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Synesthesia: Beyond the Five Senses
Helen Keller: Mind Over Instrumentation
Following the Beat of a Different Drummer

Again, What Makes Sense? The Extended Sensorium

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EIR

From the Managing Editor

In view of the explosive events taking place around the world at the time of this writing—revolutionary upsurges across the Maghreb, and into Southwest Asia—you might reasonably ask: Why is *EIR* devoting an entire issue to the research of LaRouche's young scientific collaborators, known affectionately, as the Basement Team? Is there a connection between the two?

As LaRouche emphasized in a discussion this week with colleagues: "The whole future of this nation, and of society depends upon people, largely, between 25 and 45." That age group makes up the largest portion of the mass phenomenon we are seeing in Tunisia, Egypt, and beyond. It is also the age group of the Basement Team that has contributed the contents of this week's issue, on "The Extended Sensorium."

LaRouche identifies the unifying principle between the stunning changes that are taking place across the globe, and our scientific work, as being that which Shelley describes in his "The Defence of Poetry": That there are certain moments in history, in which masses of people become open to assimilating "profound and impassioned conceptions respecting man and nature." Ordinary people suddenly become willing to lay down their lives for an idea, be it political freedom, economic justice, or just a decent future for themselves and their children. Thus, they are, at such times, not bound by their "five senses," by the search for pleasure and the avoidance of pain. At such times, LaRouche observes, there is an upsurge in individual creativity: "That's what we're working on, in the Basement. . . ." But, up until now, "mankind has not yet come to maturity, because the development of the quality of true creativity is not bestirred in them. . . .

"So therefore, the science, which is what we're actually dealing with . . . the idea of the Sensorium: The Sensorium is a prison: If you can't master it, it will control you." Could there be a better example of an individual who refused to be bound by the Sensorium, than that of the beautiful soul, Helen Keller, whose image graces our cover? You will read more inside about this exceptional genius.

So, we invite you to break out of the prison, and plunge into the exciting new work that the Basement is producing, which is published in these pages, and at http://larouchepac.com/node/17172.

EIR Contents

Cover This Week

Wikimedia Commons

Helen Keller reading brail: Beyond the "five senses."

The Extended Sensorium

Overview

"Thus, in summary, we are confronted with three categories of direct, or indirect human experience: 1.) What is traditionally regarded as the subject of human sense-experience; 2.) An intermediate domain, which recognizes qualities of sense-experience which can be recognized in domains much broader than conventional notions of sense-perception; 3.) The known domain whose characteristic is the role of specifically human creative powers of insight and innovation.

"In earlier reports on this subject, the emphasis had been placed on the crucial importance of the second, middle ground, that of sensible experiences beyond the category of the five heretofore 'conventional' notions of sense-perception, including the prominent role of the added experience expressed by aid of the role of scientific instruments.

"Now, in this present report, our attention is focused on the domain of a middle stage of our obligatory investigations, a stage which is represented by the seeking out of the subject of those additional sensory powers which are expressed within the ranges of cosmic radiation, which now includes what are both useful and tolerable for both human and other forms of life, but are, nonetheless, not yet the voluntary expressions of specifically human creative powers.

"Although these extended powers of sense-perception, include, for example, the special senses expressed as being employed through the design of migratory birds, the extended categories of sense-perceptions, such as those of such birds, do represent an intermediate quality of types, which all share the quality of the intermediate quality lying between what might be regarded as presently accepted notions of sense-perception and the cognitive powers unique to the human species among known species of living organisms. Next, comes creativity in and of itself.

"It is my function in this report, to identify the mission which this

indicated set of steps implies, the mission which other members of the team will, chiefly, carry out."

—Lyndon LaRouche, "What Makes Sense?"[1]

In the following report, you'll find a discussion that is of the utmost significance to understanding not only the current strategic situation, but also principles of economic science more generally.

The recent events in Tucson, Ariz. have prompted many to present ridiculous kinetic arguments in a search for what "set off" the shooter. In reality, there is no simplistic point-to-point explanation for what occurred. There is only the explanation that the events of that day were a singular expression of a much more general cultural trend, which is connected to the last several decades of cultural and economic decline in the United States and the world; a decline which is now finding its lawful expression in a generation of youth with no sense of a viable future for the human species, a generation plagued by a vicious and pervasive existentialism, in complete philosophical agreement with the hedonistic and anti-human purposelessness of "market economics."

The question of what such youth are responding to in their singular moments of explosive violence (of which the shooting in Tucson is only the tip of the iceberg), is not to be found in an examination of the shooter's personal history, or what he read on the Internet in the weeks prior. His characteristics, as a singularity, are to be found in the characteristics of the medium that produced him. An investigation of that relationship between singularity and medium is most clearly carried out via a study of what Lyndon LaRouche has referred to as "cosmic radiation."

In the report that follows, you will find an arc, meant to serve as a jumping-off point for that investigation.

The first chapter, by Oyang Teng, is titled "Synesthesia: Beyond the Five Senses." In it, he will demonstrate that, even what we commonly tend to recognize as sense perception, cannot be neatly divided into five distinct categories.

This idea if further developed in the chapter by Meghan Rouillard—a case study of Helen Keller titled, "Mind Over Instrumentation." Here, we will begin to see the peculiar relationship between mind and the senses, and see that mind, as a principle, is not, in fact, dependent upon any specific "set" of given senses.

From this point, we begin to expand our notion of sense perception, with an examination of the peculiar—sometimes unconscious "senses" to be found in the animal world.

Peter Martinson's "Following the Beat of a Different Drummer" is a study of biological rhythms in animals and humans, and discusses the ability of organisms to respond to solar and other extra-terrestrial cycles. (For related reading, see Sky Shields' earlier paper on correlations between astronomic cycles and biospheric evolution, "Kesha Rogers' Victory Signals Rebirthof a Mars Colonization Policy," *EIR*, March 19, 2010, also addressed in his paper below.)

A more detailed view of the role of electromagnetic phenomena in the biosphere is contained in Meghan Rouillard's "Polarization Sensitivity: A Strong and Weak Sense," where she describes a sense which might, at first, seem alien to humans: the ability to sense polarized light (the characteristics of which are described in an appended note by Jason Ross).

Oyang Teng continues this thread with a discussion of insects using infrared emissions as a sense of "smell."

This all sets the stage for Ben Deniston's detailed discussion of the still-puzzling phenomenon of magnetoreception in birds and other animals—their ability to perceive the detailed structure of the Earth's magnetic field, for use in navigation.

With the discussion of electromagnetic perception so situated, Sky Shields then takes up various expressions of the human ability to perceive electromagnetic phenomena in his chapter, "Unheard Melodies," with a specific emphasis on the electromagnetic conditions to be found as humanity migrates poleward, as we implement the proposed North American Water and Power Alliance (NAWAPA). This is followed up by a discussion of Classical musical composition and human culture in Aaron Halevy's "The Sounds of a Cosmic Chorus."

Readers who are interested in continuing this discussion, are invited to read an earlier report by Cody Jones, Sky Shields, and Michelle Lerner, entitled "In What Sense do you Mean Immortality?" (http://larouchepac.com/node/15672) That report might serve as a sort of appendix to the current one, taking up the necessity for space-faring humanity to alter fundamentally its relationship to its sense perceptions as it moves towards an electromagnetic environment which differs fundamentally from even that found at Earth's poles.

1. Lyndon H. LaRouche, Jr., "Science's Next New Undertaking: What Makes Sense?" *EIR*, Dec. 17, 2010; and http://www.larouchepac.com/node/16836

Synesthesia: Beyond The Five Senses

by Oyang Teng

Gottfried Leibniz once wrote that our sense perceptions are occult qualities, whose familiarity does nothing to render their essential nature more intelligible. After all, each person's sense experience is ultimately subjective. And despite the fact that language establishes a correspondence between the sensations of each and all, could anyone, for example, precisely define the color red?

Nevertheless, as Leibniz conceded, the study of human perception does yield important truths about that aspect of the physical world represented by our physiology, and the way the mind deploys such physiological functions to construct knowledge of the universe. That is, as messengers, we receive through our sensorium, "as through a glass darkly," the distorted shadows of the external world, shadows whose mutual interplay—and mutual contradictions—prompt our mind to discover order in the world.

Long before brain-imaging technology showed that even basic perceptual acts involve many different areas of the brain, common observation (and common sense) showed that there is no strict autonomy of any of the senses; rather, they each exist as interconnected aspects in a continuum of perception. Consider the following, from psychologist Erich von Hornbostel's 1927 paper, "The Unity of the Senses":

> Here is a tone, here are a number of different grey papers from black to white; choose the one which is as bright as the tone. This one? (Indignantly) "Too dark!" This one? "Too bright!" That one? "Still too bright!" And so on. It can be done quite easily and with great precision; and everyone, except the colour-blind, can find a grey to match the tone. Furthermore, anyone can find on the piano that tone which sounds as bright as lilac smells. (Generally he thinks the task nonsense at first, but, if he can be persuaded to deal with such nonsense at all, it goes very well.)
>
> So there is a "sensuous" which is not limited to one single sense. Indeed, looking more closely, the apparent exception becomes the rule, and one must search in order to find the private property of any one sense.[1]

The unity of the senses playfully described by Hornbostel, is perhaps nowhere more dramatically expressed than in the recently studied condition known as synesthesia, which, though acutely experienced by relatively few people, demonstrates more universally that the degrees of freedom of even the five traditional senses of human perception extend far beyond conventional accounting.

Synesthesia and the Mind's Eye

People with synesthesia experience a blending of the senses, such as sight and hearing, or a blending of characteristics within a sense modality, such as associating colors with written letters. More precisely, synesthesia occurs when "a triggering stimulus evokes the automatic, involuntary, affect-laden, and conscious perception of a physical or conceptual property that differs from that of the trigger."[2] In other words, it can involve not only the union of two different sense modalities (and, in rare cases, more than two), but also different dimensions of perception, such as spatial extension, as well as affective characteristics like personality or gender.

