H., Yoo, H. and Pollack, G. H. 2009 Effect of Radiant Energy on Near-Surface Water. J.Phys.Chem.B, 113, 13953–13958.

Madl P, Lemaire S (2010) The Field and the Photon from a physical point of view. Conference on Fields of the Cell, Basel (CH)

O'Rourke C, Klyuzhin I., Park J.S. & Pollack G.H. 2011, Unexpected water flow through Nafion tube punctures. Phys. Rev.E Stat. Nonlin. Soft Matter Phys. 83(5/2), 055305-055310.

Ovchinnikova, K., Pollack, G.H. 2009a Cylindrical phase separation in colloidal suspensions. Phys Rev E 79(3): 036117.

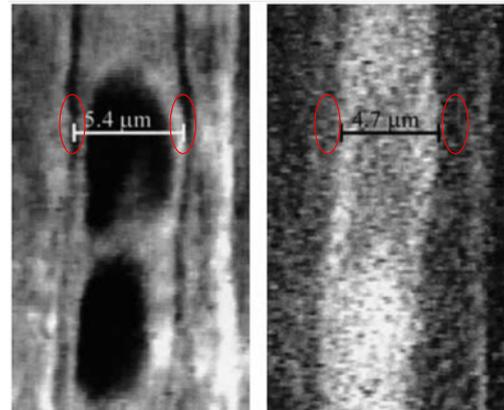
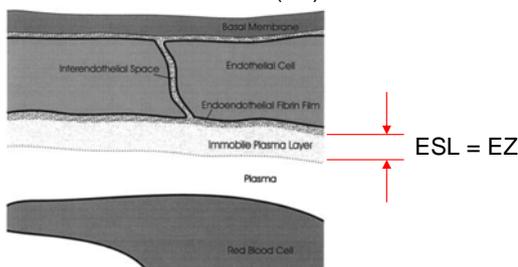
Ovchinnikova, K., Pollack, G.H. 2009b, Can water store charge? Langmuir 25, 542-547.

Pollack, G.H. 2001, Gels, Gels and the Engine of Life: A new unifying Approach to Cell Function. Ebner & Sons, Seattle.

4th State of Water (5b/5)

- i) Exclusion Zone & Interfaces
- ii) Water-motion driven by IR
- iii) Water battery
- iv) 4th state of Water (forcefully induced) in organisms

The **endothelial surface layer** (ESL) is equivalent with the **exclusion zone** (EZ)



Pries et al., 2000

EDG

27

The endothelial lining of blood vessels presents a large surface area for exchange of materials between blood and tissues, and is critically involved in many other processes such as regulation of blood flow, inflammatory responses and blood coagulation. It has long been known that the luminal surface of the endothelium is lined with a glycocalyx, a layer of membrane-bound macromolecules which has been determined by electron microscopy to be several tens of nanometers thick. However, investigations *in vivo* have indicated the presence of a much thicker endothelial surface layer (ESL), with an estimated thickness ranging from 0.5 μm to over 1 μm , that restricts the flow of plasma and can exclude red blood cells and some macromolecular solutes. The evidence for the existence of the ESL, hypotheses about its composition and biophysical properties, its relevance to physiological processes, and its possible clinical implications are considered in this review.

Images: Insert: Structure of the endothelial surface and the blood flowing adjacent to it. A thin layer molecular layer is directly attached to the endothelial cell membrane, assumed to consist mainly of fibrin (endoendothelial fibrin film). The plasma region adjacent to this film was considered to be immobile.

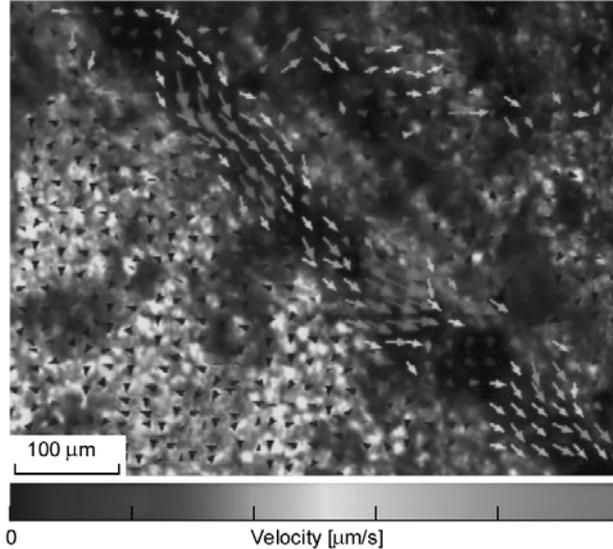
Micropgraph: A capillary in the hamster cremaster recorded during intravital microscopy. The anatomical width of the capillary as demonstrated with bright field illumination is about 0.8 μm wider than the width of the plasma column visualized by fluorescently labelled dextran. The difference indicates the existence of a layer on the endothelial surface which is not easily accessible to dextran.

Source: Pries AR, Secomb TW, Gaehtgens P (2000). The endothelial surface layer. *Eur J Physiol* Vol.440: 653–666

4th State of Water (5c/5)

- i) Exclusion Zone & Interfaces
- ii) Water-motion driven by IR
- iii) Water battery
- iv) 4th state of Water (forcefully induced) in organisms

Absorbed external energy seems to assist blood flow
(Mice: **blood flow continues even 1 hour post mortem!**)



Meglinski, et al., 2013

16-05-04

Madl

To confirm these results, we performed direct measurements of the motion of the blood cells before and after stopping the work of the cardiac muscle of the animal. The measurements were performed using an installation specially developed to visualize the microcirculation of the blood flow and the lymph flow in vivo The method was used to obtain high resolution images from relatively large areas of the vascular system of the skin on the external ear of the mouse (1 cm × 1 cm) for the objective determination of the instant of stopping the cardiac activity and disappearance of the pulse wave. Ten female mice of a line of hairless mice (Nude CD1) were used in the experiments

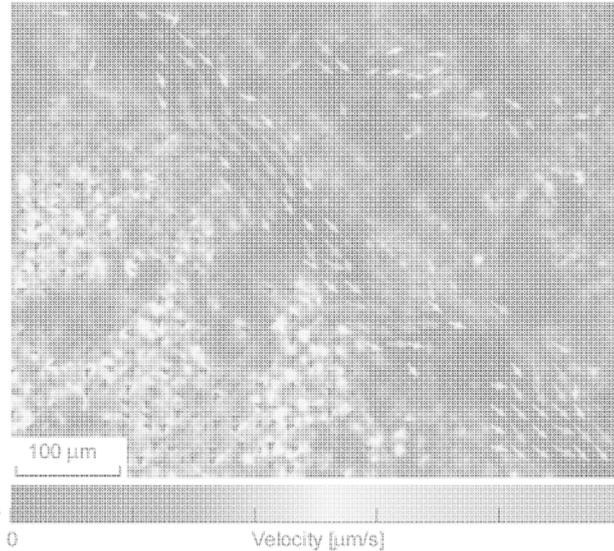
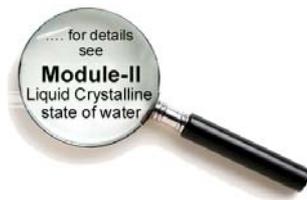
the complete stop of cardiac activity (euthanasia), the blood corpuscles continue the motion in the form of directed flow rather than in the form of Brownian motion. The mobility vector of the red blood cells is single directed but does not always correspond to the direction that existed before the occlusion. The sanguimotion continues for **no less than two hours** after the complete cessation of cardiac activity.

Image: Monochrome image of the blood flow obtained an hour after euthanasia. The arrows show the motion direction of the blood corpuscles and their average velocity.

Source: Meglinski IV, Kal'chenko VV, Kuznetsov YL, Kuznik BI, Tuchin VV (2013). Towards the nature of biological zero in the dynamic light scattering diagnostic modalities. Doklady Physics, Vol.58(8): 323-326

4th State of Water (5c/5)

- i) Exclusion Zone & Interfaces
- ii) Water-motion driven by IR
- iii) Water battery
- iv) 4th state of Water (forcefully induced) in organisms



16-05-04

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For an in-depth presentation on issues on the 4th state of Water, see Module-II (Liquid Crystalline State of Water)

Electro-Magnetic Field

.... and its relevance in Biology

Electromagnetic Field (1/6)

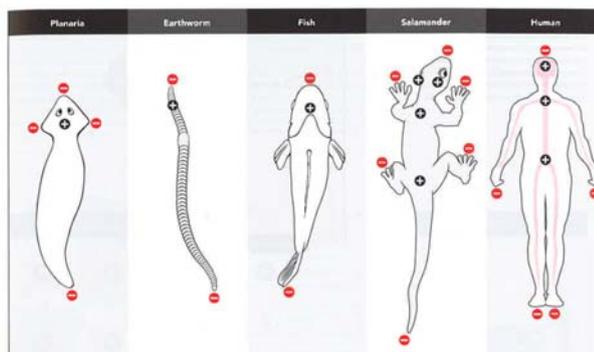
i) Electrical Polarity in organisms

Setup:

Reference electrodes attached to body,
moving recording electrode

Results:

Increasingly negative the further away
from nerve centers



Presman, 1970; Becker & Marino, 1982,

16-05-04

Madl

EDG_E

31

MGF (Morfogeneetic Field) and the Birth and Growth of the Photon Field
Concept: The second part of the journey began in the early 1900's vis-a-vis a better understanding of a biological organism as a system. This perspective accepted a field of organization with properties specific to the totality of the form, not solely about the particles that make up the form. In searching for a non-mechanical/non-particle regulatory principle, an alternative principle developed: a morphogenetic field based on radiation. Although this part of the journey offers many fascinating scientific explorations, it took a long time and many developments in physics before biology definitively and internationally, in the 1970's, accepted the existence of universal ultra-weak biological radiation. At that time, one could finally begin to document the richness of information from measurements of biological photon emission. The new photovoltaic and multiplier technologies connected photon emission with the biochemistry of oxygen and oxygen reactive species. However, during this part of the journey, the original interest in the informational content of radiation related to "form" was perhaps forgotten, or at least it was no longer obvious, or when present, only an issue of minor importance.

Source: Presman AS (1970). *Electromagnetic Fields and Life*. Springer, (FRG)

Becker RO, Marino AA (1982) *Electromagnetism and Life*. State University of New York Press, Albany (USA)

Electromagnetic Field (2/6)

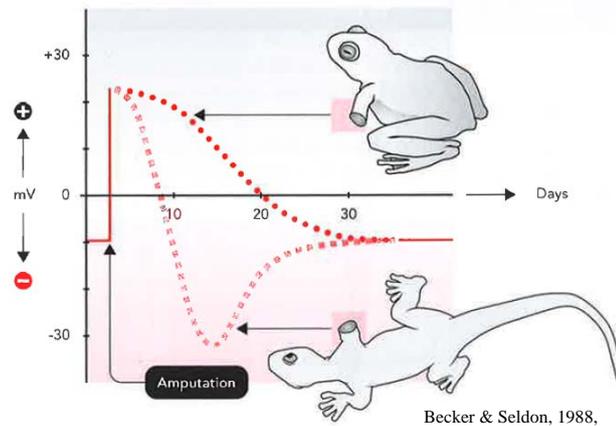
- i) Electrical Polarity in organisms
- ii) Current of Injury and

Setup:

Reference electrodes attached to body, moving recording electrode

Results:

Increasingly negative the further away from nerve centers



16-05-04

Madl

EDG

32

The second topic that Becker researched dealt with injury and healing. He evaluated whether the surface potentials and the current of injury came from the same source. He studied frogs and salamanders while their fractured limbs healed. Becker began the actual experiment by amputating (under anesthesia) the right forelimbs (between elbow and wrist) from fourteen *salamanders* and fourteen *grass frogs*. He took no special precautions against the bleeding since blood clots formed very rapidly. The wounds were left open, not only because closing the skin over the salamanders' amputation sites would have stopped regeneration, but also, because amputation is a "natural process". In the wild, both frogs and salamanders (favorite foods of the freshwater basins) had spontaneous injuries similar to the ones that were experimentally produced. Both healed without surgery. Becker found that the polarity at the stump reversed to positive immediately after the injury. He made measurements daily to observe.

