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Vortical Structure of Light and Space: Biological Implications

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Abstract

Vladimir B Ginzburg published 5 books on the vortical structure of space and electromagnetic fields, tracing the repeating cycles as such models went in and out of vogue over the centuries. James Clerk Maxwell and his friend, Michael Faraday supported a vortex theory of electromagnetism with potential fields as the centerpiece. In his final classic paper on the electromagnetic field Maxwell left out vortex models, and used 20 quaternion equations. Two years after Maxwell's early death (he was only 48 years old), Oliver Heaviside replaced the quaternions with vector algebra, and eliminated the potential fields as "arbitrary" and unnecessary. By the end of the 1800's the Maxwell equations had been reduced from the original 20 to the 4 we find in physics texts today. Deleting the potentials deprived physics, biology and medicine of important theoretical tools for nearly a century. For biology and medicine the forgotten potentials have important implications for regulatory physiology. The standard model of signal molecules randomly diffusing through the body fluids and interacting with distant receptors according to a lock-and-key model is seriously deficient and outdated. Evidence accumulates for a biophotonic model involving electromagnetic resonance between vibrating signal molecules and their targets. We trace the pathway followed by light through the vortically organized corneal stroma of the eye and the alpha-helical rhodopsin molecules in the outer segments of the retina. We suggest that alpha helical portions of membrane receptors are vortical "light pipes" that convey light into the cells. While this is a new idea for animal physiology, it is well known in plant physiology, where alpha helical membrane proteins are thought to function as light collectors and enable algae to survive in weak light environments. Direct photonic stimulation of cellular processes without mediation of "second messengers" is feasible and has been demonstrated.

A valuable and entertaining inquiry into the geometric structure of space and electromagnetism is provided in 5 books by Vladimir B Ginzburg [1-5]. In his 2002 book entitled *Unified Spiral Nature of the Quantum and Relativistic Universe* Ginzburg acknowledges scholars from ancient times whose works advanced the development of what he refers to as the Spiral Field Theory (SFT), in which space and light are organized as vortices. The list includes such luminaries as Archimedes, Kepler, Descartes, Leibniz, Swedenborg, Ampère, Fresnel, Stokes, Helmholtz, Beltrami, Schauberger W and JJ Thompson, Tait, Maxwell, Alfvèn, Wheeler, Crick, Watson, Bostick, Penrose, and Russell. Ginzburg traces repeating historical cycles of vortical models becoming fashionable and then disappearing, again and again, down through the ages.

Like Meyl [6] Ginzburg recounts how James Clerk Maxwell strongly supported the vortex theory of electromagnetism throughout much of his scientific career. This came about in part because of his close friendship with Michael Faraday. In 1861 and 1862, Maxwell published his famous four-part paper *Physical Lines of Force*, proposing an analogy between lines of force in the electromagnetic field and vortex filaments in a bounded liquid. In Part IV of the series, entitled *The Theory of Molecular Vortices Applied to Statical Electricity*, Maxwell expanded on the significance of the concept of the vortex to the electromagnetic theory of light [7]. In his earlier modeling of the electromagnetic field and the properties of space, Maxwell had relied on his expertise in the field of fluid mechanics.

Maxwell eventually left vortex theory and other physical analogies out of his writings, replacing them with equations and some assumptions regarding the elastic structure of the medium. In 1865 he published his seminal theory of electromagnetism, *A Dynamical Theory of the Electromagnetic Field* [8]. His 20 equations describing the electromagnetic field consisted of three equations each for magnetic force, electric currents, electromotive force, electric elasticity, electric resistance, total currents; and one equation each for free electricity and continuity. Maxwell expressed electromagnetism with quaternion mathematics and made the electromagnetic potential the centerpiece of his theory. Faraday and Maxwell had agreed that the potentials were the real movers in electricity, magnetism, and electromagnetism, causing things to happen like the puppets are moved by the invisible puppeteers behind a curtain.

Unfortunately, in 1881, two years after Maxwell's death, Oliver Heaviside replaced the electromagnetic potential with force fields (vectors) as the centerpiece of a revised electromagnetic theory. According to Heaviside, the electromagnetic potential was arbitrary and needed to be eliminated. A great debate took place about the relative merits of vector analysis vs. quaternions [9]. In the end, Heinrich Hertz, Josiah Gibbs and Oliver Heaviside prevailed, deleting the potential concepts that both Faraday and Maxwell had considered the most important features of the theory of electromagnetism. By the end of the 1800's the physical insights provided by quaternions had been set aside, and vector algebra was substituted, leading to THE four Maxwell equations as they are taught today. Deleting the potentials deprived physics, biology and medicine of important theoretical tools for nearly a century. As a result, some of the most pressing and unsolved mysteries related to health and disease persist, and some powerful healing technologies were bypassed because there was no adequate electrodynamics theory to explain and advance them.