Some form of synesthesia is currently estimated to occur in roughly 4% of the population, the most common form being the experience of color for days of the week, followed by colored graphemes (a unit form in writing, usually letters or numbers), in which the color appears whether the grapheme is read, heard, or merely thought of. In this case, it is the *concept*, and not the literal *shape*, of the grapheme that is important, indicating that synesthesia involves both lower-level perceptual processes, such as the recognition of color, and higher-level processes more directly influenced by cultural development and language. For example, one experiment used a distorted shape that in one context could be interpreted as an "A," and in another, an "H," and the re-

1. Erich von Hornbostel, "The Unity of the Senses," 1927. http://gestalttheory.net/musicology/hornbostel1.html.

2. David Eagleman and Richard Cytowic, *Wednesday is Indigo Blue: Rediscovering the Brain of Synesthesia* (Cambridge, Mass.: The MIT Press, 2009).

spective synesthetic association was evoked in each case.

Synesthesia is far more common in children than adults. It is thought to occur universally in infants, reflecting a brain that is still in the process of differentiating the combined sensory experiences that characterize the infant's purblind state.

Other common synesthesias include number forms, a specific type of spatial sequence synesthesia, which is any that involves the combination of color and spatial configuration with concepts involving sequence; tasted words, triggered by either spoken or written words; colored hearing, involving the elicitation of color, shape, and movement by sound, whether environmental or musical; and the personification of letters and numbers. A typical example of the latter: For one woman, the letter V is "yellow beige but subdued (more beige than A; deeper than S; more yellow than L or K); female; very feminine, unflauntingly sexy, sophisticated."[3]

Beyond these more common types, just about every other sensory combination has been documented, including tasting shapes, feeling musical notes, and hearing temperature. With the exception of cases of sensory overload, most synesthetes report that the experience is pleasant, and in general, it is found to help with memory, because of the multiple perceptual associations bound up with certain events or experiences. Musical memory is no exception: In a skill that many would envy, some musical synesthetes can automatically check their pitch or key based on its characteristic color or taste.

www.synesthete.org

This screenshot displays one of a battery of online tests that someone can take to determine whether or not they are synesthetic. In this particular test, a color palette is provided for a person to match with a given tone.

3. Ibid.

Lying somewhere below the threshold of the percepton of an actual external stimulus, but above that of a merely imagined effect, synesthetic perception provides a striking insight into the operation of the "mind's eye" (and ear, nose, etc.). That is, the experience is real, immediate, and vivid, but at the same time, synesthetes can easily distinguish between the stimulus and the effect, so that an evoked color, for example, doesn't obscure one's visual field, and isn't mistaken for some kind of actual floating, colored object in space.

It is also worth considering to what degree synesthetic perceptions are more than the sum of their "parts," constituting perceptual categories for which we, as yet, have no names, as the analogous case of the relationship between a bird's vision and its magnetic sense demonstrates: Is it sufficient to say that it simply "sees" the magnetic field?[4] Other cases call into question the very meaning of existing definitions, as in the case of auditory effects from aurorae or meteors whose cause cannot be attributed to those associated with conventional hearing.[5]

The types of synesthetic sensory experience capable of spatial extension, also have the interesting property of expressing certain ordered configurations, rather than completely random and arbitrary associations. These "form constants" were first systematically catalogued by the German Gestalt psychologist Heinrich Klüver, and include such basic geometric forms as tunnels and cones, central radiations, gratings and honeycombs, and spirals, in various degrees of motion or pulsation, and can also occur in non-synesthetes under a variety of conditions. Again, such forms can apply to all experiences of spatial extension, not just visual experience. For example, someone with tactile synesthesia might feel what seem to be regularly ordered geometric shapes. This suggests that organized perceptual wholes, or gestalts, are not confined to specific sense modalities, and might offer clues as to the formation of gestalts which transcend perception per se, gestalts which are involved in such creative processes as artistic composition.

What is the underlying neural basis for synesthesia? Brain-imaging studies have shown increased "cross talk" between areas of the brain associated with the sensory functions implicated in different kinds of synes-

4. See Ben Deniston, "Magnetoreception," in this issue.

5. See Sky Shields, "Unheard Melodies: Electric and Magnetic Sense in Humans," in this issue.

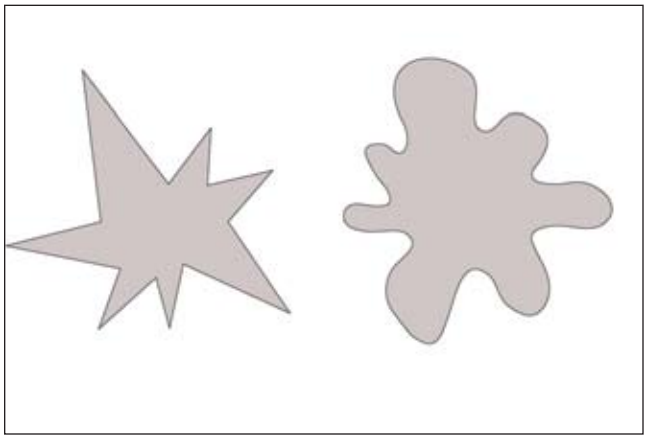
thesia, but it is not known for certain what causes the increased cross talk among different areas of the brain in synesthetes. It is likely that synesthesia simply unmasks commonly existing neural pathways, which research continues to suggest are far more interconnected throughout the entire brain than previously thought. There are a number of circumstances under which synesthesia can be temporarily acquired (such as during the period between waking and sleeping, when sudden noises can trigger perception of a burst of color) or consciously induced (as by meditation or drug use). Sensory deprivation, as in experiments with subjects blindfolded for several days, also causes a re-appropriation of the visual cortex to hearing and touch, a neural reorganization that becomes permanent in those who go blind.

Regardless of the particular brain processes involved, there is plenty of evidence for common synesthetic—or, at least, intersensory—perceptual patterns shared by all people, of which only a few examples follow.

The Common Sense

In the 1920s, Wolfgang Köhler, one of the founders of Gestalt psychology, demonstrated the tight connection between sight and hearing, in a famous experiment in which subjects were asked to identify which of two figures—one angular, the other rounded—was named "Takete," and which was named "Maluma" (**Figure 1**). An overwhelming number of test subjects associated the angular figure with Takete, the rounded one with Maluma, showing common associations exist linking the sound of certain figures and their corresponding visual representation.

FIGURE 1

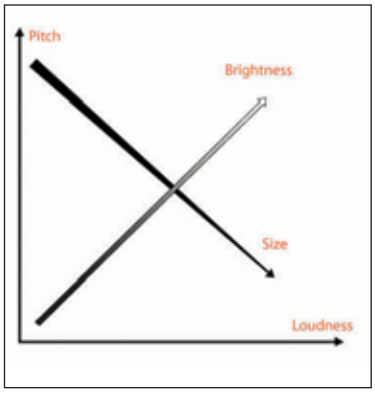


Another experiment on the mutual influence of sight and sound shows that the way a person's lips are perceived to form a sound can override the auditory stimulus itself, a phenomenon called the McGurk effect. For example, if the sound "ba" is heard corresponding to the image of a person mouthing "fa," the sound will be heard as "fa." More familiar cases also illustrate auditory-visual association, as happens every time we watch a movie, and believe the sounds emanating from the audio speakers to come from the action on screen.

Perhaps not surprisingly, spatial association with numbers is also common. In what has become known as the snarc effect (spatial numerical association of response codes), subjects are shown two numbers and asked to push a button corresponding to the larger. There is a direct relationship between the rate of response, and whether or not the larger number corresponds to the direction of larger numbers on an imagined, spatially extended number line. In synesthetes, these number forms are experienced as *explicit* projections in the space around the person's body.

Studies have long shown that pitch and color are also intrinsically linked. Synesthetes and non-synesthetes alike universally associate higher, louder tones with lighter colors, and lower, quieter tones with darker colors (**Figure 2**). Taste and smell have likewise long been associated, and simply holding one's nose while eating is enough to demonstrate their interdependence.

FIGURE 2



A recently published study showed that three-dimensional shapes, normally an inherent property of vision and touch, can be represented by artificially coded sounds. This "hearing of shapes" is treated by the authors of the study as a further demonstration of the natural "metamodal representation" of most perceptual processes.[6]

Of course, one need look no further than our use of

6. Jung-Kyong Kim & Robert J. Zatorre, "Can you hear shapes you touch?" (*Experimental Brain Research*, 2010).

language to see the deeply imbedded integration among the senses: whether describing someone's *loud* shirt or *dark* mood, the *soft* tones of a musical piece, or the "wonderful *rhythmical* flow of lines and curves" in sculpture, "more subtly felt than seen," as Helen Keller described it.