Source: Becker R, Seldon G (1988). *The Body Electric: Electromagnetism And The Foundation Of Life*. William Morrow Paperbacks (USA)

Electromagnetic Field (3/7)

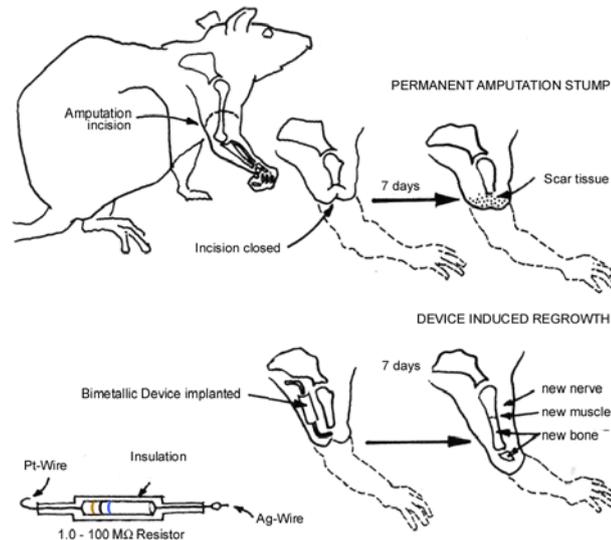
- i) Electrical Polarity in organisms
- ii) Current of Injury and Making limbs regrow

Setup:

Placing Ag-Pt-element (w/ 10MΩ) into wound & not sowing tissue together

Results:

Regrowth of lost extremity



Becker & Seldon, 1988,

Madl

16-05-04

EDG

33

In 1971, Becker amputated the right forelegs of thirty-five rats. He made the cuts through the upper foreleg well away from the elbow so that only the bone shaft, which had long ago ceased growing, would remain at the tip. He used all males, to obviate as many hormonal variables as possible He did the actual test on twenty-two of the rats, implanting our batteries with the negative platinum electrode at the wound. He tucked the outer electrode into the marrow cavity and sutured the inner one to the skin of the shoulder After three days the stumps of the controls had begun to heal over or even, in the case of the highest-current couplings, die back a little behind the amputation line. But the experimental legs with our medium-current devices, supplying 1nA, were doing well

The rat had regrown a shaft of bone extending from the severed humerus. At the proper length to complete the original bone there was a typical transverse growth plate of cartilage, its complex anatomical structure perfectly regular. Beyond that was a fine-looking epiphysis, the articulated knob at each end of a limb bone. Along the shaft were newly forming muscles, blood vessels, and nerves. At least ten different kinds of cells had differentiated out from the blastema, and we'd succeeded in getting regeneration from a mammal

Source: Becker R.O.; Selden G.; 1985; The Body Electric; William Morrow and Company Inc. New York - USA

Electromagnetic Field (3/7)

- i) Electrical Polarity in organisms
- ii) Current of Injury and Making limbs regrow

Setup:

Placing Ag-Pt-element (w/ 10MΩ) into wound & not sowing tissue together

Results:

Regrowth of lost fingertip

Becker & Seldon, 1988,

16-05-04



US05814094A

United States Patent [19] [11] **Patent Number:** 5,814,094

Becker et al. [45] **Date of Patent:** Sep. 29, 1998

[54] **IONTOPHORETIC SYSTEM FOR STIMULATION OF TISSUE HEALING AND REGENERATION**

[76] Inventors: Robert O. Becker, Box 278, Erie Canal Rd., Lovell, N.Y. 13367; A. Bartholomew Flick, 1 Lake Robin Rd., P.O. Box 2088, Lakewood, Ga. 30552; Adam J. Becker, 2 Chateaux Cir., Apt. 21, Scarsdale, N.Y. 10583

[31] Appl. No. 623,846

[22] Filed: Mar. 28, 1996

[51] Int. Cl. A61M 5/32

[52] U.S. Cl. 607/58; 604/20

J. A. Spadaro, et al., "Experience With Anodic Silver in the Treatment of Osteomyelitis," 25th Ann. ORS Mtg., Feb. 20-22, 1979.

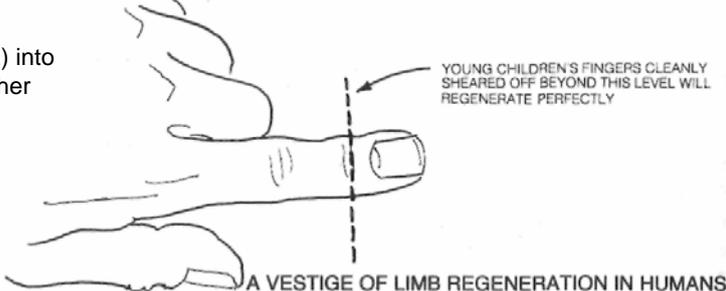
R. O. Becker, et al., "Treatment of Orthopaedic Infections With Electrically Generated Silver Ions," J. Bone & Joint Surgery, vol. 60-A, pp. 871-88 (1978), USA.

R. O. Becker, et al., "Clinical Exp. With Low Intensity Direct Current Stimulation of Bone Growth," Clin. Orthop. & Rel. Res., vol. 124, pp. 75-83 (1977), USA.

T. J. Berger, et al., "Antifungal Properties of Electrically Generated Metallic Ions," Antimicrob. Agents & Chemother., vol. 10, pp. 856-860 (1976), USA.

T. J. Berger, et al., "Electrically Generated Silver Ions: Quantitative Effects on Bacterial & Mammalian Cells," Antimicrob. Agents & Chemother., vol. 9, pp. 357-358 (1975), USA.

J. A. Spadaro, et al., "Some Specific Cellular Effects of



Madl

EDG 34

An iontophoretic system for promoting tissue healing processes and inducing regeneration. The system includes a device and a method, a composition, and methods for making the composition in vitro and in vivo. The system is implemented by placing a flexible, silver-containing anode in contact with the wound, placing a cathode on intact skin near the anode, and applying a wound-specific DC voltage between the anode and the cathode. Electrically-generated silver ions from the anode penetrate into the adjacent tissues and undergo a sequence of reactions leading to formation of a silver-collagen complex. This complex acts as a biological inducer to cause the formation in vivo of an adequate blastema to support regeneration.

Source: <http://www.google.com/patents/US5814094>

Becker R.O.; Seldon G.; 1985; The Body Electric; William Morrow and Company Inc. New York - USA

Electromagnetic Field (4/7)

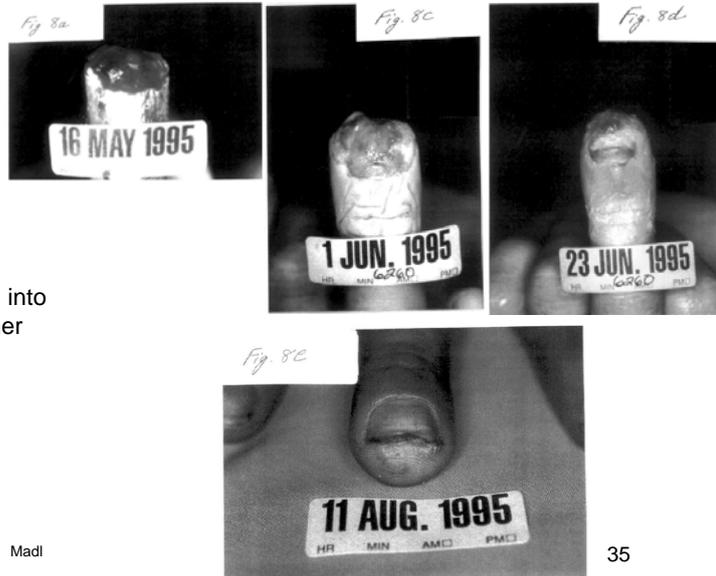
- i) Electrical Polarity in organisms
- ii) Current of Injury and Making limbs regrow

Setup:

Placing Ag-Pt-element (w/ 10M Ω) into wound & not sowing tissue together

Results:

Regrowth of lost fingertip



Becker & Seldon, 1988,

16-05-04

Madl

35

An iontophoretic system for promoting tissue healing processes and inducing regeneration. The system includes a device and a method, a composition, and methods for making the composition in vitro and in vivo. The system is implemented by placing a flexible, silver-containing anode in contact with the wound, placing a cathode on intact skin near the anode, and applying a wound-specific DC voltage between the anode and the cathode. Electrically-generated silver ions from the anode penetrate into the adjacent tissues and undergo a sequence of reactions leading to formation of a silver-collagen complex. This complex acts as a biological inducer to cause the formation in vivo of an adequate blastema to support regeneration.

Source: <http://www.google.com/patents/US5814094>

Electromagnetic Field (4/6)

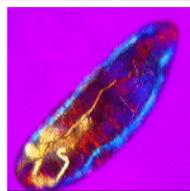
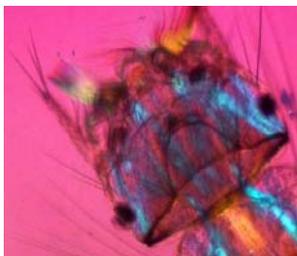
- i) Electrical Polarity in organisms
- ii) Current of Injury and Making limbs regrow
- iii) MGF-concept during embryogenesis (polarization requires coherence)

Setup:

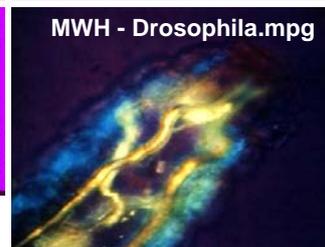
Polarization light microscopy of freshly hatched *Drosophila* larva

Results:

liquid crystalline phases based on interference colors. The colors indicate that all the molecules, including especially the water are aligned (molecular alignment and their degree of birefringence)



Ho, 2003



MWH - *Drosophila*.mpg

16-05-04

Madl

EDG_E

36

Order in the Exclusion Zone: Mae-wan Ho's wonderful book, *The Rainbow and the Worm* (2008), contains beautiful polarizing microscopic images showing biological order. Polarizing microscopy is a standard approach for detecting order, especially in minerals. The principle is simple: if molecular structures are lined up, then the optical properties will vary in different directions, giving rise to so-called birefringence. Ho shows order extending over extensive regions of a worm's body and concludes that the observed ordering comes largely from water.

Quote:

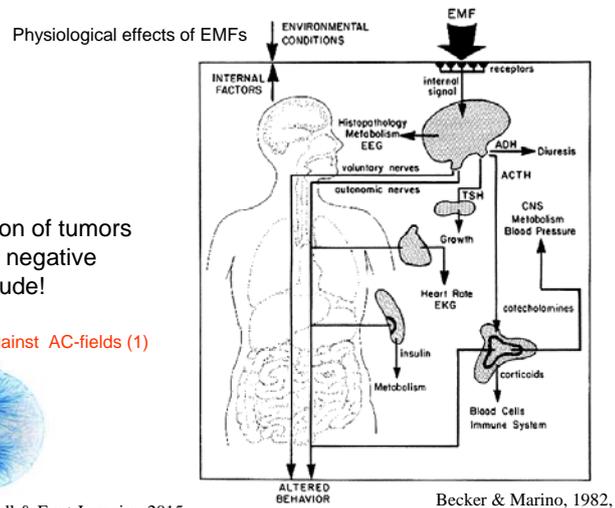
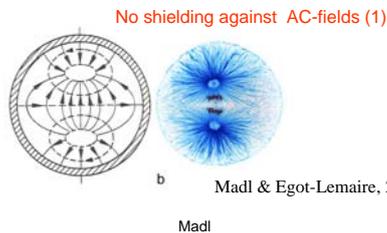
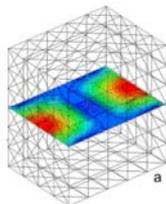
The *Drosophila* larva, all of 1mm in length and perfectly formed in every minute detail, comes into focus of the color-TV monitor as though straight out of a dream. **As it crawls along**, it weaves its head from side to side flashing jaw muscles in blue and orange stripes on a magenta background. The segmental muscle band switch from brilliant turquoise to bright vermillion, **tracking waves of contraction** along its body The egg yolk, trapped in the alimentary canal, shimmers a dull chartreuse as it gurgles back and forth in commotion **The technique depends on using the polarizing microscope unconventionally, so as to optimise the detection of small birefringences or coherently aligned anisotropies in the molecular structures of the tissues** The full colors only appear under **our conditions**, and leads us to think we are picking up phase ordering in biological molecules in living organisms that have never been observed before, and **cannot be observed under conventional conditions** The very idea of using polarizing light microscopy to look at dynamic order within the organism is also new It confirms my belief that the best experiments always tell one something unexpected, as **they are acts of communicating with nature** The technique works on all live biological tissues. Tissues which have been fixed and stained often fail to show any colors, unless they are freshly fixed and well preserved. **Thus, we seem to have a technique for imaging dynamic order which is correlated with the energetic status of the organism** The most remarkable implication of our findings is **that organisms are completely liquid crystalline**

Source: Ho MW (2003); *The Rainbow and the Worm – The Physics of Organism* – World Scientific – Singapore

www.i-sis.org.uk/lab.php

Electromagnetic Field (5/6)

- i) Electrical Polarity in organisms
- ii) Current of Injury and Making limbs regrow
- iii) MGF-concept during embryogenesis
- iv) Tumorbiology
 -) influence on development & progression of tumors
 -) rapidly growing tissues are electrically negative (blastema) - tumors highest in magnitude!