For biology and medicine the forgotten potentials have immediate applications in regulatory physiology. The classic model of regulations is based on chemical messengers such as hormones released from an endocrine gland, for example. These messengers are supposed to diffuse randomly through the various fluid compartments within the body until they chance to reach receptors on distant cells, where they interact via a lock-and-key mechanism to trigger a cellular event (Figure 1a). The interaction of the messenger with the receptor is thought to trigger the release of second messengers such as cyclic adenosine monophosphate (cyclic AMP) or calcium ions inside the cell.

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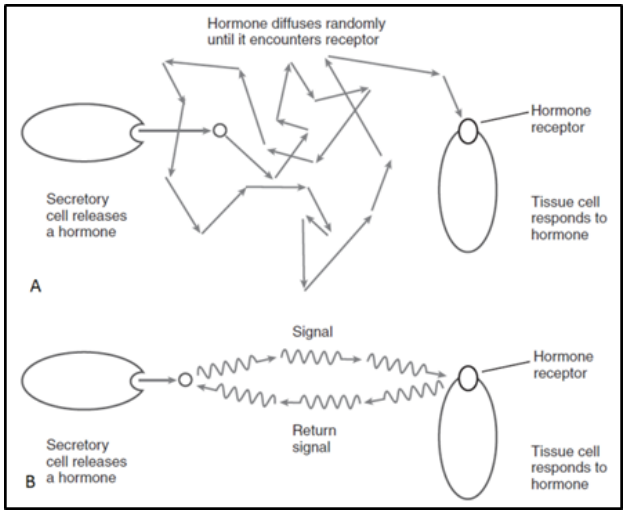

Figure 1: Dominant model of physiological regulations.

Since this article is an "opinion" piece, we can state our opinion: Along with others, we think this conventional model is seriously deficient and outdated, and thwarts progress in many areas, including biomedicine. The model is based on the ancient concepts of Lucretius and Epicurus, who pioneered the idea that matter is composed of hard, indivisible 'billiard-ball' units called atoms. And the lock-and-key model dates to Emil Fischer in 1894 [10]. One difficulty with this model is that it does not provide the essential cybernetic feedback from the receptor back to the signal source. The structural complementarity between hormones and receptors, which is traditionally assumed to be the basis for the lock-and-key model, is also a basis for resonant electromagnetic molecular communications, often referred to as "the tuning-fork effect." Structures with similar geometry will tend to resonate with one another. Another difficulty is that the mechanism is too slow to explain the ability of organisms to quickly adjust their activities when their environment changes. Increasing evidence supports a model (Figure 1b) involving electromagnetic resonance between a vibrating signal molecule and its target. Feedback is provided by co-resonance and is instantaneous. There is growing evidence that some regulations take place via electromagnetic resonance or bio photons (b).

Biophoton models have been reviewed [11]. The light involved is known as squeezed light, which can carry large amounts of information [12]. We now ask if potential fields such as scalar waves and vector potentials are involved in regulations.

Support for a vortex model of light comes from the design of the light-sensing systems in the eye. The first helically organized structure that light must pass through is the corneal stroma (*substantia propria*) (Figure 2a and b). The stroma is about 500 μm thick and forms the bulk of the cornea. It combines optical transparency with mechanical resilience. These properties are possible because of an extracellular matrix containing narrow (36 nm diameter) parallel type I collagen fibrils spaced and organized uniformly into 200-250 sequential lamellae or sheets. Each sheet is arranged orthogonal to its neighbor and to the path of light through the cornea (Figure 2b and d) [13-15]. Strength arises from the plywood-like architecture. The collagen fibrils are much smaller than the wavelength of light, and their spacing is such that light they scatter is eliminated by destructive interference in all directions other than forwards into the retina.

Trelstad [14] analyzed serial sections of corneas of birds, fishes, amphibians, and reptiles, cut perpendicular to the optical axis. The collagenous stroma is a cholesteric liquid crystal-like lattice which has the same right handedness in both eyes and is thus bilaterally asymmetrical (Figure 2d). Bilateral symmetry is the general rule for the heads of animals, with mirror symmetry in the sagittal plane dividing the body vertically into left and right halves, with one of each of the sense organs and limbs paired on either side. Why would this universal symmetry rule be broken for the corneal stroma? A logical answer is that both eyes must accommodate to light moving vortically in the same right-handed path (Figure 3). Different displacements between adjacent layers in different species (Figure 2e) may relate to matching of the index of refraction for life in different environments.

If biophotons from vibrating signal molecules follow vortical paths through the body, an interesting scenario arises at the receptors in cell membranes. Most if not all of the receptors on cell surfaces are composed long proteins that snake back and forth across the membrane from 7 to 24 times. Seven-trans-membrane-helix (7TM) receptors (Figure 4) are responsible for transducing information initiated by signals as diverse as photons, odorants, tastants, hormones, and neurotransmitters. Several thousand such receptors are now known, and the list continues to grow. These are sometimes referred to as serpentine receptors because the single polypeptide chain "snakes" back and forth across the membrane. One of the most important receptor proteins is the voltage gated calcium channel because it regulates many cellular activities and responds rapidly to very weak electromagnetic fields [16]. This receptor protein traverses the cell surface 24 times (Figure 5a).