Keller's case is particularly interesting. Although she sensed the world almost entirely by touch, her use of language contains such vivid and sensuous imagery that one wonders whether it reflects a kind of synesthesia, or simply her amazing ability to absorb all that she read. In any case, there is no way to be certain what resemblance, if any, the "colors" in her mind's eye, or the "sounds" in her mind's ear, would have had to the corresponding senses of those with sight and hearing.[7]

There is also a reciprocal influence of language on perception. In one 2007 study, researchers showed that blue color discrimination was different for Russian and English speakers, based on the fact that Russian makes a categorical distinction between lighter shades (*goluboy*) and darker shades (*siniy*) of blue.[8] Like synesthesia itself, in which triggering stimuli are often products of learning and language, this suggests a dynamic interplay between culture and perception, in which our senses, rather than being "hard-wired," are instead somewhat conditional, subordinated to the continuing evolution of our cognitive powers. Other phenomena, such as sensory substitution—for example, the use of a device that produces tactile sensations on the tongue to simulate vision, or, alternately, the development of echolocation abilities in the blind—further underscore this point.[9]

Some have been prompted to conclude that synesthetic associations at the foundation of perception may have been necessary for the development of language itself:

> Marks concludes that perceptual experiences of meaning are multidimensional and that verbal (semantic) knowledge taps earlier perceptual knowledge. This conclusion is echoed by Sean Day who notes that colored sounds are the most common expression of perceptual synesthesia, whereas metaphoric elaborations of tactile sound are most common in (English) literary synesthesia. It appears likely that human thought itself is largely metaphoric. Hearing is the sense most frequently expanded by both perceptual synesthesia and synesthetic metaphors. Sean Day also concludes that synesthetically seeing sounds, which antedates language, has probably influenced language development.[10]

It is important to note, however, that metaphor is not a mere epiphenomenon of cross-sensory perception—it is, rather, given in the very structure of the universe as we know it. The idea that the universe *can* be known literally, is an artifact of the naïve presumption that our senses should somehow convey, even if only ideally, a more or less direct picture of reality. But true knowledge cannot be literal; it is only through paradox, through the principle of contradiction, that universals are known and communicated: what Nicholas of Cusa precisely termed "learned ignorance." This ontological principle of mind demands a corresponding form of organization of our neurological and perceptual apparatus, and it is this top-down requirement that makes possible all of the phenomena so far described.

From this standpoint, language is necessarily metaphoric. Despite the objections of positivists and others similarly wedded to sense certainty, the ambiguities that words inherently embody, represent, not a limitation, but rather a reflection of the interplay of the infinitely subtle "shadows" that form the backdrop to human thinking. Since no object of sense perception is self-defined, no language—mathematical or otherwise—can ever reach a state of completion.

Neither, it seems, can our own sensorium.

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"Derek Tastes of Earwax," BBC Documentary, 2004. http://www.youtube.com/watch?v=zrkyurkPhlY.

7. See Meghan Rouillard, "Helen Keller: Mind Over Instrumentation," in this issue.

8. Jonathan Winawer et al., "Russian blues reveal effects of language on color discrimination" (PNAS, 2007). http://www-psych.stanford.edu/~lera/papers/pnas-2007.pdf.

9. Indeed, what might all of this imply about the brain's capacity to be "tuned" to different modes of perception, such as through the still-poorly understood effects of different types of electromagnetic radiation?

10. Eagleman and Cytowic, op. cit.

Helen Keller: Mind Over Instrumentation

by Meghan Rouillard

In his recent report, "What Makes Sense,"[1] Lyndon LaRouche refers to the case of Helen Keller (1880-1968), as a case which can provoke us to think about the relationship between the human sensorium and the power of the human mind. LaRouche writes:

> I have emphasized, on this account, that if we treat experiences of sense-perception as being shadows cast by some unseen reality, as a now rich harvest of scientific instruments suggests, our attention is turned to the evidence of cases such as that of the celebrated case of Helen Keller, which warn us that a realm of five attributed human senses, is not the essential means on which the human mind should rely to steer efficient interventions into whatever the real world might be, that apart from a presumed direct and unique reality linking the world around us into the fruits of sense-perception as such. For example, could a person blind from birth, gain knowledge of the real world, which can be ultimately, as reliable, in effect, as an idea of the real world around us had by one with ordinary use of the five preferred senses?

Let us examine this, here, by exploring aspects of her case, which, although extraordinary, is the case of how a human being is capable of operating with an impaired sensorium.

Helen's Senses

Helen's account of her senses begins with the "seeing hand" of the "blind seeing," the sense of touch, which she says is unique:

"My fingers cannot, of course, get the impression of a large whole at a glance; but I feel the parts and my mind puts them together. I move around my house, touching object after object in order, before I can form an idea of the entire house.... It is not a complete conception, but a collection of object-impressions which, as they come to me, are disconnected and isolated. But my mind is full of associations, sensations, theories, and with them it constructs the house. The process reminds me of the building of Solomon's temple, where was neither saw, nor hammer, nor any tool heard while the stones were being laid one upon the other.

"Touch cannot bridge distance,—it is fit only for the contact of surfaces,—but thought leaps the chasm. For this reason I am able to use words descriptive of objects distant from my senses. I have felt the rondure of the infant's tender form. I can apply this perception to the landscape and to the far-off hills."[2]

However, she says she is not in a position to say whether vision or touch is a better sense to have. Smell for her is "the fallen angel" of the senses.

"Touch sensations are permanent and definite. Odors deviate and are fugitive, changing in their shades, de-

1. Lyndon H. LaRouche, Jr., "Science's Next New Undertaking: What Makes Sense?" *EIR*, Dec. 17, 2010; and http://www.larouchepac.com/node/16836

2. Helen Keller, *The World I Live In* (1907), in *New York Review of Books,* 2003.

Helen Keller referred to the sense of small as "the fallen angel." She is shown here, ca. 1920, holding a fragrant magnolia flower.

grees, and location. There is something else in odor which gives me a sense of distance. I should call it horizon—the line where odor and fancy meet at the farthest limit of scent. Smell gives me more idea than touch or taste of the manner in which sight and hearing probably discharge their functions. Touch seems to reside in the object touched, because there is a contact of surfaces. In smell there is no notion of relievo, and odor seems to reside not in the object smelt, but in the organ. Since I smell a tree at a distance, it is comprehensible to me that a person sees it without touching it."

On the one hand, Keller clearly demonstrates and expresses the capability to "milk," if you will, her other senses more than most of us are able to. Her descriptions of these impressions are surely more vivid than for those of us who are neither blind nor deaf. But studies have shown that she did not, in fact, have senses that were extraordinary relative to our own (those of us with vision and hearing, that is). This, and Helen's own words, will point us to an important fact about the power of the human mind over the senses.

In 1928, University of Chicago neurologist Dr. Frederick Tilney spent time with Keller and tested the acuity of her senses of touch and smell, as compared with those of people who have optimal vision and hearing. The results were rather surprising. Helen's sense of touch and smell registered as no more keen than average. Dr. Tilney, in his research paper, a comparative sensory analysis of Helen Keller and Laura Bridgman,[3] had hypothesized that Keller's sense of smell must have contributed significantly to her development; Bridgman lacked this sense, in addition to sight and hearing. Among other differences, Bridgman's command of language was much less developed than Keller's. The following is an account of Tilney's test of Keller's sense of smell:

"To measure the sensitiveness of Helen Keller's olfactory nerves, Dr. Tilney prepared oils, such as wintergreen and asafetida, in various dilutions (also alcohol, peppermint, formaldehyde, eucalyptus), and asked her to tell him when she could notice any difference between various odors. The weakest dilution of alcohol that she could smell was one part in 16. She detected eucalyptus as weak as one part in 64, wintergreen one part in 128, peppermint one part in 1024, and asafetida one part in 2048. And this is about the sensitiveness of the average person's smelling equipment."[4]

To Dr. Tilney's surprise, his tests of Helen's olfactory sense showed that it was no more keen than that of the so-called average person. Tilney cites a letter from Keller to himself, written at his request, on her impressions of the sense of smell. In it she referenced various passages from Shakespeare's plays, Greek philosophers, and the Bible, in which she thought the sense of smell was referenced in an especially poetic way. He also tested the other sense which we might assume was a kind of supersense for Helen Keller, that of touch. He tested various aspects, such as localization, pressure, temperature, vibration, and found, in each and every case, that she scored only average.

An interesting side note regarding these tests, which alludes to another part of this report, is the reason given, at the time, to account for the discrepancy in "sense of direction" between Keller and Bridgman. This was a feature of the balance test. The action of spinning in a chair was only sensed by Keller by the wind blowing on her face. She experienced no other feeling associated with it. For Bridgman, there was more sensation involved, including dizziness, which Keller did not feel. Bridgman could also more accurately determine the difference between the direction she faced in the chair before and after bring turned. Interestingly, Dr. Tilney attributed this difference in "sense of direction" to "a sense which would explain the mysterious homing of the pigeon and the straight, sure flight of the birds to their summer and winter homes. Experiments now underway at Columbia University indicate that this sense may prove to be a magnetic sense located in the retina of the eye.... Bridgman had a retina which may have functioned magnetically, even in blindness, to aid her a little in sensing direction. Whereas, Miss Keller, lacking this aid almost from birth, illustrates the negative side of the case."

This is a provocative point to consider, but the results of these studies, and the further work since done on this, have not been explored much, and will not be addressed further here, but it should be kept in mind in the context of this entire report.[5]

Of course, we can question the kinds of tests which were performed, in terms of measuring the senses, but

3. Frederick A. Tilney, "Comparative Sensory Analysis of Helen Keller and Laura Bridgman," *Archives of Neurology and Psychiatry*, 1928.

4. Emily C. Davis, "Helen Keller Shows Future of Brain," *The Science Newsletter,* Vol. 14, No. 387 (Sept. 8, 1928) pp. 141-42, 147-48.

5. See Benjamin Deniston's report on "Magnetoreception," in this issue.

the results, and Dr. Tilney's ultimate conclusion, are interesting, nonetheless. On the one hand, we can ask whether the tests for the senses, in fact, test all of their possible dimensionalities. The possibility that they did not, and still do not, is alluded to in various other reports here.[6] The other conclusion which can be drawn, is, in a sense, Dr. Tilney's own main conclusion, that, "Miss Keller's sensory organization for the primary conduction of afferent impulses thus does not appear to be different from that of the average run of humanity. Her sensory supremacy is entirely in the realm of the intellect."