EDG 37

Tumorbiology: Humphrey and Seal attempted a scientific evaluation of the old clinical techniques of electrical control of tumor growth (30). It had been observed many times that rapidly growing tissues were electrically negative in polarity, with tumors being the highest in magnitude With the idea that the nervous system in some ways possessed a growth-controlling function, Hasson reasoned that there should be a similar relationship between denervation and tumor formation (32). In 1958 he reported that tumor induction by carcinogenic agents was facilitated by denervation, and these observations were subsequently confirmed in 1967 by Pawlowski and Weddell (33).

Image: Example of parallel-epipedic cavity resonator. A map of the electric field is displayed for one particular mode of resonance at a specific frequency (left). Simulation of mitotic divisions using cavity resonator waves (center) and epipedic cavity resonance of a mitotic cell division during late anaphase showing microtubules of sea urchin (right).

Source: Becker RO, Marino AA (1982) Electromagnetism and Life. State University of New York Press, Albany (USA)

30. Humphrey CE, & Seal EH (1959). Biophysical approach toward tumor regression in mice. *Science* 130:388.

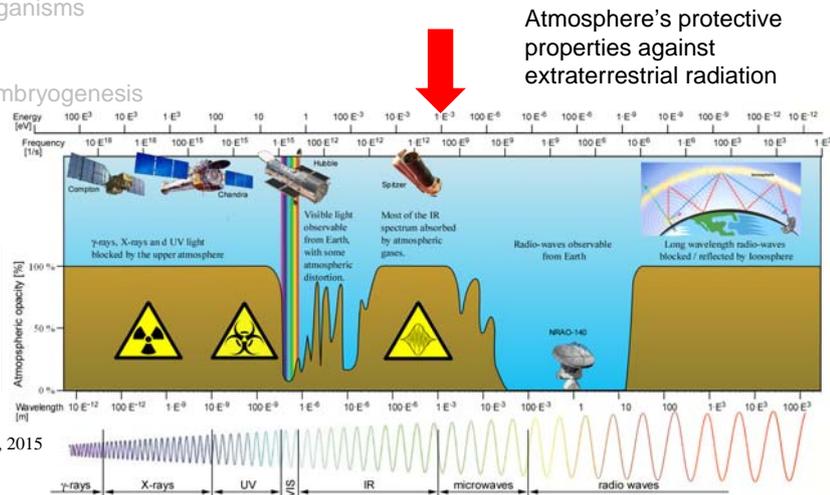
31. Huggins C, & Yang NC (1962). Induction and extinction of mammary cancer. *Science* 137: 257.

33. Pawlowski A, & Wedell G (1967). Induction of tumors in denervated skin. *Nature* 213:1234.

Madl P., Egot-Lemaire S (2015) Chapter-2: General Introduction into electromagnetic radiation and photobiology. In: Fels D, Cifra M, Scholkmann F (eds), Field of the Cells Volume 1. Signpost Research (IND)

Electromagnetic Field (5/6 cont'd)

- i) Electrical Polarity in organisms
- ii) Current of Injury and Making limbs regrow
- iii) MGF-concept during embryogenesis
- iv) Tumorbiology



Madl & Lemaire, 2015

16-05-04

The electromagnetic spectrum contains a wide range of different wavelengths, each of which exhibits different characteristics. It is divided into various domains that are named according to their dominant mode of application. Beginning with the most energetic spectral segment – one can find among others γ -radiation and X-rays (ionizing radiation) and less energetic radiation (non-ionizing), with the threshold within the ultraviolet (UV) band. The latter covers a spectrum of roughly 10 to 390 nm Light waves (VIS) in the range of 390 to 780 nm code for the visible color-spectrum Near infrared radiation (IR) greater than 780 nm all the way down to 1 mm is most often related to thermal radiation Then there is far-IR, or microwaves from 1 mm to 30 cm wavelengths Radio waves cover a wavelength range of 30 cm to several km All wavelength segments mentioned so far seem to differ from each other, yet still all belong to the single electromagnetic spectrum, which is commonly referred to as the spectrum of electromagnetic radiation (EMR). **The only thing that is really different from one wave to another is frequency of oscillation.**

Figure 1: The electromagnetic spectrum and its domains. The abscissa highlights the various modes of reference, given as wavelength [m], energy [eV], frequency [s⁻¹]. The entire spectrum spans over approximately 73 octaves (Ho, 1997). The ordinate reveals the atmospheric transmissivity, the so-called windows to outer space along with the "forbidden" sections unfavorable for biotic entities. The depicted satellites underline their principle detection windows within the EMR-spectrum.

Source: <http://www.abc.net.au/catalyst/stories/3568512.htm>

Ho MW (1997). Towards a Theory of the Organism. Integrative Physiological and Behavioral Science, 32(4), 343-363.

Madl P., Egot-Lemaire S (2015) Chapter-2: General Introduction into electromagnetic radiation and photobiology. In: Fels D, Cifra M, Scholkmann F (eds), Field of the Cells Volume 1. Signpost Research (IND)

Electromagnetic Field (5/6 cont'd)

- i) Electrical Polarity in organisms
- ii) Current of Injury and Making limbs regrow
- iii) MGF-concept during embryoge
- iv) Tumorbiology

Biologically active EMF-window



“Full body scanner”
& Biological Resonators
e.g. Stemm-cells
 $\lambda/2 = \text{few mm}$
 $= 3 \text{ THz}$
 $= \text{far IR}$

Alexandrov et al., 2011

16-05-04

Madl

The screenshot shows the Biomedical Optics EXPRESS journal website. The article title is "Non-thermal effects of terahertz radiation on gene expression in mouse stem cells" by Bolan S. Alexandrov, Kim Ø. Rasmussen, Alan R. Bishop, Anny Usheva, Ludmil B. Alexandrov, Shou Chong, Yossi Dagon, Layla G. Booshehri, Charles H. Mielke, M. Lisa Phipps, Jennifer S. Martinez, Hou-Tong Chen, and George Rodriguez. The journal information is Biomedical Optics Express, Vol. 2, Issue 9, pp. 2679-2689 (2011). The URL is http://dx.doi.org/10.1364/BOE.2.002679. The page also includes a navigation menu on the left, a search bar, and article tools.

EDGE

39

In recent years, terahertz radiation sources are increasingly being exploited in military and civil applications. However, only a few studies have so far been conducted to examine the biological effects associated with terahertz radiation. In this study, we evaluated the cellular response of mesenchymal mouse stem cells exposed to THz radiation. We apply low-power radiation from both a pulsed broad-band (centered at 10 THz) source and from a CW laser (2.52 THz) source. Modeling, empirical characterization, and monitoring techniques were applied to minimize the impact of radiation-induced increases in temperature. qRT-PCR was used to evaluate changes in the transcriptional activity of selected hyperthermic genes. We found that temperature increases were minimal, and that the differential expression of the investigated heat shock proteins (HSP105, HSP90, and CPR) was unaffected, while the expression of certain other genes (Adiponectin, GLUT4, and PPARG) showed clear effects of the THz irradiation after prolonged, broad-band exposure.

Source: Alexandrov B.S., Rasmussen K.Ø., Bishop A.R., Usheva A., Alexandrov L.B., Chong S., Dagon Y., Booshehri L.G., Mielke C.H., Phipps M.L., Martinez J.S., Chen H.T., Rodriguez G. (2011). Non-thermal effects of terahertz radiation on gene expression in mouse stem cells. Biomedical Optics Express, Vol.2(9): 2680-2689.

Electromagnetic Field (6/6)

- i) Electrical Polarity in organisms
- ii) Current of Injury and Making limbs regrow
- iii) MGF-concept during embryogenesis
- iv) Tumorbiology
- v) Health & Disease

Interference of technical EMFs with intra- & intercellular biocommunicative EMFs

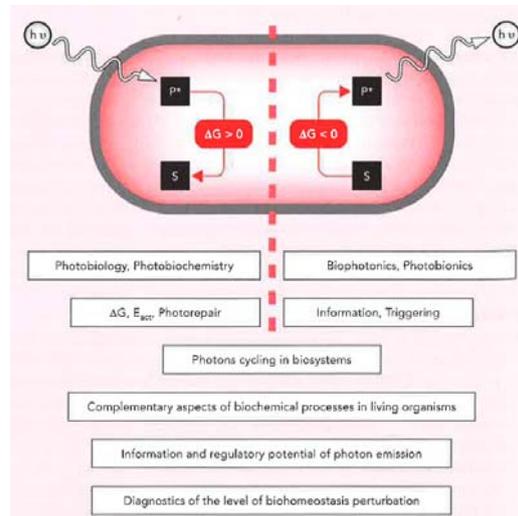


Presman, 1970

Pulsed UHF s on garlic chromosomes

16-05-04

Madl



vanWijk, 2014

EDG_E

40

Improving Understanding and Application of the Photon Field Concept in Health and Disease: Since the time that Presman published his work on *Electromagnetic Fields and Life* (1970), it became evident that biological systems not only emit electromagnetic waves but also respond to radiation from extremely slow fluctuations up to the extremely rapid short waves in the UV region.

Image: Photons as driving force in relationship to products {P} of metabolic processes and sources of information in biosystems, as studied in different disciplines.

Image: The effect of EmFs on the genetic apparatus was first discovered in experiments with growing garlic roots. The roots were exposed to pulsed UHF fields in the following conditions: frequency range, 5-40 MHz, pulse length, 15-50J/sec; pulse repetition rate, 500-1000 pulses/sec; field strength (in pulse), 250-6000 V/m; and duration of exposure, 5 min. Such treatment led to chromosome aberrations in the garlic root cells - the formation of bridges and fragments and the formation of micronuclei. Photomicrographs illustrating these effects are shown in Fig. 46.

Source: Presman AS (1970). *Electromagnetic Fields and Life*. Springer, (FRG)

vanWijk R (2014) *Light in Shaping Life – Biophotons in Biology & Medicine*. Meluna, Geldermalsen (NL), EU

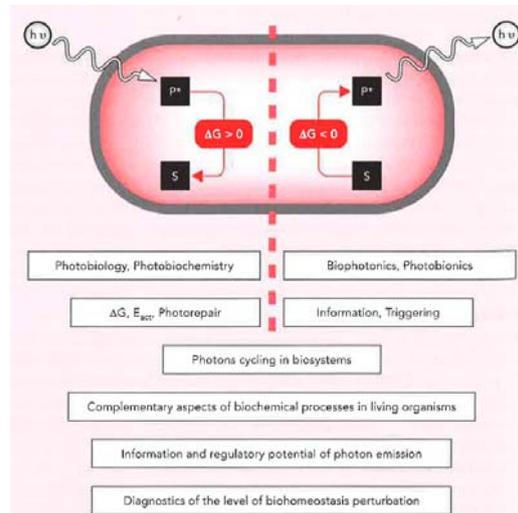
Electromagnetic Field (6/6)

- i) Electrical Polarity in organisms
 - ii) Current of Injury and Making limbs regrow
 - iii) MGF-concept during embryogenesis
 - iv) Tumorbiology
 - v) Health & Disease
- Interference of technical EMFs with intra- & intercellular biocommunicative EMFs



16-05-04

Madl



vanWijk, 2014

EDG_E

41

Improving Understanding and Application of the Photon Field Concept in Health and Disease: Since the time that Presman published his work on *Electromagnetic Fields and Life* (1970), it became evident that biological systems not only emit electromagnetic waves but also respond to radiation from extremely slow fluctuations up to the extremely rapid short waves in the UV region.