Now to the key point of this article: The receptor proteins crossing cell surfaces are right-handed alpha helices. What is the nature of the interaction between light, a right handed vortex, and the alpha

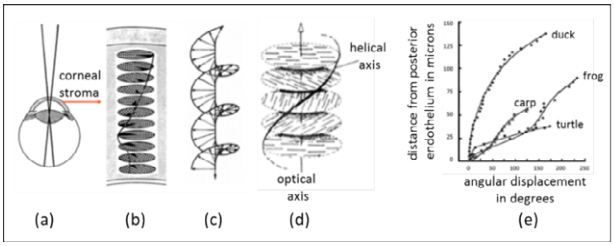

Figure 2: Structure and optical properties of the corneal stroma of the eye.

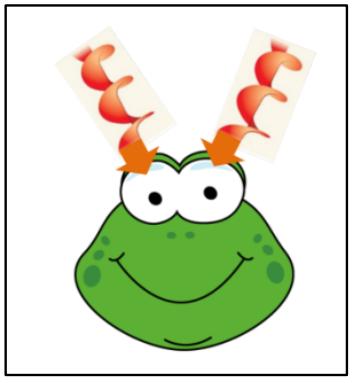

Figure 3: Anatomical arrangement of the fibers in the corneal stroma.

helices in cell membranes, which are also right handed? The possibility arises that these alpha helical proteins at cell surfaces are actually "light pipes" that facilitate the entry of photonic messages into cells. While this might at first seem to be a preposterous idea, there is abundant supporting evidence from the literature of plant physiology. Specifically, Red and blue-green algae have intricate light-absorbing structures called phycobilisomes. These "antenna" complexes contain many alpha helical regions, and are described as "light pipes" funneling excitation energy (photons) into the reaction centers of chlorophyll a of photosystem II. Chlorophyll a, in turn, is another membrane protein with five trans-membrane helices [17]. It is thought that this arrangement enables the algae to survive in weak light environments. The arrangement permits 95% efficiency of energy transfer, as reviewed by Glazer [18]. Moreover, the light sensitive pigment in the human eye, rhodopsin, is also a seven-trans-membrane-helix (Figure 5c).

Much less seems to be known about the functions of alpha helical proteins in eukaryotic cells, including those in mammals. It has been speculated that the alpha helices contribute strength to protein assemblies. Right handed helices are energetically more stable because there is less "steric clash" or unnatural overlap of nonbonding atoms between the side chains and the protein backbone. Essentially all helices found in proteins are right-handed.

We suggest that the alpha helical structures in animal cells may serve the same purpose so well-documented in plants, i.e. they provide channels or "light pipes" for biophotons to cross the cell surface so they may interact with enzymes and other molecules within the cell. As with the algae, the alpha helices may permit animal cells to funnel into cells weak electromagnetic signals emitted from vibrating hormones, neurohormones, growth factors, cytokines, etc. Some biochemists will assert that this is impossible because the alpha helices are not hollow and therefore do not provide a pathway for photons. This assertion is based on "space-filling" models of the alpha helix, which show that the amino acids protrude into the channel and therefore occlude it (Figure 4). This is another example in which the ancient Lucretian concepts create confusion. We now know that atoms consist mainly of empty space. In other words there is virtually nothing in the spaces in "space-filling" models.

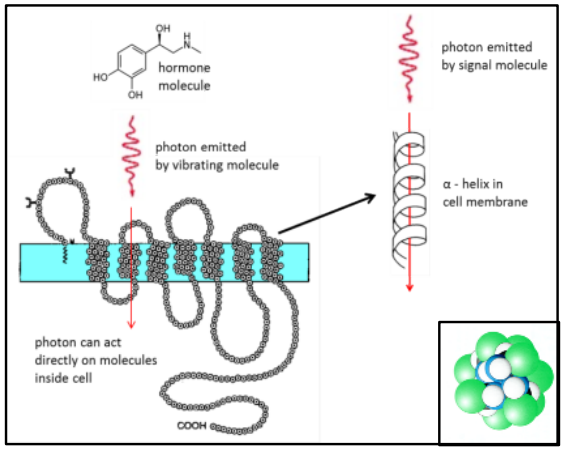

Figure 4: Vibrations of anepinephrine molecule.

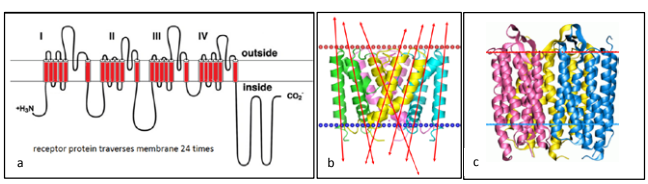

Figure 5: Voltage-gated calcium channel.

Finally, there is evidence for electromagnetic fields acting as first messengers for activating cellular processes [19]. If these speculations are borne out, we will have a new and more realistic model of biological regulations and how they can be optimized for the benefit of biomedicine.

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