He further specified that he thought that, "the great difference exists in her use of the senses by the development of her brain." He referred to the parietal lobe being potentially very developed, but this was not tested. The ability to test neuroplasticity was not available in 1928—for example, those investigations as to whether parts of Helen's brain, which would have been activated through the senses of sound and sight, were otherwise engaged. Tilney's suggestion that she appeared to be using more of her brain than we five-sensed creatures remains somewhat ambiguous as to its meaning, and it is a question we cannot answer now through studying her brain, of course.

Regardless, what we will be confronted with here, is that Helen's mind may have been more engaged and active than those of some typical seeing and hearing members of the population. How? Through some more active "higher brain functions"? Was it through the tools of irony and metaphor, those associated with human creativity? Whether or not Dr. Tilney spoke of this per se, it was clearly on his mind, and it is for you to judge based on the facts of her case.

The Analogy of the Senses

In addition to an added reliance on her senses of smell, taste, and touch, Helen also used what she called analogies, among these senses, to fill in for the missing senses, such as vision, whose impressions she adduced from a sense of taste. Today, we might call this a kind of synesthesia.[7] She says of it:

"I understand how scarlet can differ from crimson because I know that the smell of an orange is not the smell of a grapefruit. I can also conceive that colors have shades, and guess what shades are. In smell and taste, there are varieties not broad enough to be fundamental, so I call them shades."

"Through an inner law of completeness my thoughts are not permitted to remain colorless."

She is attacked sometimes for using such controversial imagery as "color" in her poetry. For, of course, according to such critics, she does not understand the right idea of color. Keller's obituary recounts the story of one particular reaction to her 1902 autobiography:

"Most reviewers found the book well written, but some critics, including that of *The Nation*, scoffed. 'All of her knowledge is hearsay knowledge,' *The Nation* said, 'her very sensations are for the most part vicarious and she writes of things beyond her power of perception and with the assurance of one who had verified every word.'"[8]

Sense perceptions clearly vary from individual to individual, another reason why a single visual perception, for example, is not reality. She agrees that her concept of color may not be the same as mine, or yours, but insists that her own thoughts do not lack that attribute. We may ask ourselves the question—was she tuned into some other dimensionality of these senses? LaRouche has now made this a provocative point to consider. But we can also ask ourselves how the power of the human mind itself serves to overcome these frailties. On this she says:

"Philosophy constantly points out the untrustworthiness of the five senses and the important work of reason which corrects the errors of sight and reveals its illusions."

Let us explore for a bit this philosophical debate.

The Mind's Role

In 1886, six years after Helen Keller's birth, Ernst Mach, associated with the positivist school of thought, said that the only thing which is, in fact, real, is the sum of our sense impression; the human soul is the receptacle for these impressions, nothing more. It is as though Mach would say, that when we stop seeing and hearing, we lose 40% of ourselves, since 40% of so-called reality is no longer accessible to us through our senses.

From Mach's *Contributions to the Analysis of Sensations,* "The Sensations as Elements: Antimetaphysical":[9]

6. See variously, the reports by Aaron Halevy, Sky Shields, etc., this issue.

7. See Oyang Teng's "Synesthesia," this issue.

8. http://www.nytimes.com/learning/general/onthisday/bday/0627.html

9. Ernst Mach, *The Classical Psychologists," compiled by Benjamin Rand, PhD (New York: Houghton Mifflin, 1912).*

"The primary fact is not the I, the ego, but the elements (sensations). The elements constitute the I. That I have the sensation green, signifies that the element green occurs in a given complex of other elements (sensations, memories). When I cease to have the sensation green, when I die, then the elements no longer occur in their ordinary, familiar way of association. That is all. Only an ideal mental-economical unity, not a real unity, has ceased to exist.... For us [the positivists] colors, sounds, spaces, times ... are the ultimate elements, whose given connexion it is our business to investigate. In this investigation we must not allow ourselves to be impeded by such intellectual abridgments and delimitations as body, ego, matter, mind, etc."[10]

We can imagine the 12-year-old Keller, taunting the misanthropic Mach: "Mind, mind alone, is life and hope and light and power!" Keller was clearly no philosophical student of Mach:

"From philosophy I learn that we see only shadows and know only in part, and that all things change; but the mind, the unconquerable mind, compasses all truth, embraces the universe as it is, converts the shadows to realities ... though with my hand I grasp only a small part of the universe, with my spirit I see the whole, and in my thought I can compass the beneficent laws by which it is governed."

In addition to her own words, Keller's very existence shows Mach's outlook to be problematic in several ways. On the one hand, we can ask ourselves whether losing the ability to perceive visible light really means losing vision entirely, and she herself questions this:

"Has any chamber of the blind man's brain been opened and found empty? Has any psychologist explored the mind of the sightless and been able to say, 'There is no sensation here?'"

But more important, reflect on the point which became a source of much contention between Mach and the behaviorist school in psychology, on the one hand, and the likes of Max Planck and Wolfgang Köhler, on the other. What is implied in the writings by these latter two scientists, is that, that which we know to be real is first and foremost our own thoughts. Of course, we can test their efficiency; and the conceptions communicated by Helen Keller, about the nature of man, for example, resonate with us because they are true. Unlike the animals, we can create an efficient conception in the mind, known to be efficient because it can be tested experimentally. And if it represents a true discovery, it would represent, in potential, a complete break from all that we have experienced. But, the main point missed by Mach, and the most glaring thing that he cannot account for, is that after one's death, something real, in terms of something efficient, does persist. Something which has no sensual perceptions, but whose presence can be powerful in its effect.

As a young girl, Keller, challenged the misanthropic Ernst Mach: "Mind, mind alone, is life and hope and light and power!"

As Helen Keller's case illustrates and reveals to us, the reality which is most important, is that which we know through the mind. It is that part of us which lives on, and acts when we are no longer able to perceive.

Gottfried Wilhelm Leibniz, in a correspondence with the Prussian Queen Sophie Charlotte, elaborated why it is that, contrary to positivist belief, sense impressions are something other than truth which the mind gleans:

"Being itself and truth are not known wholly through the senses; for it would not be impossible for a creature to have long and orderly dreams, resembling our life, of such a sort that everything which it thought it perceived through the senses would be but mere appearances. There must therefore be something beyond the senses, which distinguishes the true from the apparent. But the truth of the demonstrative sciences is exempt from these doubts, and must even serve for judging the truth of sensible things. For as able philosophers, ancient and modern, have already well-remarked:—if all that I should think that I see should be but a dream, it would always be true that I who think while dreaming, would be something, and would actually think in many ways, for which there must always be some reason.

10. Or, as one of Newton's worst enemies pointed out to me, see the end of Newton's *Principia*, to the same effect: "What the real substance of any thing is we know not. In bodies, we see only their figures and colours. We hear only the sounds. We touch only their outward surfaces. We smell only the smells, and taste the flavours; but their inward substances are not to be known either by our senses, or by any reflex act of our minds...." See Michael Kirsch's report on the history of empiricism at: http://www.larouchepac.com/node/13834

"Thus what the ancient Platonists have observed is very true, and is very worthy of being considered, that the existence of intelligible things and particularly of the Ego which thinks and which is called the spirit or soul, is incomparably more sure than the existence of sensible things; and that thus it would not be impossible, speaking with metaphysical rigor, that there should be at bottom only those intelligible substances, and that sensible things should be but appearances. While on the other hand our lack of attention makes us take sensible things for the only true things. It is well also to observe that if I should discover any demonstrative truth, mathematical or other, while dreaming (as might in fact be), it would be just as certain as if had been awake. This shows us how intelligible truth is independent of the truth or of the existence outside of us of sensible and material things. This conception of being and of truth is found therefore in the Ego and in the understanding, rather than in the external senses and in perception of external objects."[11]

From philosophy I learn that we see only shadows and know only in part, and that all things change; but the mind, the unconquerable mind, compasses all truth, embraces the universe as it is, converts the shadows to realities . . . though with my hand I grasp only a small part of the universe, with my spirit I see the whole, and in my thought I can compass the beneficent laws by which it is governed.—Helen Keller

Max Planck, who refers to Leibniz in his writings, used this same example to convey the same idea, over 200 years later, against the positivists such as Mach.

"I may dream all sorts of things during the night; but the moment I wake up the reality of my surroundings gives the lie to the dream. The empiricist however cannot logically admit that. For him there is no waking reality; because the subjective sensation is the sole basis and criterion of knowledge. Now the dreamer during the dream believes automatically in its reality and, according to the empiricists, the wideawake person believes automatically in the reality of his sense-perceptions; but has no more reason than the dreamer has for saying that one set of perceptions is false and the other true. . . . All of this of course amounts to a repudiation of common sense; so much so that even the most advanced sceptics of this school find themselves constantly compromising between the claims of common sense and the purely logical conclusions of their own philosophic system."[12]

He clarifies the fundamentally opposed outlooks himself:

"As long as we logically pursue the positivist teaching we must exclude every influence of a sentimental, aesthetic, or ethical character from our minds. . ."

But, he elaborates, this alone leaves out entirely the role of hypothesis, which no one can deny has been the source of science's achievements. He refers to the case of astronomy, as a science which has developed not simply because of the catalogued observations of individuals. The very nature of science as a study by mankind depends on recognizing the contradictory nature of various experiments done by various individuals, from which new conceptions must be developed. The unique conceptions of individuals, not simply their cataloguing of observations, is what has caused science and mankind to advance.

"If we look at [empiricism] purely from the viewpoint of knowledge it leads to a blind alley. . . . In order to escape from this impasse there is no other way open but to jump the wall at some part of it, and preferably at the beginning. This can be done only by introducing once and for all, a metaphysical hypothesis which has nothing to do with the immediate experience of sense-perceptions or the conclusions logically drawn from them."

With Helen, we have a clear case of someone who thought of herself as having instrumentation, from which an image of reality could be gleaned through the mind; through generating a mental picture which can, potentially, be something completely efficient. She implies that her imagination is more actively engaged as a result of lacking the sense of vision. The particular

11. G.W. Leibniz, "On the Supersensible Element in Knowledge, and "On the Immaterial in Nature," *Philosophical Essays* (1702), trans. by Roger Ariew and Daniel Garber (Indianapolis, Ind.: Hackett Publishing, 1989).