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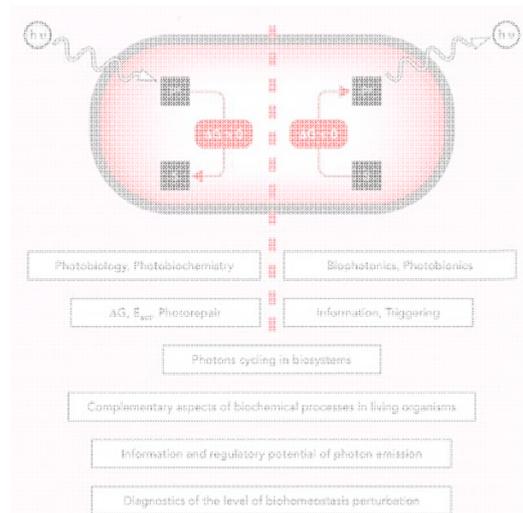
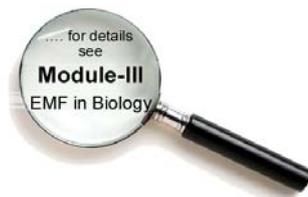
Source: <http://www.abc.net.au/catalyst/stories/s2056788.htm>

Presman AS (1970). *Electromagnetic Fields and Life*. Springer, (FRG)

vanWijk R (2014) *Light in Shaping Life – Biophotons in Biology & Medicine*. Meluna, Geldermalsen (NL), EU

Electromagnetic Field (6/6)

- i) Electrical Polarity in organisms
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- v) Health & Disease



16-05-04

Madl

vanWijk, 2014



42

For an in-depth presentation on issues of Electromagnetic Fields in Biology, see Module-III (EMF in Biology)

Intro

UwPE

4th H₂O

EMF

QFT

Conclusio

Quantum Field Theory

.... and why it matters in Biology

16-05-04

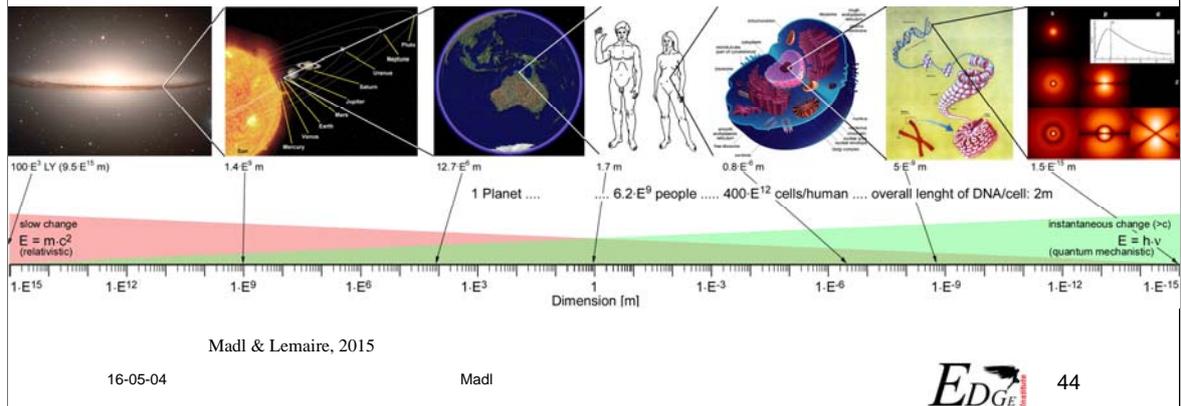
Madl



43

Quantum Field Theory (1/10)

- i) At the cross-road between $E = m \cdot c^2$ & $E = h \cdot \nu$ bridged by $\nu = m \cdot (c^2/h)$
 Charges are found in all domains and are subject to quantum fluctuations
 Charges are essential parts of spatial and functional organization (particularly in biota)
 Charges are influenced by EMFs



Moving from such a hope Fröhlich observed that, although great energy and many valuable efforts have been put into play in biochemistry, nevertheless the question still remains open of how order and efficiency arise in living systems, and then coexist with random fluctuations in biochemical processes. **Living matter presents several levels of spatial organization (cells, tissues and other ordered domains), time ordering (sequentially ordered chains of chemical reactions), functional organization (functional differentiation among different parts and compartments, hierarchical and temporal sequences of functions).** Thus, from one side, there is the high level of space and time ordering, and the high and stable functional efficiency; on the other side, there is the randomness of kinematics which rules any chemical reaction. As a matter of fact, the question of how order, efficiency and functional stability arise in living systems also was a motivation for Erwin Schrodinger (Schrodinger 1944).

Figure 4: Moving charges – from galactic dimensions all the way down to atomic dimensions. While charges on the astronomical scale are easier to imagine (e.g. the constant exposure of solar wind on the rotating earth), or on the atomic scale (quantum jumps of electrons), moving charges on cellular level are more peculiar, as these depend more on the electron charge distribution of the affected molecular structures.

Source: Schrödinger E (1944) What is Life? The Physical Aspect of the Living Cell, Cambridge University Press, Cambridge, UK

<http://www.ib.bioninja.com.au/standard-level/topic-2-cells/21-cell-theory.html>

Madl P., Egot-Lemaire S (2015) Chapter-2: General Introduction into electromagnetic radiation and photobiology. In: Fels D, Cifra M, Scholkmann F (eds), Field of the Cells Volume 1. Signpost Research (IND)

Penrose R (2004). The Road to Reality – a complete guide to the laws of the Universe. A.A. Knopf eds. (NY) USA;

Quantum Field Theory (2/10)

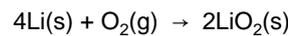
- i) At the cross-road between $E = m \cdot c^2$ & $E = h \cdot \nu$
 ii) Quantum Physics enables Entanglement

If two quantum systems interact, they do so not via interaction of their ψ -functions, rather they cease to exist to establish a unique function that describes that new state.

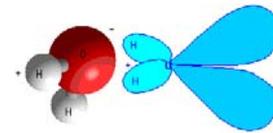
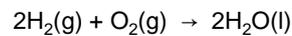
Which means

The whole is not just than the sum of their parts

In Quantum Physics the correct statement must be:
 The whole thing is something **completely different**
 than the sum of its original constituents!



Similarly



16-05-04

Madl

EDG

45

Wenn zwei Systeme in Wechselwirkung treten, treten nicht etwa ihre ψ -Funktionen in Wechselwirkung, sondern diese hören sofort zu existieren auf und eine einzige für das Gesamtsystem tritt an ihre Stelle. Somit ist das Ganze ist nicht bloss die Summe seiner Teile NEIN Dieser Satz ist lt. Quantenfysik falsch. Es muss lauten: Das Ganze ist nun etwas voellig anderes als die Summe seiner AUsgangsteile!

If two systems interact, its not just their ψ -functions that interact, rather these functions cease to exist and will be replaced by a single new one. Thus, the whole is not merely the sum of their parts NO According to wquantum physics, this statement is wrong. Instead it should read: the whole thing is now something completely different than the sum of its original part prior to the reaction!

Source: <https://www.youtube.com/watch?v=SKZO6BfQf5g>

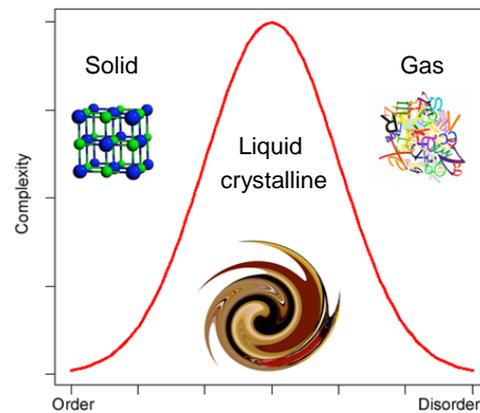
Pietschmann H (2003).: Quantenmechanik verstehen. Springer Verl. Berlin 2003.

Quantum Field Theory (3a/10)

- i) At the cross-road between $E = m \cdot c^2$ & $E = h \cdot \nu$
- ii) Quantum Physics enables Entanglement
- iii) Properties of *Many-body-Physics* of biota

Even the simplest chemical reaction pathway, once embedded in a random chemical environment **is not self-maintaining**.

Chemical efficiency and functional stability to the degree observed in living matter ... seem to be **out of reach** of any probabilistic approach *solely* based on microscopic random kinematics. (Schrödinger 1944)



Rossi et al., 2014

16-05-04

Madl

EDG

46

Diffusion is the most common example of *regular* flow of a certain substance, diluted, e.g., in water, from regions where the concentration is higher to regions where the concentration is smaller. Such a *regularity* only concerns the macroscopic behavior of the diluted substance, since at a microscopic level each of its component particles moves in a completely random way with displacements in any arbitrary direction, not necessarily or preferentially in the direction of the flow. Such a flow direction arises because of the large number of particles, and in this sense it characterizes the *macroscopic* behavior of the diluted substance. If one would make the observation solely of the motion of the single component particle, it would be impossible to predict the flow direction. **So diffusion is an ordered phenomenon of statistical origin** Since living systems are made by a large number of particles, statistical regularities may well emerge in their macroscopic phenomenology.

Schrodinger however points out that such an order, better, in his words, such "regularities only in the average" emerging from the "statistical mechanisms" is not enough to explain the "enigmatic biological stability". Pretending to explain the biological functional stability in terms of the regularities of statistical origin would be the "classical physicist's expectation" that "far from being trivial, is wrong" (Schrodinger 1944). The intention here is not to discuss the details of Schrodinger arguments The question of using quantum theory in the study of some biological features is a complex and difficult question which leads even farther than Schrodinger conclusions. **Schrodinger's distinction** (Schrodinger 1944) **between ordering generated by the "statistical mechanisms" and ordering generated by "dynamical" quantum (necessarily quantum!) interactions among the atoms and the molecules.**

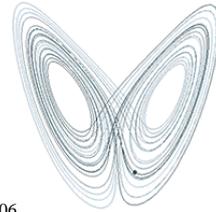
Biological systems are made by a large number of components and explain-ing the collective behavior of an ensemble of a large number of elementary components is the objective of Statistical Mechanics. In the case of neural components, Hopfield asked whether stability of memory and other macroscopic properties of neural nets are also derivable as collective phenomena and emergent properties **The available tool, experimentally tested, to study collective modes of quantum origin in many-body physics is QFT.** The statistical mechanics content of QFT is on the other hand very rich, so that, to stress it, one can talk in some circumstances of statistical field theory.

Common experience is that even the simplest chemical reaction pathway, once embedded in a random chemical environment, soon collapses. Chemical efficiency and functional stability to the degree observed in living matter, i.e. not as "regularity only in the average", seem to be out of reach of any probabilistic approach *solely* based on microscopic random kinematics (Schrodinger 1944).

Source: Vitieilo G (2001). My Double unveiled – The dissipative Quantum Model of the Brain. J.Benjamins Press.

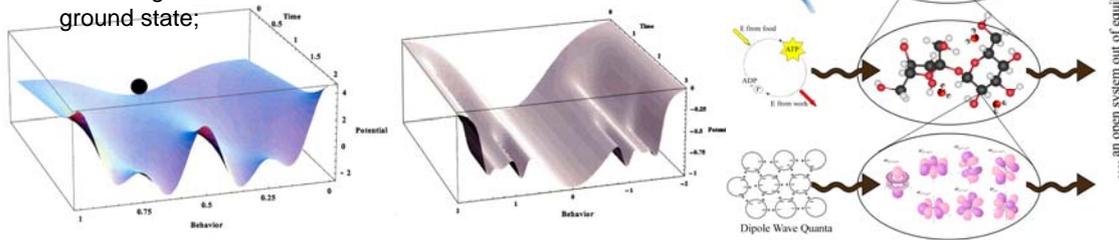
Schrödinger E (1944) What is Life? The Physical Aspect of the Living Cell, Cambridge University Press, Cambridge, UK

Quantum Field Theory (3b/10)



- i) At the cross-road between $E = m \cdot c^2$ & $E = h \cdot \nu$
- ii) Quantum Physics enables Entanglement
- iii) Properties of *Many-body-Physics* of biota - **Brain**
 - **Order** appears upon spontaneous breakdown of symmetry (SBS) in dynamic systems;
 - SBS implies the existence of NG-bosons – being massless they form long-range correlations (LRC);
 - Amplitude & Phase modulation act as carrier in LRC;
 - **Memory** storage in the form of **attractor landscapes**;
 - Knowledge retrieval via **Bose-Einstein-condensate-like** ground state;