12. Max Planck, *Where Is Science Going?* (Woodbridge, Conn.: Ox Bow Press, 1981).

burden of vision, as she describes it, is that sensing persons are less clear of the fact that their minds are forming a picture of reality from impressions of instruments. Reality is not being imparted from the eyes to the mind, which is simply a receptacle. Rather, the mind is always working to construct this picture of reality, and perhaps more so when the impressions are not being perceived at the same time, as with an image which can only be built up over time. At least the primacy of the mind's role may be more clear to the perceiver in this case. She says that she will not claim who generates a more efficient conception, the seer or the blind, who sees through touch, but, as her own writings show clearly, this woman, who could not see or hear, had a real sense of the power of her own mind, and an efficient conception of reality, which we know because her thoughts can move us, and can generate powerful ideas within our own minds.

"Order, proportion, form, cannot generate in the mind the abstract idea of beauty, unless there is already a soul, intelligence to breathe life into the elements. Many persons, having perfect eyes, are blind in their perceptions. Many persons, having perfect ears, are emotionally deaf. Yet these are the very ones who dare to set limits to the vision of those who, lacking a sense or two, have will, soul, passion, imagination.... I, too, may construct my better world, for I am a child of God, an inheritor of a fragment of the Mind that created all worlds."

She constructed an image of the universe outside of herself, and within herself, which, as we can attest from reading her writings, is not foreign to those of us who lack her impairments. We have suggested that Helen's senses, those she possessed, were not more powerful than our own. The question can be asked, to what extent was she also tuned more into dimensions of the senses than those associated with their characteristic impressions? Are there perhaps other aspects to which we are less sensitive, or simply less aware?

Cosmic Tuning

In a recent report, LaRouche, provocatively referred to the possible implications that the "extra senses" of animals had for the case of Helen Keller:

"As in the case of bird migration dependent upon a feature of cosmic radiation, there are a large number of types of cosmic radiation, within the relevant ranges, which have such a function specific to one or another type of living entity of either plant or animal life.

"One might ask, what might be the relevance of this latter consideration to the case of Helen Keller?"[13]

Some of Helen Keller's thoughts on this subject are provocative, and I think can be thought of in a new light in this context, in that they can point the mind in the direction of thinking about what, in fact, she was "tuned into," potentially from this standpoint of cosmic radiation. I think it is fair and appropriate to leave as a question provoked by her own words:

"Critics delight to tell us what we cannot do. They assume that blindness and deafness sever us completely from the things which the seeing and the hearing enjoy, and hence they assert we have no moral right to talk about beauty, the skies, mountains, the songs of birds, and colors.... Some brave doubters have gone so far even as to deny my existence.... I throw upon the doubters the burden of proving my non-existence. When we consider how little has been found out about the mind, is it not amazing that anyone should presume to define what one can know or cannot know? I admit that there are innumerable marvels in the visible universe unguessed by me. Likewise, O confident critic, there are a myriad sensations perceived by me of which you do not dream.... Certainly the language of the senses is full of contradictions,

What was Helen enjoying when she "heard" the tenor Enrico Caruso sing, and was moved to tears? Vibrations? Or something more?

13. Lyndon LaRouche, "The Global Crisis Now at Hand," 2010, larouchepac.com

and my fellows who have five doors to their house are not more surely at home in themselves than I. . . ."

This quote from Shelley's *Prometheus Unbound* is also referred to by her, respecting her condition:

> My wings are folded o'er mine ears,
> My wings are folded o'er mine eyes,
> Yet through their silver shade appears,
> And through their lulling plumes arise,
> A shape, a throng of sounds.

Is it really the case that the deaf cannot hear music? Keller says of the voice of a soprano, "When I read the lips of a woman whose voice is soprano, I note a low tone or a glad tone in the midst of a high, flowing voice." What was Helen enjoying when she "heard" the tenor Enrico Caruso, and was moved to tears? Vibrations? Or something more?[14] Perhaps it involved a kind of sixth sense, as LaRouche has referred to, which perceives other characteristics of performed Classical music than simple audible sounds.

The critic from *The Nation* who reacted so strongly to Keller's use of the concept of color would probably be sent into a rage in response to the following, by Keller, on the work of the artist:

"In their highest creative moments, the great poet, the great musician cease to use the crude instruments of sight and hearing. They break away from their sense moorings, rise on strong compelling wings of spirit far above our misty hills and darkened valleys into the region of light, music, intellect."

But could we deny that this woman herself was not a veritable poet? However, perhaps the most provocative question yet, is, how she developed her language capability, which seems to suggests a means that surpasses that of sense perception.[15]

The Human Element

We can examine this question through reflecting again, now, upon a question posed by Lyndon LaRouche a couple of years ago: How did Keller know that her teacher was a member of the same species as herself? The answer does not lie in some kind of group communication signal, like that which we see in the cephalopods or the mantis shrimp.

Before meeting her teacher Anne Sullivan (right), Helen described herself as living in a "no-world," in which she responded mainly to sensory stimulation. She is shown here in July 1888, at age 8.

As a young girl, before being introduced to her teacher, Anne Sullivan, Keller's relationship to the outside world was extremely limited. She describes herself as living in a "no-world." She says she responded mainly to sensory stimulation and desire, and did not understand that dogs and other animals were much different than she was. She only realized later that they did not have the cognitive powers which she says she only later developed—recognizing and reflecting on the fact that her earlier responses to these desires and sensations were not something fundamentally human.

Her role as part of a human species was made increasingly clear to her through the process of human interaction and communication, and this is clear from her own telling of her story. This question became more clear through specific kinds of interactions based on language. For example, being presented with a paradox, in language, as presented by her teacher. This word, which you thought you understood, also means

14. See Sky Shields' report on Auroral hearing, and Aaron Halevy's report on Digital vs. Analog music, this issue.

15. Lyndon LaRouche, "The Sixth Sense," *EIR*, Jan. 14, 2011, and http://www.larouchepac.com/node/17156

this! She describes various experiences of this kind, where a flash of insight, almost like a flash of light, thus expanded her capability to communicate, and also, to think. When we learn that the word "love" can be used to describe an idea about the entire human species, and not simply the feelings about one person, we have a case of this. We make sense of this through a process of challenging our old idea, and this can put us at ease, in a certain way, through then knowing a more truthful idea. Perhaps an example of why Keller said Greek was her favorite language, had to do with the more precise words, in this language, to indicate the different meanings in this case.

"I cannot always distinguish my own thoughts from those I read, because what I read becomes the very substance and texture of my mind," Keller wrote. Helen (left), at age 18, "reading" with Anne Sullivan.

This process of overthrowing old conceptions is actually what any young child experiences learning a language, and the child's universe expands through this process.[16] Dr. Tilney had also concluded that the main explanation for the overall difference in the development of Laura Bridgman and Keller, lay in the different approaches to introducing them to language and to society. Bridgman, who only used 50-60 monosyllablic sounds, which were not words, but were known to those who knew her, led a life which was much more isolated, and her education was halted at 20 years of age.

It would seem that, in order to explain the clear quality of genius, and the ability to overcome a sensory handicap in a person like Keller, if it were not able to be explained by senses or supersenses, as Dr. Tilney concluded, then perhaps it was primarily through something like paradox, something which involves the contradiction between experiences. The ability to comprehend a paradox is what arms us with the highest powers of language, which can be learned precisely because we can grasp ideas which bridge single sense impressions, and can develop through such a means.

Let us continue to dwell on this, because it would seem that the answer lies beyond sense perception or information: We can ask ourselves how one would teach a blind and deaf child concepts which were not merely the names of objects. Initially, when Helen was taught the word "to think," it was a word which her teacher Anne Sullivan wrote on her head while Helen was beading a necklace. Keller said this made sense. But how was she then able, later in life, to wield the power of this word in such a different context? For example, we have these much more advanced uses of the word thought:

"I cannot always distinguish my own thoughts from those I read, because what I read becomes the very substance and texture of my mind," or, "Just as the wonder-working mantle of the Nautilus changes the material it absorbs from the water and makes it a part of itself, so the bits and pieces of knowledge one gathers undergo a similar change and become pearls of thought," or, "Greek is the loveliest language that I know anything about. If it is true that the violin is the most perfect of musical instruments, then Greek is the violin of human thought."[17]

Clearly, we can only bridge this gap through conceiving of the mind resolving new paradoxical uses of this idea over time. Here we have a hint as to a kind of characteristic of the mind which is transcendental to the declarative statements of information presented to it.

16. Jean Sherwood Rankin, "Helen Keller and the Language Teaching Problem," *The Elementary School Teacher,* Vol. 9, No. 2 (October 1908), pp. 84-93.

17. Helen Keller, *The Story of My Life* (1902) (New York: Bantam Classic Reissue, 2005).

Sullivan reveals in the journal that she kept throughout her years of teaching Helen, a Platonic view of the human mind, as opposed to the outlook which she found to be more prevalent among educators. Keller herself said that a deaf-blind person could find special meaning in the writings of Plato. Sullivan wrote that the more typical and cynical outlook reflected the idea that "Every child is an idiot which must be taught to think." Sullivan's own experience in teaching Helen taught her otherwise, and she approached the task, from the beginning, with confidence in another view. She wrote:

"It is as easy to teach the name of an idea, if it is clearly formulated in the child's mind, as to teach the name of an object. It would indeed be a herculean task to teach the words if the ideas did not already exist in the child's mind. . . ."

She insisted on speaking to Helen in complete sentences, so that she could "catch from context the meaning of those words she did not know," and did not overly explain words which were new: "Little by little the meaning will come to her."

Informed by this outlook, Sullivan had the confidence that there was an activity of the mind which superseded sense impressions, here, in the form of communicated words. As we have seen, Helen herself was later able to wield the power of language, by which we change our self-conception as a species. As a human species, we, unlike the animals, have this power to hone the powers of the mind, and to increase our power over nature. Unlike the animals, who do this through cleaning their instruments, as Keller herself says of our role, "All men shall bring mind and soul to the control of matter."

In reviewing the facts of the case of Helen Keller, it seems that it is our ability to grasp various levels of irony which permits the true development of the human species, in science, and in language. For without that, there is no pathway by which a blind and deaf girl could develop a broader concept of love, for example, another of the first concepts she learned, than that associated with her first experience of it. But this same word took on a far greater meaning over time, which became as great as mankind and his garden, the Earth, of which she spoke and wrote, but whose characteristics she was never able to sensually perceive in the same sense as one with five optimally functioning senses. Let us keep this case in mind as we explore the differences and similarities between the human and animal sensoriums in the rest of this report.

Following the Beat of A Different Drummer

by Peter Martinson

Involuntary rhythmic activity in biology is a phenomenon common to every organism studied, and covers virtually every vital process in those organisms. Such processes cannot be ascribed simply to an internal clock-mechanism within the organisms, nor to purely external geophysical or cosmic influences. There is a deeper process at work, which can be approximated by assuming a combination of both causes. This consideration leads directly to not only a broader definition of sense perception, but to implications about the long-term anti-entropic development of life on the Earth, and into the manned exploration of other planets within the Solar System.

Lyndon LaRouche has demanded that fundamental science proceed with the understanding that the universe is composed of three interacting, but hierarchically arranged phase spaces: the abiotic, the biotic, and the noëtic. These phase spaces were established by no later than 1938, by Russian academician Vladimir I. Vernadsky, who had already demonstrated that the world of abiotic physics did not have a monopoly on such deep issues as the construction of physical space-time.[1] No form of fundamental science in the biotic phase (or either of the other phases, for that matter) should ever be allowed to be reduced to abiotic physical explanations. This should be extended to imply that further discoveries in what can be imagined as "abiotic physics," can only be made by coming down from discoveries in biology. The assumption that any investigation into biological phenomena can be explained in terms of what is already known in physics, is as insane as saying that your Mom is no more than a very complicated spatula.

With this in mind, the responsible scientist will recognize that something like the phenomenon of biologi-

1. V.I. Vernadsky, *Problems of Biogeochemistry II: On the Fundamental Material-Energetic Distinction Between Living and Nonliving Natural Bodies of the Biosphere.* First published in 1938 in Russian. First English translation, *21st Century Science & Technology*, Winter 2000-2001, pp. 20-39.

cal rhythms has the potential to reveal not only as-yet unknown domains of cosmic radiation, but also, unknown aspects of radiations that have hitherto been barely contained by their mathematical formulations. For example, what will be seen is that organisms tend to respond to incredibly weak fields, which are apt to be missed by conventional instruments. Those organisms have been responding to those weak fields for billions of years, much longer than humans have known they existed. This opens up the possibility that organisms respond not only to weak fields, but also to extremely long-cycle radiations, on the temporal scale of geological time, which correspond with evolutionary changes in life on the Earth.

Are individual organisms really individual organisms, struggling for individual existence against external waves and particles, or are they better understood as within the category of cosmic radiation itself? Even better, perhaps cosmic radiation must be studied as the prime expression of that higher phase than the abiotic—life—the organisms thus understood as contractions within the field. Hence, the term "sense organ" refers to something fashioned by cosmic radiation itself, in order to mediate an intergalactic system.

Before embarking on a survey of crucial experiments regarding biological rhythms, let us first review the notion of senses, from the perspective of astrophysicist Johannes Kepler.

Kepler

An object that is sensed by somebody, must be able to act in some way on the sense instruments of his body. Thus, the retina of the eye must be able to respond to some disturbance caused by a seen object. The disturbance is caused, in this case, by what we call light, although the light itself is not seen—light is what is generated by the seen object, which can act on the eye's retina. By some as yet unknown path, the soul of the viewing person must be able to judge whether his retina is being affected by an outside object. In this way, the person is not watching the external object, but his own retina. LaRouche has described this paradox as that of the space traveler, within a spacecraft which has no windows, only instrument readings.[2] He witnesses the instrument readings, not what causes those readings. Hence, there is no window between external physical reality, and the soul of the observer, through which the emanations from the observed object pass from out to in. Those emanations essentially stop at the instrument. It is your mind, which creates the image of a viewed external, extended world—this perceived world is not what the "real external world" "looks like."

Humans and other organisms are capable of acting proportionally to what is sensed. In other words, they can judge how long they should do certain activities, how far to travel, how far to turn, etc. Johannes Kepler assembled an exhaustive study of all the constructable visual and auditory proportions in his *World Harmonics* of 1618.[3] He put this work together, after having followed up his initial study of the Solar System (presented in his *Mysterium Cosmographicum*[4]), with the identification of the key parameters of planetary orbits, by focusing on Mars and the Earth.[5] Kepler's goal, right from the start, which he most fully expressed in the *World Harmonics*, was to show that the universe functions on the basis of a pre-established harmony, and that it was composed with the mind of Man, in mind. In other words, Man's mind can comprehend how and why the Creator created the universe in the way that it was, because the universe was designed to be thus comprehended.

Kepler places the motive faculty within the powers of reason, which he bestows only on Man and God. Man recognizes the proportionality, and then decides on appropriate action. Since other organisms also act according to reason, yet do not possess the faculty of reason themselves, Kepler hypothesized an agent to mediate between them and God, which he called "Sublunary Nature"—a soul for the Earth.[6] Specifically,

2. Lyndon H. LaRouche, Jr., "An Election's Terrible After-Taste: The Global Crisis Now at Hand," *EIR*, Jan. 7, 2011. Also at http://www.larouchepac.com/node/16929

3. Johannes Kepler, *Harmonices Mundi*, 1619. English translation: *The Harmony of the World by Johannes Kepler*, trans. by E.J. Aiton, A.M. Duncan, and J.V. Field (Philadelphia: American Philosophical Society, 1997).

4. Johannes Kepler, *Mysterium Cosmographicum*, 1595. English translation: *Mysterium Cosmographicum—The Secret of the Universe*, trans. by A.M. Duncan (New York: Abaris Books, 1981).

5. Johannes Kepler, *Nova Astronomica*, 1609. English translation: *New Astronomy*, trans. by W.H. Donahue (Cambridge, U.K.: Cambridge University Press, 1992).

6. It should be noted, that Bernhard Riemann addressed this same issue when he was still a student. In his writings on *Geistesmassen* (roughly translated as "thought objects"), he referred to the Earth Soul, which uses plants as a form of sense-perception, and can act on the basis of such perceptions.

Sublunary Nature can perceive the apparent angles between the lines of sight to the other planets in the system, including the Moon and Sun, and determine how to react to them. Kepler is careful to make clear, that the perception itself is not what *causes* such reactions. In no way is the emanation from the sense object the direct cause of any action of any organism, including Man. That action is on account of the perceived proportionality, which itself bears no motive force.

Kepler discovered, based on knowable and constructable congruences between the plane figures, which angles, or "aspects," should be more or less influential on Sublunary Nature. For example, opposition and conjunction between two bodies (both equal two right angles, or 180°) are the most influential, while one right angle between lines-of-sight will be somewhat less influential. Most of the apparent angles between any two bodies will not coincide with any influential aspects, which is why Sublunary Nature will ignore them. But, when it perceives the passing of influential aspects, Sublunary Nature acts accordingly, through its organs, including weather systems, volcanic and seismic activity, the tides—and living organisms.[7] What must be added to this, is that complete cycles exist for each aspect, such as from one conjunction to the next, which are the temporal representation of such influences. This will figure in to the regular biological cycles.

Let's apply Vernadsky's three-phase-space criteria. What should be the difference between the responses of humans, and the other organisms on Earth? The responses of organisms should appear novel and creative overall, but should show relatively little variation over members of one species. Humans, on the other hand, should be able to individually change their responses to the aspects, within certain limits. For example, although it exacts a toll on the biological system, humans are capable of performing shift-work. No fruit fly can independently decide to go on night shift, while the others still work days, and vice versa, although the insect can be trained, by humans, to shift its sleep cycle. Humans can decide to act contrary to any of their sense perceptions, although many do not.

In addition, as LaRouche has been trying to tell you, over and over,[8] humans have the ability to recognize that what they think they are perceiving, represents shadows of what they are not seeing, and then, they can respond to the causes of the shadows instead, again, through their own volition.

As will become clear in the examples that follow, organisms typically function in rhythmic cycles which correspond to periods determined by the relative angular positions of the planets in the Solar System, and other relations outside of the system, on galactic and intergalactic scales. Thus, it should be reasonable to hunt for sense faculties within organisms that can respond to appropriate signals from the Earth, which are generated in response to those larger and deeper systems. But, it should not be assumed that those sense functions work the way a physics textbook would imply.

Biological Rhythms

First, let us survey the phenomena of biological rhythms, and then examine how they work in relation to the cosmic sensorium.

Most of the biological cycles studied are about 24 hours in length, and are thus called circadian (from the Latin *circa*, around; and *dian*, a day). This includes wake-sleep cycles, sometimes measured as "locomotor activity" in animals. A rhythm found typically in shore creatures, is a twice-daily cycle associated with the daily tides, and thus, half the lunar day. Longer cycles on the order of a lunar month also exist, such as the average human female menstrual cycle.[9] Even longer cycles, on the order of a Solar year, are seen in the hibernation activities of many organisms ("diapause"), the de-greening and loss of leaves on deciduous trees,

7. Riemann thought that the Earth Soul had, as sense organs, each species of plant in a given region. Based on what was sensed, through these plants, as the conditions of the atmosphere and land, the Earth Soul could decide what to do next, regarding the evolution of life on its surface.