Freeman & Vitiello, 2006



QFT consists in solving the field equations (the dynamical level) in terms of physical fields acting on the space of the physical states (the physical level) Hence there are (infinitely) many possibilities in which the same basic dynamics may be realized in terms of physical observables: there are many possible "physically different worlds" in which the same basic dynamics may manifest itself. "Different" spaces of physical states means that the physical observables acquire different values depending on which one is the space of physical states (the world) One central theorem regards spontaneous breakdown of symmetry (SBS) - it implies the existence of massless particles, called Nambu-Goldstone (NG) bosons (these can be collected or condensed and, since they are massless, they can span the whole system volume and are therefore responsible for the occurrence of long-range correlations, namely of the ordering which thus is established in the system: Order appears as a result of the spontaneous symmetry breakdown (SBS); order is lack of symmetry

Brains acquire knowledge by acting into the environment to confirm or reject hypotheses imagined from memory in the action-perception cycle. Memories are created and updated through phase transitions from a gas-like ground state to a liquid-like condensate that we model as a dissipative quantum field. Each field in the liquid state is based in a superconductor-like sheet comparable to a Bose-Einstein Condensate (BEC). Each retrieved memory is imposed in the amplitude modulation (AM) of a narrow band carrier frequency of a macroscopic wave packet in the beta-gamma range of brain waves. Brains imagine hypotheses about the world by copying AM patterns and mirroring them in time. We postulate that the AM pattern in forward thermodynamic time implements the action (matter), while the copy in the Double in reversed time governs the perception (mind, awareness). They are entangled dynamical modes that we distinguish by the patterns of phase modulation (PM) that accompany the AM patterns in the ECoG.[1]

Neural activity patterns related to behavior occur at many scales in time and space from the atomic and molecular to the whole brain Neural populations have a low velocity range of information and energy transfers, and a high velocity range of the spread of phase transitions Using concepts of energy dissipation, the maintenance by cortex of multiple ground states corresponding to AM patterns, and the exclusive selection by spontaneous breakdown of symmetry (SBS) of single states in sequential phase transitions shed light on this issue.[2]

Source: [1] Freeman WJ, Vitiello G (2016) Matter and Mind are entangled in two streams of images that guide behavior and inform the subject through awareness. Researchgate.net

[2] Freeman WJ, Vitiello G (2006). Nonlinear brain dynamics as macroscopic manifestation of underlying many - body field dynamics. Physics Life Rev. 3: 93-118.

<http://ac4.ei.columbia.edu/ac4-supported-initiatives/dynamical-systems-theory-at-columbia-university-v2/>

<https://cervrovortex.com/2013/11/05/why-things-dont-fall-down-anti-tensegrity/>

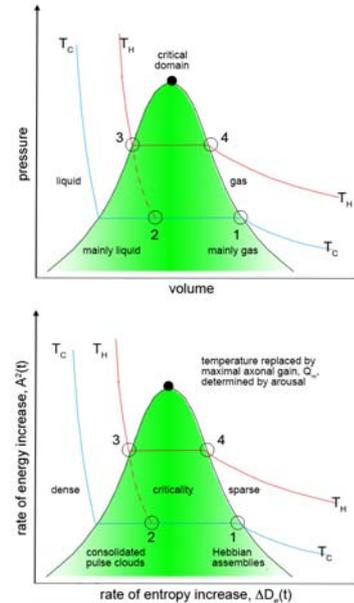
Quantum Field Theory (3c/10)

- i) At the cross-road between $E = m \cdot c^2$ & $E = h \cdot \nu$
- ii) Quantum Physics enables Entanglement
- iii) Properties of *Many-body-Physics* of biota
 - **Order** appears upon spontaneous breakdown of symmetry (SBS);
 - SBS implies the existence of NG-bosons – being massless they form long-range correlations (LRC);
 - Amplitude & Phase modulation act as carrier in LRC;
 - **Memory** storage in the form of **attractor landscapes**;
 - Knowledge retrieval via **Bose-Einstein-condensate-like** ground state;
 - Brain as a **macroscopic quantum system**;
 - The cortex uses information (1) to construct and transmit knowledge (3). The AM pattern is fixed (2) but expenditure of energy in transmission (adiabatic heating) leads to maximal power and minimal entropy.

Capolupo et al., 2013

16-05-04

Madl



Energy consumption of the brain in the framework of the dissipative many-body model and the generalized Carnot cycle model: The general picture of the process, by which brains construct knowledge from information and how the generalized Carnot cycle describes it, is presented in terms of Bose-Einstein condensate in the system ground state. It is postulated that the extremely high density of energy sequestered briefly in cortical activity patterns can account for the vividness, richness of associations, and emotional intensity of memories recalled by stimuli.

Image: a) The the generalized Carnot cycle. (b) The cortex generalized Carnot cycle. The thermodynamic process of creating knowledge from information in a sensory cortex is cyclic. We have modelled it using the generalized Carnot cycle, in which entropy is reduced by the expenditure of energy to facilitate the emergence of patterns. In Fig.a, the gas and liquid phases coexist in varying degrees. Energy is put in by heating (2-3) and removed as waste heat in cooling (4-1). In Fig.b, a cycle begins with a sensory cortex in a state of random background activity with low analytic power, $A^2(t)$, that is symmetric in having $1/f$ power spectral density (PSD) and no spatial or temporal pattern. The arrival of a stimulus-evoked sensory volley of pulses breaks the symmetry by initiating a narrow band oscillation that synchronizes the background pulse firings without increasing mean rates (isothermal compression). A peak on the PSD and a spatial pattern of amplitude modulation (AM) in the EEG appear. The cortex uses information from step (1) to construct, and transmit knowledge in step (3). In step (2) the AM pattern is fixed and the analytic power continues to rise, not by synchronization but by expenditure of energy in transmission of the AM pattern (adiabatic heating), leading to maximal power and minimal entropy, with maximal classification of EEG patterns with respect to the conditioned stimuli containing information. The height of the cycle (2-3) is determined by the degree of arousal as indexed by the asymptotic maximum of axonal gain, Q_m . Average brain temperature is homeostatically regulated by blood circulation, but local fluctuations are widespread and closely related to analytic power. In step three the AM pattern dissolves as the firing rates diminish owing to the refractory periods of the neurons, and the strength of synaptic coupling wanes (isothermal expansion). Free energy is derived from oxidative metabolism and is dissipated as heat in all four steps. In step (4) the distribution of characteristic frequencies in the PSD spectral peak go out of phase and cancel (adiabatic cooling). The area enclosed by the loop is a measure of pragmatic information, i.e. the ratio of the rate of energy dissipation (power) to the rate of decrease in entropy (increase in information).

Source: Capolupo A, Freeman WJ, Vitiello G (2013) The Dissipative Many-Body Model and Phase Transitions in Brain Nonlinear Dynamics. In: Liljenström H (ed) Advances in Cognitive Neurodynamics (IV). Proceedings of the Fourth International Conference on Cognitive Neurodynamics. Springer, Heidelberg, FRG.

Quantum Field Theory (5/10)

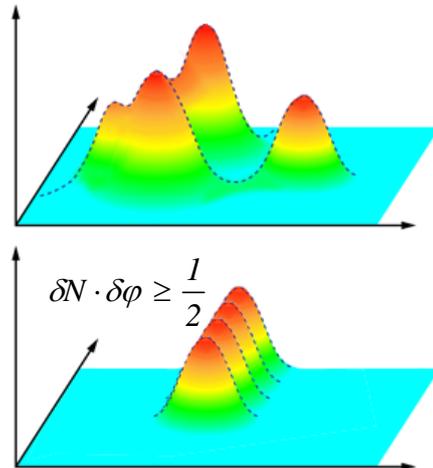
- i) At the cross-road between $E = m \cdot c^2$ & $E = h \cdot \nu$
- ii) Quantum Physics enables Entanglement
- iii) Properties of *Many-body-Physics* of biota
- iv) QFT (and not QM) for Biology
spatial and functional organization requires coherence

Classical QM-Transition:

- particle-like (ensemble of quanta in a coarse-grained structure): imperfection theory
classical photo-biochemistry w/ many **DoFs!**

Coherence Theory - *Heisenberg* relation:

- wave-like (phase-correlation grouping particle-wave-function together): delocalized coherent EMF modern QED-approach (conversion t/w single **DoF!**)



Bischof & DelGiudice, 2013

16-05-04

Madl

EDG

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There are two opposite "theories" about UwP-emission, i.e., the "imperfection theory" and the "coherence theory"[2]:

- The imperfection theory explains emission on the basis of photobiochemistry, i.e., as weak luminescence in terms of rare and random metabolic aberrations which lead to excited compounds in the visible range of the electromagnetic spectrum, e.g. electronic excitations of radicals. The emission of photons can then be assigned to the permanent tendency of excited living matter to return to thermal equilibrium.

- The coherence theory, on the other hand, based on the physics of interactions of weak radiation in and with optically dense matter, claims that UwP-emission originates from a delocalized coherent electromagnetic field within living tissue, in particular from its optical modes. In contrast to imperfection theory, this field is claimed to stabilize around a threshold between a "chaotic" and an "ordered" regime far away from thermal equilibrium in the sense of "dissipative structures". Essentially, coherence theory takes account of the laws of Cavity Quantum Electrodynamics.

The relation between these two representations is expressed by the uncertainty relation, similar to the Heisenberg relation between position and momentum, connecting the uncertainty δN of the number of quanta (particle structure of the system) and the uncertainty $\delta \varphi$ of the phase (which describes the rhythm of fluctuation of the system). Consequently, the two representations we have introduced above correspond to the two extreme cases[1]:

(1) If , the number of quanta is well defined, so that we obtain an atomistic description of the system but lose the information on its capability to fluctuate, since becomes infinite. This choice corresponds to the usual description of objects in terms of the component atoms/molecules.

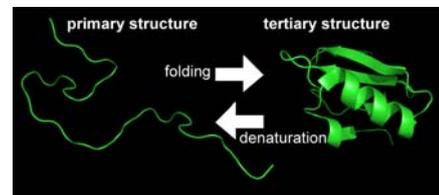
(2) If , the phase is well defined, so that we obtain a description of the movement of the system but lose the information on its particle-like features which become undefined since becomes infinite. Such a system having a well-defined phase is termed coherent in the physical jargon.

Source: [1]Bischof M, DelGiudice E (2013). Communication and Emergence of collective Behavior in Living Organisms: A Quantum Approach. Mol.Biol.Int. Vol. 2013, Article ID 987549, 19 pages, 2013. doi:10.1155/2013/987549

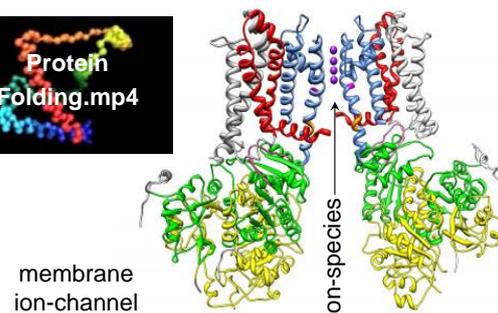
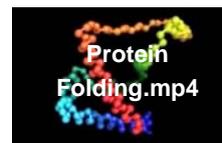
[2]Popp FA (1992). Some essential Questions of Biophoton Research and possible answers. In: Popp FA, Li KH, Gu Q (eds) Recent Advances in Biophoton Research and its Applications. World Scientific Publ., Singapore.

Quantum Field Theory (6/10)

- i) At the cross-road between $E = m \cdot c^2$ & $E = h \cdot \nu$
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- v) Biomolecules as highly efficient transducers



-) Protein folding occurs at very short time scales (incompatible with classical kinematics).
-) Quantum process driven optimization reduces possible folding configurations to just the biologically active one (DoF).
-) selectivity of trans-membrane proteins to specific ions as a result of Quantum resonance coupling of the channel cavity with ionic species.



16-05-04

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EDG 50

Similar difficulties arise with the **understanding of the generation of order in space, resulting in organized domains and tissues of the living systems.** Understanding how and why cells are assembled in tissues is certainly an urgent task in biology and medicine in order to understand and possibly to prevent the opposite situation, namely the evolution of a tissue into a cancer unfortunately, basic dynamical laws ruling cell ordering in tissue are not yet known.

The high efficiency in protein folding with its very short time scale also seems not to be understandable in terms of classical kinematics. A quantum process must be at work so as to optimize, by shortening it, the time needed to realize the effective folding through the spanning of all possible allowed configurations (Pain 1994).