8. Lyndon H. LaRouche, Jr. "A Wedding Anniversary: The Sixth Sense," *EIR*, Jan. 14, 2011.

9. In order to clear some things up: The human female menstrual cycle has a period which varies among women from several days to several months. The average span of the cycle, though, is about 29 days—approximately one lunar month. The question of whether this cycle has a connection with the Moon is complicated by widespread evidence that women who live and work together tend to begin "cycling" together. The cycle itself can also be heavily modified by hormone supplements. Overall, this should be viewed as another case where cycling is inherent in the organism, while being sensitive to external factors.

plant blooming, seasonal flu, etc. Cycles of longer period also exist, which coincide with other cosmic cycles such as the sunspot cycle.

The big question in the study of these cycles has been whether they are caused by some clock mechanism within the organism, or whether the cycles are caused by the external, typically cosmic motions with which they seem to coincide. Evidence has been found on both sides of the fence, and the question becomes somewhat paradoxical.[10] It has been found that organisms, when held in environments that block out the external cycles they appear to coincide with, go into what is called "free-run," where the period begins to deviate from the external cue.

For example, the bean plant opens and closes its leaves on a 24-hour cycle (12:12—12 hours up, 12 hours down). When placed in an environment of constant light intensity, the period will migrate to slightly longer than 24 hours. Early on in these investigations, Wilhelm Pfeffer demonstrated that bean plants grown in complete darkness do not display any cycles—the leaves just stay open. Upon shining light on the plants, though, they immediately begin their roughly 24-hour cycle. The cycles begin and continue, even if only one short period of light is given to the plant, which then lives the rest of its life in darkness.[11] Hence, the plant has the internal capacity to cycle, but responds to cues from the outside.

One problem with experiments performed in so-called constant conditions, is that the only conditions held constant are those that the experimenter assumes are acting on the organism. By definition, this does not block out unknown influences. Thus, the circadian locomotor activity of the fruit fly, which runs over 24 hours in constant light or constant dark, could be attributed to some other unaccounted for external cycle, a bit longer than 24 hours, but which has a weaker influence than the cycle of light and dark. An experiment was proposed to test this. If an organism's cycle is driven by some other external stimulus, then the phase of the cycle should be shifted, if the organism is transported, within an environment of constant conditions, to another longitude.

The results on this were contradictory. Frank Brown showed that an oyster, which responds to the twice-daily tides, if transported from the New England coast to Chicago (where there are no tides), will shift its tide-cycle to match what the tides would be in Chicago, if it had tides (**Figures 1-3**).[12] This would imply an external agent.

On the other hand, another scientist, Max Renner, trained bees in constant conditions to get food at a specific time of day in Paris. If the time-sense were given by external cues, then transporting the bees (holding all other conditions constant) to New York should shift the time at which they hunt for food. Exactly the contrary was shown: They kept coming out exactly 24 hours after their feeding time in Paris, day after day. When the same experiment was done, but the bees could see the daily motions of the Sun, they responded to both their 24-hour "internal clock," and to the local time.[13] Hence, Renner's experiments showed that there is some combination of internal and external timings.

One wrench thrown into the gears of all studies, is the fact that the cycles appear, across all organisms, to be independent of temperature. In other words, if an organism, whose temperature is not internally regulated, is cooled down, all of its vital functions tend to slow down, and vice versa, if it is warmed up. If the "clock" were an internal organ or mechanism, then it, too, should speed up or slow down with temperature. Brown,[14] Colin Pittendrigh,[15] and others demonstrated that all organisms were virtually immune, with respect to their rhythms, to changes of temperature. Brown went so far as to take fiddler crabs, whose skin color changes on a daily cycle, and lower their body tempera-

10. Frank A. Brown, "Living Clocks," *Science*, New Series, Vol. 130, No. 3388, pp. 1,535-1,544 (1959).

11. Pfeffer found that he could also use light to force the plants into periods longer or shorter than 24 hours, by alternating light and dark. Antonia Kleinhoonte went further with this experiment, and demonstrated that, if the periods go outside the bounds of 8:8 or 15:15, then the plant would "rebel," and snap back into a roughly 12:12 cycle again.

12. Ibid.

13. Max Renner, "The Contribution of the Honey Bee to the Study of Time-Sense and Astronomical Orientation," *Proceedings*, Cold Spring Harbor symposia on quantitative biologyORPHAN }, Vol. 25, pp. 361-367 (1960).

14. F. Brown and M. Webb, "Temperature Relations of an Endogenous Daily Rhythmicity in the Fiddler Crab, Uca," Physiological Zoology, Vol. 21, No. 4, pp. 371-381 (1948).

15. Colin Pittendrigh, "On Temperature Independence in the Clock System Controlling Emergence Time in Drosophila," *Proceedings of the National Academy of Sciences*, Vol. 40, No. 10, pp. 1,018-1,029 (1954).

FIGURE 1
Oysters in New Haven Harbor

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FIGURE 2
Oyster, Newly Arrived in Illinois

LPAC-TV, "The Extraterrestrial Imperative, Part 2," http://www.larouchepac.com/node/16049

FIGURE 3
Oyster in Illinois, Two Weeks Later

LPAC-TV, "The Extraterrestrial Imperative, Part 2," http://www.larouchepac.com/node/16049

ture to freezing, to demonstrate that the cycle remained circadian, although the intensity of color change became fainter and fainter up to death. Thus, either there is still some external driver, or the internal mechanism has a seemingly miraculous way to regulate speed with temperature.

As will be explored in more detail below, one factor in biological rhythms is that organisms respond to very weak magnetic and electric fields. For example, Jürgen Aschoff and Rütger Wever converted two wartime fallout shelters into apartments that gave absolutely no cues as to the time of day. They even went so far as to deliver food and messages via a type of air-lock, to prevent the subjects from having any contact with people from the outside. One of the apartments was shielded from all outside electromagnetic fields, and was equipped to supply artificial oscillating electric fields of low intensity, while the other had no EM shielding. In all cases, the basal temperature oscillations of the experimental subjects free-ran to about 25-hour intervals, as did the sleep schedule. In some of the subjects, though, the sleep schedule became massively decoupled from the temperature oscillations, heading upwards of 50-hour sleep-wake cycles, while the temperature remained on the same circadian clock.

All of the subjects in which decoupling was observed lived in the apartment shielded from all EM fields.[16] Once an electric field was supplied at low intensity (2.5 V/m; the subjects could not feel it consciously), but oscillating at 10 Hz, the sleep schedules immediately snapped back in line with the circadian temperature cycles. None of the test subjects sensed any difference.[17]

16. Rütger Wever, "Human Circadian Rhythms Under the Influence of Weak Electric Fields and the Different Aspects of These Studies," *International Journal of Biometeorology*, Vol. 17, No. 3, pp. 227-232 (1973).

17. All of the test subjects, including those who experienced the 50-hour "days," ate regular meals, three times during their subjective days. It is apparently a common misconception that you get hungry around lunchtime, simply because you've "worked off" your breakfast. It is a

These are just a sampling of experiments that have been done, to give some flavor of the problem. The wrong question would be, "Well, are the cycles driven by an internal clock, or by the cosmos?!" Kepler already demonstrated that there must be some close interconnection between distant, cosmic processes and those of life here on Earth. Review of the paradoxes of the inherent cycles of biology confirms this: that there is something within the organism that can respond according to the cyclic aspects, which means that there must be a cyclic potential within the organism. Both the "external cues" and the supposed internal clock system should be seen as, essentially, external, in that neither is the cause of the cycles. Both cyclic systems (geophysical/cosmic vs. biological) are connected, but not necessarily in a causal relationship. While the cause itself remains unknown, it should be sought through the method that Kepler used in his life's work, the method of *harmonics*.

For another clue in the puzzle, we will now see that the response to cosmic cyclic variations is inherently tied also to the spatial orientation of organisms. In other words, we are, yet again, tapping into the study of physical space-time, which Vernadsky emphasized, held the secret of the distinction between life and non-life.

Let's dig deeper into this aspect.

Cryptic Chemistry

As was seen in the case of bird migration, it is clear that birds somehow sense the geomagnetic field, and that this sense is intimately connected with their sense of vision.[18] Specifically, it was seen that, when their eyes were prevented from receiving blue light, young birds would lose their ability to navigate. Thorsten Ritz and Kurt Schulten proposed that some chemical could be involved that becomes magnetically sensitive after activation by the blue light.[19] The chemical they proposed had already been located in plants, and called cryptochrome.

Plants can be grown in complete darkness. When a sprout begins from a seed, that sprout has to make its way up through the dirt, and then the ground cover of leaves and other things, before it finally reaches sunlight. Plants have a distinct mode of operation under these conditions, called "etiolation," which includes growing longer, thinner stems (the hypocotyl), with smaller leaves (cotyledons) spaced further apart and deficient in chlorophyll. When the sprout finally reaches light, it stops the rapid lengthening of the hypocotyl, pops out new leaves that are closer together, and begins to turn green from chlorophyll. This is called "de-etiolation," or just "greening."

It was found that de-etiolation doesn't require the entire spectrum of light. Normal plants will turn green under either blue or red light, or both. Scientists believed that this meant there were two pathways, initiated by two distinct sets of photoreceptors, that led to the same result. The photoreceptors for the red-light response were found and called phytochromes. The blue-light photoreceptors were apparently more difficult to hunt down, and were thus called cryptochromes. Using the model genetic plant,[20] *Arabidopsis thaliana* (thale cress), scientists were able to isolate a strain that was immune to blue light—i.e., they would only de-etiolate under red light, not blue.