On a similar line of thought, Ricciardi and Umezawa (1967) observed that in the case of the natural brain, any modeling of its functioning cannot rely on the knowledge of the behavior of any single neuron. They thought that it is in fact pure optimism to hope to determine the numerical values for the coupling coefficients and the thresholds of all neurons by means of anatomical or physiological methods. Moreover, the behavior of any single neuron should not be significant for functioning of the whole brain, otherwise a higher and higher degree of malfunctioning should be observed as some of the neurons die. Due to the brain metabolism constituent biomolecules undergo chemical changes and disassembly in a relatively short span of time (a couple of weeks). They are then replaced by new ones in a sort of "turn over". This clearly excludes that the high stability of brain functions, e.g. of memory, over a long period of time could be explained in terms of specific, localized arrangements of biomolecules. Observations show, on the contrary, that a long range correlation appears in the brain as a response to external stimuli. Thus Ricciardi and Umezawa proposed their QFT model for the brain.

Animation: askbiologist.asu.edu/venom/protein-folding

Source: Pain, R.H. (Ed.) (1994). *Mechanism of protein folding*. Oxford: IRL Press.

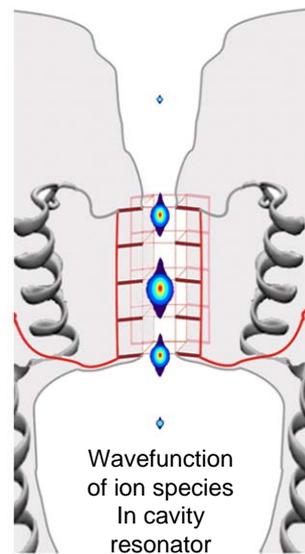
Ricciardi, L.M. and H. Umezawa (1967). Brain physics and many-body problems. *Kibernetik*, 4, 44-48.

Quantum Field Theory (6/10 cont'd)

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- v) spatial and functional organization requires coherence
- vi) Biomolecules as highly efficient transducers

Excitons & Solitons in α -sheets of proteins

-) selectivity induced by resonating structures, e.g. ionic wave interaction with the matter-fields of the cell (ion-channel);
-) couples with the EMF of water, giving rise to a superconducting-like current (Davydov regime)
-) leading to coherent boson condensation
-) build-up of long-range correlations (Fröhlich regime) carrier of ordered information



Salari & Alaei, 2010

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Exciton: is an elementary excitation is formed when a photon is absorbed; i.e a photon excites an electron from the valence- into the conduction band. It this leaves behind a localized positively charged hole the exciton can transport energy without transporting net electric charge This excited state travels in a particle-like fashion through the lattice without the net transfer of charge Excitons can have a relatively long lifetime (up to several milliseconds) after which the ground electronic state is restored and the molecule undergoes photon emission

Solitons: Is a "Wave of Translation" In 1834, Russell noted: "... When a boat suddenly stops - the mass of water accumulated round the prow of the vessel is in a state of violent agitation rolls forward with great velocity, assuming the form of a large solitary elevation, a rounded, smooth and well-defined heap of water, which continued its course along the channel apparently without change of form or diminution of speed "Translation" here relates to real mass transport That is: a fluid parcel acquires momentum during the passage of the solitary wave and comes to rest again after the passage of the wave. However, the fluid parcel had been displaced substantially forward during the process and a net mass transport is the result:

- a) The waves are stable and can travel over large distances;
- b) The speed depends on the size of the wave and its width throughout the depth of the water;
- c) The waves will never merge; and
- d) If the wave is too big for the depth of water, the wave splits i/o 2 units, one big and one small.

.... A soliton's inherent stability facilitates long distance transmission possible without the use of repeaters. It could potentially double transmission capacity. Solitons may occur in proteins and DNA. They are related to the low frequency collective motion category When traveling on infinite length chains, solitons do not undergo the spreading of familiar wave-packets in quantum mechanics; on finite length chains they, though more stable than usual wave-packets, have finite life-times.

Soliton motion (and thus charge motion) is quasi-non-dissipative a superconducting-like current is then originated which may couple to the electromagnetic field of the surrounding water. Soliton propagation also produce mechanical effects on the chain such as deformations, straightening, contractions, etc., which in turn produce variations of the chain dipole field and consequent additional effects on surrounding water dipoles Owing to the finite length of the chain the soliton decays, releasing its energy in a non-thermalizing way. Heat propagates indeed in the organized medium (the water electret) in a wave-like fashion and not in a diffusive way On the other hand, the water electret state has a finite life-time (also due to thermal effects) and therefore, to keep itself organized, the system needs to be "fed" again. A cyclic sequence of charge and discharge regimes is thus obtained. Any imbalance between the charge and the discharge regime turns into "pathology" for the system

Animation: Salari V, Alaei M (2010) Ionic Wave Propagation as a "Matter Field" between Excitable Cells. Conference on Fields of the Cell, Basel (CH)

Source: Vitieilo G (2001). My Double unveiled – The dissipative Quantum Model of the Brain. J.Benjamins Press.

Quantum Field Theory (7/10)

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- vi) Structure & Function maintained by **phonons**

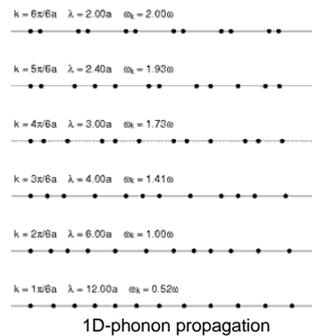
Phonons are the carrier of the information as:

-) they maintain crystal **ordering** (assign the atoms their place);
-) propagate over the entire lattice as **elastic waves** and as such are true massless particles "*living*" in the crystal;
-) act as **long range correlation** among atoms (*collective modes*)
.... Individual atoms loose their DoFs - are trapped w/n the phonon's net;

Ergo:

-) yield **macroscopic** manifestation of quantum dynamics
-) destruction of the crystal = loss of the associated phonons

Cytosol of cells is a gel (= liquid-crystalline matrix)



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Thus when physicists say "matter", they do not think of the mere collection of elementary constituents; they always refer to the full dynamical description of matter In the crystal phase one may experimentally study the scattering of, say, neutrons on phonons. The atoms in the crystal sites are continuously vibrating, and these vibrations manifest in the form of elastic waves which propagate all over the crystal. The vibrating atoms interact among themselves by means of the elastic waves and are thus correlated by them over large distances. **It is such a long range correlation which keeps the atoms in the crystal ordering The phonons are true particles living in the crystal.** We observe them indeed in the scattering with neutrons. As a matter of fact, they are the same thing as the elastic waves. In quantum theory, to any wave can be associated a corresponding "quantum" which behaves as particle; in this way "wave description" and "particle description" become *complementary* descriptions. **Thus phonons propagate over the whole system as the elastic waves do and therefore act as long range correlation among the atoms (for this reason they are also called *collective modes*).** The atoms in the crystal do not behave anymore as free atoms. They are "trapped", like in a net, by the long range correlation mediated by the phonons. The phonons (or the elastic waves) are in fact the messengers exchanged by the atoms and are responsible for holding the atoms in their lattice sites in a *stable* configuration **When one destroys the crystal one is left only with the atoms; one does not find the phonons! They disappear!** Thus the phonons are "confined" to exist only "inside" the bulk crystal.

On the other hand, if one wants to reconstruct the crystal in its stable configuration after having broken it, the atoms one was left with are not enough: **one must supplement with the long range correlation fields** (or quanta of the elastic waves, the phonons) **which tells the atoms to sit in the special lattice one wants** (cubic or whatever). One needs, in short, to supplement the **ordering information** which was lost when the crystal was destroyed.

From the crystal example it is clear that "matter" is not simply a list of constituents, it is not simply a lot of phenomenological data and statistics. Matter is also the dynamics Moreover, there is no hope of building up a stable crystal without the *long range* correlation mediated by the phonons: **if you try to fix up atom by atom in their lattice sites, holding them by hooks, you will never get the coherent orchestra of vibrating atoms playing the crystal function.** In that case, you would only be like one of those extremely patient and skillful Swiss watch-makers who in the past centuries, by mechanically assembling together a lot of wheels and levers and hooks, were building beautiful puppets able to simulate many human movements, but no more than that.

Image: Normal modes of vibration progression through a crystal. The amplitude of the motion has been exaggerated for ease of viewing; in an actual crystal, it is typically much smaller than the lattice spacing. (<http://en.wikipedia.org/wiki/Phonon>)

Source: Vitieilo G (2001). My Double unveiled – The dissipative Quantum Model of the Brain. J.Benjamins Press.

Quantum Field Theory (8/10)

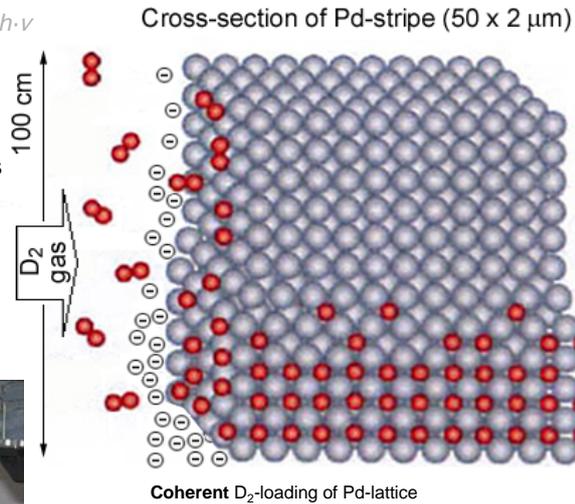
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Low Energy Nuclear Reaction (LENR)

- Pd-stripes sputtered on ceramic bed;
- loaded with deuterium: i.e LiOD;
- bias-current applied (10-40mA);
- stripping of D-electrons upon contact with Pd-matrix;
- induction of *Preparata*-effect;

Ergo:

16-05-04



deNinno et al., 2002

EDG_E

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We report the simultaneous production of excess enthalpy and of ^4He in a one dimensional Palladium (Pd) stripe cathode electrolytically loaded with Deuterium (D, isotope of Hydrogen, its nucleus has an additional neutron), occurring when the stoichiometric ratio $x=[\text{D}]/[\text{Pd}]$ exceeds 1. The excess heat is signaled by the local temperature rise, measured by a commercial Peltier element in good thermal contact with the thin effectively film cathode substrate. In order to detect the very small amount of ^4He expected in the gas mixture exiting from the cell, we remove all non inert components of the gas mixture (especially hydrogen isotopes) with a non-evaporable getter (NEG) pump. Noble gases remain in the gas phase and they are periodically analysed by the mass spectrometer. The observation of a sizeable transmutation of Deuterium into Helium proves unequivocally that a nuclear transmutation process is the cause of the so called "Cold Fusion". From the amount of Helium, under the assumption of the conversion $2\text{D} \rightarrow ^4\text{He} + 23.8 \text{ MeV}$, one can estimate the produced power. We find that such power generally exceeds the one trivially estimated from the temperature rise. This mismatch is increasing with the produced power level and it is well understood by the non equilibrium thermal conditions in the immediate vicinity of the stripe and the consequent leakage of a major fraction of the produced heat by radiation. Indeed, further increasing the produced power, we have induced the actual melting of the thin cathode, proving that one has reached locally a temperature of 1828 K. The phenomenon has been reproduced several times: the quantitative outcomes of Helium indifferent experiments obviously depend on the level of Deuterium loading inside the Palladium matrix .

DeNinno A, Frattolillo A, Rizzo A, DelGiudice E, Preparata G (2002). Experimental evidence of ^4He production in a cold fusion experiment. ENEA - Unità Tecnico Scientifica Fusione Centro Ricerche Frascati, Roma

Meulenber A, Sinha KP (2011) Tunneling Beneath the ^4He Fragmentation Energy. J. Condensed Matter Nucl. Sci. 4 241–255

Il processo scoperto era in sintesi il seguente: attraverso un processo elettrolitico, una quantità di deuterio, eccedente di molto le quantità usualmente prese in considerazione dagli elettrochimici, veniva immessa all'interno del palladio. Dopo un tempo di caricamento di almeno quattro settimane, comparivano quantità anomale di energia compatibili con un processo nucleare e incompatibili con un processo chimico. Infatti, l'energia prodotta era dell'ordine di centinaia di elettronvolt per atomo di palladio, mentre gli usuali processi chimici raggiungono al più qualche decina di elettronvolt.

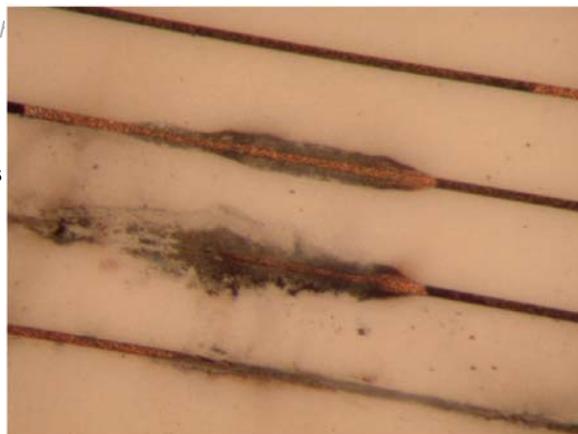
Torrealla M., DelGiudice E (2010) Il Segreto delle Tre Pallottole. Verdenero (MI), ITA, p.228

Quantum Field Theory (8/10 cont'd)

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- stripping of D-electrons upon contact with Pd-matrix;
- induction of *Preparata*-effect;



Pd-cathode molten during experimental run

Ergo: 5% of the sputtered Pd-stripe burnt off;

16-05- i.e.: a **150-fold increase in energetic throughput (!)**



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While in the supercritical phase, with a Peltier reading of $P_c \approx 20$ mW, the cathode suddenly melted. The electric parameters (current and voltage) measured during this run did not account for an electrical cause of the melting The extended damage in many separated subsections makes unlikely the hypothesis of a melting due to Joule effect. The melting occurred where the potential V_c was most negative and then, according to the *Preparata* effect (see the Appendix A), the cathode most highly loaded. The molten section accounted for the 5% of the total volume. The accident of the "molten" cathode provides evidence that at high temperature the bulk of the excess energy escapes the thermal calorimeter as has been suggested above The melting interests about 5% of the stripe, for which the radiated power will be as much as 3.15 W! based on standard QED, we summarize here its main prediction:

- i) when the stoichiometric ratio $x = [D]/[Pd]$ exceeds 0.7 (at room temperature) D nuclei (deuterons) enter a stationary coherent oscillatory state, whose phase is sharply defined.
- i) when x exceeds 1, the probability that oscillating deuterons reach a distance that might allow the fusion becomes appreciable.
- i) the fusion among deuterons occurs in a plasma within a medium and not in vacuum.

H (D) exists in the Pd lattice in the ionic form; its electron is transferred to the Pd electron bands. As a matter of fact, the transition of the D₂ molecule from the initial gaseous state to the final ionised state requires the crossing of an energy barrier of about 30 eV, a huge value indeed in the framework of the conventional chemical-electrostatic interactions. The phenomenon of the ordinary loading has been quite mysterious so far, at least in the frame of the generally accepted theories of the solid state. However, it has been shown that coherent QED can explain the ionization of the D₂ molecule by virtue of the strong electromagnetic fields, acting inside the Pd lattice, produced by the coherent oscillations of the Pd electrons. Nuclear processes have never been observed at ordinary loading (namely when $x < 0.7$).

DeNinno A, Frattolillo A, Rizzo A, DelGiudice E, Preparata G (2002). Experimental evidence of 4He production in a cold fusion experiment. ENEA - Unità Tecnico Scientifica Fusione Centro Ricerche Frascati, Roma

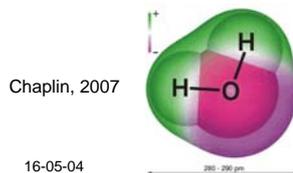
All'interno del metallo si possono formare blob di elettroni capaci di muoversi unitariamente con movimenti relativamente autonomi rispetto ai nuclei. Che cosa succederebbe se questi blob consentissero alle cariche positive dei nuclei di idrogeno o deuterio di avvicinarsi più di quanto non avvenga nello spazio vuoto? Dobbiamo tenere presente che nello spazio vuoto le cariche dello stesso segno si respingono, ma se i nuclei vengono attratti dallo stesso blob, si verifica il cosiddetto "effetto ruffiano" che funziona così: in presenza di un blob di carica negativa, un nucleo di carica positiva si avvicina da un lato, un altro nucleo di carica positiva si avvicina dall'altro ed entrambi vengono attratti dallo stesso blob. In pratica, è come osservare due persone vicine e in procinto di litigare, ma la presenza di un mediatore nel mezzo, che parla con entrambi tirandoli a sé, determina un avvicinamento dei due che finiscono per non vedersi più. In questo modo si ottiene un forte aumento della densità dei nuclei di deuterio. A questo punto ha luogo la stessa magia suggerita dalla fisica quantistica - che aveva portato alla formazione dei blob di elettroni, ma nel nostro caso con i nuclei di deuterio - il principio *like likes like* (il simile ama il simile). Quando la densità di un insieme di cariche elettriche supera un valore critico, le interazioni elettrodinamiche prevalgono sulle forze elettrostatiche, per cui il regime repulsivo elettrostatico viene rimpiazzato da un regime attrattivo. Una volta superata una soglia critica di densità, grazie alla mediazione dei blob di elettroni, i nuclei di deuterio invece di respingersi si attraggono. I nuclei si fondono e questo produce un'altissima energia. Così si può arrivare a capire perché in materiali come i metalli pesanti, con al proprio interno blob di cariche negative, la probabilità di fusione tra due nuclei di deuterio sia maggiore che nel vuoto».

Torrealta M., DelGiudice E (2010) Il Segreto delle Tre Pallottole. Verdenero (MI), ITA, p.34-35

Quantum Field Theory (9/10)

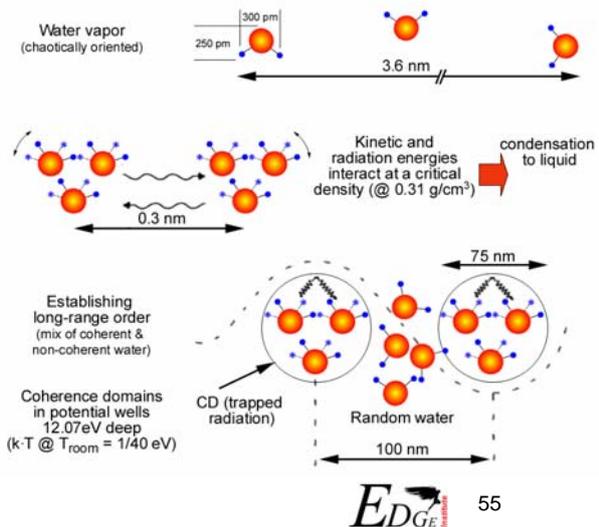
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- vi) Structure & Function maintained by phonons
- vii) Water is a peculiar medium

-) Coherent coupling among water molecules (**lasering behaviour**)
-) protected by short time scales against thermal assault (thus quite **stable**)



Madl et al., 2013

Madl



The molecular domains where dwq propagate present coherent dipole oscillations with a time scale much shorter ($10 \cdot E^{14}$ sec) than the one of short range interaction and therefore are protected against thermalization (Del Giudice, Preparata and Vitiello 1988b). An explicit analysis of the water dynamics shows phase locking of the dipole field with its own radiative em field:

water undergoes the so called "lasering" behavior, in analogy with the known mechanism in laser physics (Del Giudice et al. 1985; Vitiello 1992). Here, the term "laser" should not create confusion, however. It only stresses the crucial role of coherence in the formation of ordered domains (Preparata 1995). In water these have been found to have a size of a few hundred of microns. The analysis of the water dynamics, which started in the frame of the research program on the QFT approach to living matter, has been continued with intense activity beyond that original research program by Emilio Del Giudice, Giuliano Preparata and collaborators, leading to a number of very interesting results (Preparata 1995).

As mentioned above, the realistic finite size effects may imply an effective mass, different from zero, for the Nambu-Goldstone modes. A temperature T may be then associated to such a non-zero mass value. The finite system volume, namely the coherence domain dimensions, in this way gets related to the system temperature (Del Giudice et al. 1985).

Image: Formation of coherence domains (CDs) of aerosolized water molecules. The free-floating dipoles start to feel mutually attracted and establish coherent resonance clusters that result in the formation of 75 nm large CDs in which molecules resonate in unison. The newly formed coherent polarizing field becomes entrapped by CDs themselves and reveals a characteristic wavelength of about 100 nm. The formation of CDs is a fundamental property of liquid water and unlike the laser, no energy pumping is required to establish coherence.

Source: Chaplin M., 2007; <http://www.lsbu.ac.uk/water/index2.html>

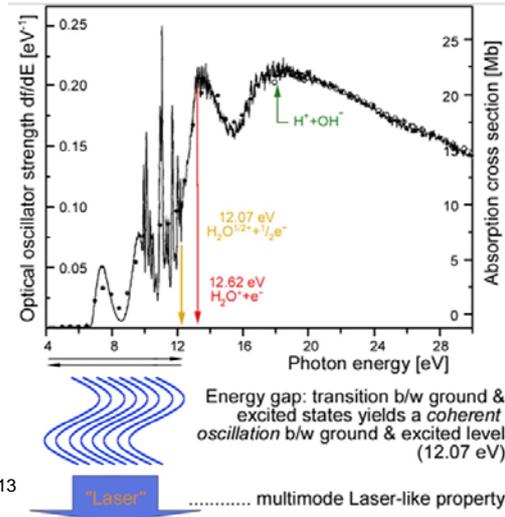
Madl P, Del Giudice E, Voeikov VL, Tedeschi A, Kolarž P, Gaisberger M and Hartl A (2013), Evidence of Coherent Dynamics in Water Droplets of Waterfalls. *Water*, Vol 5: 57-68.

Quantum Field Theory (9/10 cont'd)

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H₂O as an Energy transducer:

-) pumping of laser-like entities by IR to form coherent domains!
-) stable “energized” ground state - just 0.5eV below ionization of H₂O
-) source of “quasi-free” electrons



Madl et al., 2013

16-05-04

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Image: Formation of the multimode laser properties due to the energy gap establishes a pumping mechanism. This process results in synchronized excitation and relaxation patterns between the ground level and excitation at 12.07 eV of the involved water molecules.

The system enters into a state which in the physical jargon is termed “coherent state”. The energy of an ensemble of components in a coherent state is lower than the energy of the same ensemble in a noncoherent state, since the onset of coherence eliminates all the “useless” movements of components which give rise to the entropy of the system and concentrates the energy on a smaller number of degrees of freedom able to use this energy to produce external work. This property of coherent systems could implement the requirements of Prigogine for dissipative structures [10]. In order to abide by the second law of thermodynamics, the process of energy concentration demands that some energy should be released outwards, so that, in order to become coherent, a system should be an open system. In a coherent system made up of atoms/molecules, there is therefore a physical field able to keep the long-range correlation among the components. This correlation field can be shown to be just the electromagnetic potential, whose space-time derivatives give rise to the well-known electromagnetic fields.[2]

Source: [1]Madl P, Del Giudice E, Voeikov VL, Tedeschi A, Kolarž P, Gaisberger M and Hartl A (2013), Evidence of Coherent Dynamics in Water Droplets of Waterfalls. *Water*, Vol 5: 57-68.

[2]Bischof M, DelGiudice E (2013). Communication and Emergence of collective Behavior in Living Organisms: A Quantum Approach. *Mol.Biol.Int.* Vol. 2013, Article ID 987549, 19 pages, 2013. doi:10.1155/2013/987549

Intro	UwPE	4 th H ₂ O	EMF	QFT	Conclusio
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Quantum Field Theory (10a/10)

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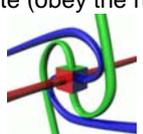
vi) Structure & Function maintained by phonons

vii) Water is a peculiar medium

viii) How is this possible? H₂O behaves like a Boson (!)

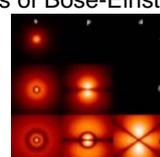
2 kinds of Quantum-Objects do exist:
Fermion (1/2, 3/2, 5/2-spin): can't attain identical quantum states (obey Pauli's exclusion principle)
Boson (0, 1, 2): can condense i/o Bose condensate (obey the rules of Bose-Einstein statistics)

Spin QN

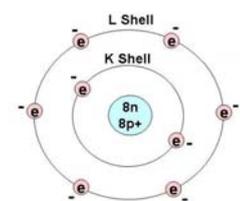


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Principal QN
Azimuthal QN



l^{th} shell can hold $l^2 \cdot 2^l$ electrons
K Shell (1) can hold 2 electrons
L Shell (2) can hold 8 electrons

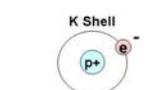


Oxygen:
8 Electrons + 8 Protons (+8 Neutrons) is Stable

Spins in Water Nuclear:
 $16 \times \frac{1}{2} = 8$ for O
 $2 \times \frac{1}{2} = 1$ for H₂

Electron:
 $8 \times \frac{1}{2} = 4$ for O
 $2 \times \frac{1}{2} = 1$ for H₂

$\Sigma: 8+1+4+1 = 14$
it's a **BOSON**



Hydrogen:
1 Electron + 1 Proton is Stable

 57

Spin (1 of 4 quantum numbers, principal, azimuthal, magnetic): As the name suggests, spin was originally conceived as the rotation of a particle around some axis. This picture is correct so far as spin obeys the same mathematical laws as quantized angular momenta do. On the other hand, spin has some peculiar properties that distinguish it from orbital angular momenta: i) Spin quantum numbers may take half-integer values. i) Although the direction of its spin can be changed, an elementary particle cannot be made to spin faster or slower. i) The spin of a charged particle is associated with a magnetic dipole moment with a g-factor differing from 1. This could only occur classically if the internal charge of the particle were distributed differently from its mass.

In nature, we know two kinds of quantum objects: Fermions with semi- and bosons with integer spin. Fermions can never occupy the same quantum state. Bosons can via the phenomenon of Bose-Condensation condense into a common, macroscopic quantum state.

i) The most prominent boson is the photon, the elementary particles of light, which has spin of 1.

i) In addition to these, there are plenty of other bosons, for example, even-numbered atomic nuclei and most atoms and molecules. These bosons are each composed of several fermions, in such a way that due to the chemical composition attain an integer spin.

i) water molecules do have indeed integer spin and as such must be considered bosons; i.e. under certain circumstances, water molecules can therefore attain a holistic status by which a cluster of molecules condenses to a unit (Hypothesis: under certain conditions water can condense into a holistic state).

Water & Bose-Condensation: the integer spin of water can be determined as follows:

Nuclear spin properties: $16 \times \frac{1}{2} = 8$ for Oxygen & $2 \times \frac{1}{2} = 1$ for H₂ (hydrogen molecule)

Electron spin properties: $8 \times \text{spin } \frac{1}{2} = 4$ for Oxygen & $2 \times \text{spin } \frac{1}{2} = 1$ for H₂ (hydrogen molecule)

Which yields a total of $8 + 1 + 4 + 1 = 14$ integer spin

Source: Klima H (2012) Biophysikalische ganzheitlich-systemische Aspekte der Heilkraft des Wassers. Gamed-Kongress, Heilkraft des Wassers, Vienna, FH-Campus. 8-9th Nov.2013.

Animation: A single point in space can spin continuously without becoming tangled. Notice that after a 360 degree rotation, the spiral flips between clockwise and counterclockwise orientations. It returns to its original configuration after spinning a full 720 degrees. http://en.wikipedia.org/wiki/Spin_%28physics%29

The atomic orbital wavefunctions of a hydrogen atom. The principal quantum number is at the right of each row and the azimuthal quantum number is denoted by letter at top of each column. http://en.wikipedia.org/wiki/Azimuthal_quantum_number

[2] <http://theinnovativeweb.com/2014/01/09/20-amazing-chemical-reaction-gifs/>

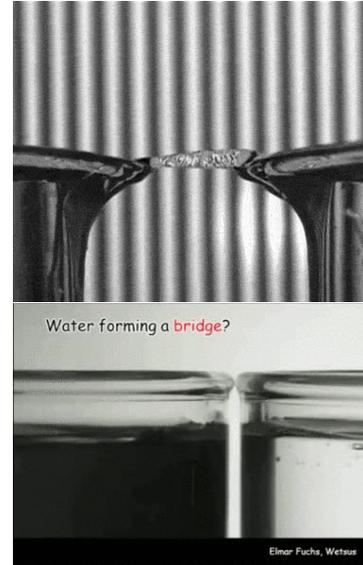
Quantum Field Theory (10b/10)

- i) At the cross-road between $E = m \cdot c^2$ & $E = h \cdot \nu$
- ii) Quantum Physics enables Entanglement
- iii) Properties of *Many-body-Physics* of biota
- iv) QFT (and not QM) for Biology
- v) Biomolecules as highly efficient transducers
- vi) Structure & Function maintained by phonons
- vii) Water is a peculiar medium
- viii) How is this possible? H₂O behaves like a Boson (!)

2 kinds of Quantum-Objects do exist:

Fermion (1/2, 3/2, 5/2-spin): can't attain identical quantum states (obey Pauli's exclusion principle)

Boson (0, 1, 2): can condense i/o Bose condensate (obey the rules of Bose-Einstein statistics)



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Proof of principle: The Water bridge (made up of liquid water) is a macroscopic example of a Bose-condensate.[2]i) The dipole of water molecules and the hydrogen bonds appear to support the ability to Bose-condensation in a holistic state. i) Therefore, one can assume that water molecules do form a Bose-Condensate under certain conditions even at room temperature!

Animation: A single point in space can spin continuously without becoming tangled. Notice that after a 360 degree rotation, the spiral flips between clockwise and counter-clockwise orientations. It returns to its original configuration after spinning a full 720 degrees. http://en.wikipedia.org/wiki/Spin_%28physics%29

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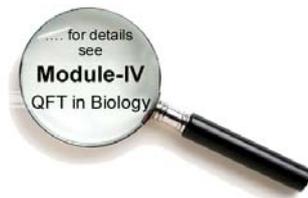
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For an in-depth presentation on issues of Quantum Field Theoretical Aspects and its Role in Biology, see Module-IV (QFT in Biology)

Concluding remarks

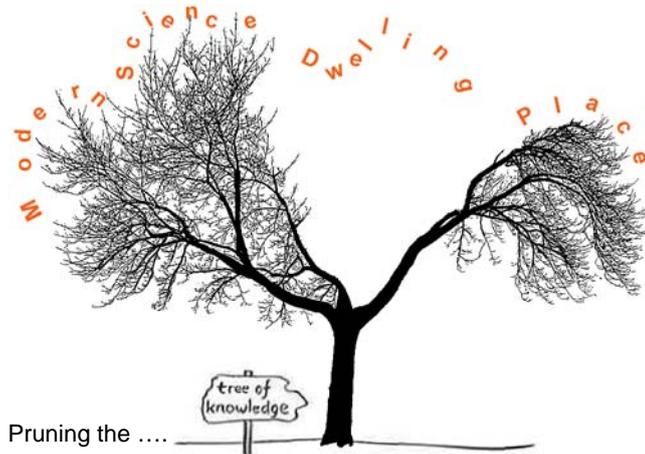
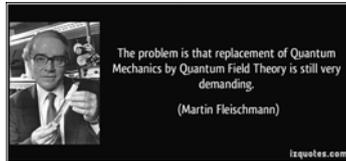
.... to promote a change in perspective

Unlocking Mysteries (1/2)

Why has this remained uncovered for so long?

.... science today focuses mainly on the twigs of the tree of knowledge, attempting to add incremental detail.

It assumes that supporting limbs are robust enough



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The culture of Science: Until the modern era, scientists focused on seeking foundational mechanisms. They tried to understand how the world works. If their efforts uncovered paradigms that could explain diverse phenomena in simpler ways, then they knew they were onto something meaningful. Thus, Mendeleev's periodic table could predictably account for the multitude of known chemical reactions, and Galileo's sun-centered solar system obviated the need to invoke complex epicycles to describe planetary orbits.

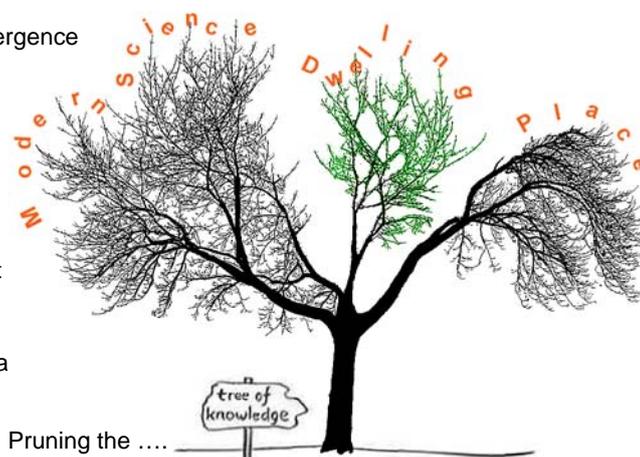
The four principles just outlined can be viewed as rules of nature, formerly obscured in some remote corner and now unveiled in a dearer light . These principles seem rich with explanatory power. They help answer simple "why" and "how" questions: Why do gels hold water? How can champagne bubbles proliferate in streams seemingly without end? How can simple hydrated wedges split apart massive boulders? How does water rise to the tops of giant redwood trees? Why do you see clouds of vapor above your hot coffee? Why does ice make you slip and fall on your face? Why clouds don't fall apart? The principles can explain many other questions whose answers have remained elusive.

<http://izquotes.com/quote/62930>

Unlocking Mysteries (2/2)

Four factors for the painfully slow emergence of new principles:

- (i) deviating from mainstream views can be unsettling;
- (ii) the blighted history of e.g. (poly-)water has kept scientists away;
- (iii) light & water are so commonly used that everyone presumes that the fundamentals have been resolved;
- (iv) questioning prevailing wisdom is a risky business, in science as elsewhere.



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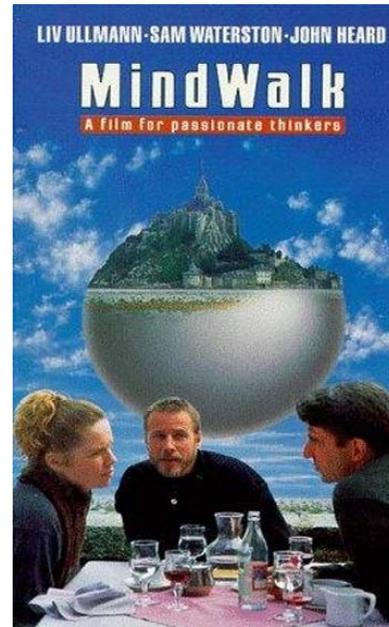
Why have these Principles Remained Secret?

- First, *water science has had a checkered history*. The polywater debacle left scars; it kept curious scientists away from water for decades. Any researcher confident enough to enter the arena and fortunate enough to discover something unexpected was inevitably attacked with the recycled darts used to ridicule polywater. Surely their water must have been contaminated (even though natural water is anything but pure); there-fore, their results can be safely dismissed with a wave of the hand. Then came water memory. Memory stored in water seemed so improbable that it became the butt of scientific jokes: Having trouble remembering names? Try drinking more water — it will restore lost information.
- A second reason for the slow emergence of understanding is water's ubiquity. Water is everywhere. Water occupies a place central to so many natural processes that *few people can conceive that the basics could remain open to question*. Surely someone must have worked out those basics, probably a century or two ago. This perception keeps scientists away. If anything, their reluctance has only intensified: today's science rewards those who focus narrowly on trendy areas, leaving little room for questioning widely taught foundational science. Especially for something as deeply rooted and common as water, the incentive to question fundamentals has all but vanished.
- A third reason for the slow emergence of such fundamental principles plagues all of science: intellectual timidity. *Relying on received wisdom feels safer than dealing with the uncertainties of revolutionary disruption*. You'd think that scientists would embrace dramatic advances in fundamental science, but most of them feel more comfortable restricting themselves to minor deviations from the *status quo*. Scientists can resist revolution in the same way as any other defender of orthodoxy.
- A fourth reason is *outright fear*. Challenging received wisdom means stepping on the toes of scientists who have built careers on that wisdom. Unpleasant responses can be anticipated. For example, I have here trampled on a lot of sacred ground. I anticipate due reprimand, particularly from those scientists whose recognition, grants, patents, and other attributes of power depend on defending their scientific standing. A child might be forgiven for such apostasy; senior scientists,

Source: Pollack J (2013) The fourth state of Water. Ebner & Sons. Publ.

*Thank You for your
attention*

Capra et al., 1990



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Suggested viewing: Mindwalk (USA: 1990 - 112 min)

A US politician visits his poet friend in Mont. St. Michael, France. While walking through the medieval island discussing their philosophies of life they happen upon Sonja, a scientist in recluse, who joins in their conversation. The two men listen to the ideas of this brilliant woman and discuss how her ideas can work in their own politician and poet lives.

Director: Bernt Amadeus Capra

Writers: Bernt Amadeus Capra, Floyd Byars, Fritjof Capra

Release Date: 5 December 1991 (Germany)

Genre: Drama

Thank You for your attention