In 1993, Margaret Ahmad and A. Cashmore identified the section of DNA that differed between one of these blue-immune strains, and normal *Arabidopsis*.[21] They found that the protein that corresponds to this DNA section bore a strong resemblance to a protein called photolyase, which can be induced to repair ultraviolet-damaged DNA, but only after being activated by violet/UV light.[22] They argued that they had found the

circadian timing! The 50-hour subjects spaced their meals proportionally throughout their subjective day, which meant they would have breakfast around the same time as you would, but would start feeling lunch-pangs around the time after you had already completed your dinner!

18. See the report on bird magnetoreception by Ben Deniston, elsewhere in this issue.

19. T. Ritz, S. Adem, K. Schulten, "A Model for Photoreceptor-based Magnetoreception in Birds," *Biophysical Journal*, Vol. 78, pp. 707-718 (2000).

20. The term "model organism" is a bit of a misnomer. On the face of it, it refers to an organism chosen to be the standard, upon which scientists around the world will perform and report on experiments. The organisms are usually extraordinary in some way, which makes them amenable to experimentation—such as the extremely rapid reproduction of *Drosophila melanogaster*—and are thus not exemplars of the rest of the living world. Each organism is a whole, and not assembled out of pieces from model organisms.

21. M. Ahmad and A. Cashmore, "Seeing Blue: the Discovery of Cryptochrome," *Plant Molecular Biology*, Vol. 30, pp. 851-861 (1996).

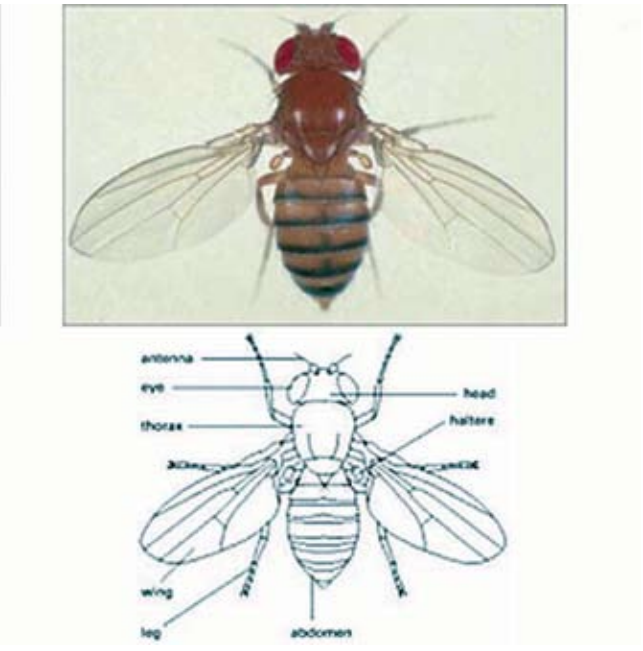
22. It is interesting to allow the mind to veer here, for a moment. Photolyase and its relative, cryptochrome, appear to be ancient chemicals. They are both present in just about every organism studied. If photolyase goes all the way back to before the existence of the ozone layer, before the Great Oxygenation Event, then it was "repairing" DNA when there was nothing to prevent Solar and other ultraviolet radiation from

Arabidopsis thaliana

elusive cryptochrome pigment's gene, which was then found in many other organisms.

In a fascinating 2007 experiment, Ahmad and others tested the hypothesis that cryptochrome was related to the magnetic sense of birds.[23] They took the two strains of *Arabidopsis*, wild-type and cryptochrome-deficient (blue-immune), and tested for response to a magnetic field. Both plants exhibited a little greening under only dim red light, but only the wild-type showed greening under dim blue light (as was expected). Then, they turned on a 5 Gauss magnetic field,[24] aligned with the local geomagnetic field. The plants under red light showed no extra response, and developed as before, while the wild type under dim blue light became greener at a faster rate. The cryptochrome-deficient plant still showed no greening under blue light and the magnetic field. The researchers concluded that cryptochrome was, indeed, part of some mechanism that responded to magnetic fields, but only when activated by blue light.

Two other experiments were performed on the fruit fly, *Drosophila melanogaster*, the model genetic



Drosophila melanogaster

insect. Cryptochrome had already been found in a variety of insects and other animals, and was present within the eyes of the fruit fly. In 2008, Robert Gegear and others used the fruit fly to test whether cryptochrome was, indeed, a magneto-sensitive photoreceptor.[25] They trained a number of fruit flies to associate food with a 5 Gauss magnetic field. They provided a travel tube for the flies, one end of which had a 5 Gauss magnetic field, the other end being magnetically neutral, and watched which direction the flies would travel. As expected, most traveled in the direction of the magnetic field. When they put a filter in front of the light source, which cut out all light bluer than 420 nanometers (nm), the fruit flies lost their sensitivity to the magnetic field, which seemed to imply that the flies were, indeed, relying on some kind of signal from their cryptochrome system. When the researchers

reaching the ground. The point is that repairing DNA and constructing are very similar, and both, through photolyase, act through various parts of the ultraviolet band. The existence of a chemical that has the capability of repairing DNA, when acted on by a form of cosmic radiation, becomes a very provocative vector in the process of evolution via cosmic radiation.

23. M. Ahmad, P. Galland, T. Ritz, R. Wiltschko, W. Wiltschko, "Magnetic Intensity Affects Cryptochrome-Dependent Responses in Arabidopsis thaliana," *Planta*, Vol. 225, pp. 615-624 (2007).

24. Ahmad and others typically measure magnetic field strength in either micro-Teslas (μT) or Gauss. One hundred μT equals 1 Gauss. The geomagnetic field averages about 0.3-0.5 Gauss, which equals 30-50 μT. Therefore, Ahmad's experimental magnetic field was about ten times the background geomagnetic field.

25. R. Gegear, A. Casselman, S. Waddell, S. Reppert, "CRYPTOCHROME Mediates Light-Dependent Magnetosensitivity, *Nature*, Vol. 454, pp. 1,014-1,028 (2008).

tested fruit flies bred to be cryptochrome deficient, they found that these flies could not be trained to respond to the magnetic field, even when they got full-spectrum light.

In another experiment on the fruit fly, performed in 2009, Tiashi Yoshii, Margaret Ahmad, and Charlotte Helfrich-Förster tested whether the magnetic effect could carry over to biological rhythms, too.[26] The locomotor activity of the fruit fly cycles between moving and standing still over a circadian period, which, under conditions of constant light or dark, will extend to a little over 25 hours. Jürgen Aschoff had shown that increasing the intensity of constant light will extend the waking periods of the flies, until a certain maximum is reached, at which point the flies go arrhythmic, and that this effect could also be produced with just blue light. Hence, by increasing the intensity of constant blue light, the waking period for the fruit fly will extend to arrhythmia.

Yoshii et al. used wild-type fruit flies, and also *Drosophila* mutants that were bred without cryptochrome, and created a chamber that could immerse them in either red or blue light of such weak intensity, that their waking periods were only a little longer than if they were in constant dark conditions. As expected, the fruit flies deficient in cryptochrome acted as if they were still in constant darkness when the blue light was turned on, although all flies responded normally to the red light. Then, they nailed the flies with 1.5, 3, and then 5 Gauss magnetic fields (3, 6, and 10 times the geomagnetic field, respectively), aligned with the local geomagnetic field. Under red light, nothing special happened, while under blue light, the wild-type flies stayed awake even longer, while the cryptochrome-lacking flies went back to sleep. In the flies affected by the field, the periods also got longer, the stronger the magnetic field.

These experiments demonstrate that, whatever faculty within the organism responds to external cyclic phenomena, is intimately tied to the faculty that responds to magnetic fields and spatial orientation. Therefore, what we are dealing with is not simply a "time-sense" or a "space-sense," but something deeper, which goes to Vernadsky's space-time distinction of the biotic phase of the universe. As will be seen in the following section, this space-time characteristic extends into other, and perhaps all, aspects of cosmic radiation and behavior.

But, first, now is the time for adding an important disclaimer, because of how scientists tend to discuss this class of phenomena. "Cryptochrome" is the name for a correlation found within plants—plants that don't turn green properly under blue light were found to also lack a section of DNA which corresponds to a complete protein, which happens to have some similarities to the protein photolyase. Matching DNA sections have been found in other organisms, such as *Drosophila* and birds, and have been associated with navigating according to the magnetic field.

As has become typical, yet not quite responsible, the discovery of a physical object was then announced and given the name cryptochrome. Does this object really exist as such? The protein that corresponds to this system was then mass-produced, crystallized, and the "molecular structure" was then "solved" through typical techniques of X-ray crystallography. Several aspects of the molecular structure suggested similarities to other chemicals, with similar molecular structure, which were associated with magnetic effects after being activated by electromagnetic radiation—so-called "spin chemistry" effects. Then, experiments were performed with several organisms that displayed characteristics suggesting the presence of the physical cryptochrome molecule within them.

Cryptochrome should be taken as a type of code word for the phenomena described through these experiments, not the causative factor. It is a danger for conclusions to be drawn on the basis of theories of spin chemistry and the crystal structure of cryptochrome; the healthier route is through more experimentation from hypothesis. In these experiments with organisms, it is clear that there is a phenomenon that has been caught between electromagnetic radiation, on the one side, and magnetic fields on the other. To assume that the cause lies somewhere in the strange, ad hoc hypothesis about the spin of an electron, is backwards. It were more honest to assume that we don't yet know what is happening on the molecular level in these creatures, since there may not, actually, be a molecular level here.

The effects are organism-wide effects. The phenom-

26. T. Yoshii, M. Ahmad, C. Helfrich-Förste, "Cryptochrome Mediates Light-Dependent Magnetosensitivity of Drosophila's Circadian Clock," *PloS Biology*, 7(4): e1000086. doi:10.1371/journal.pbio.1000086 (2009).

enon called "spin" really does exist—there are clear chemical and atomic properties that are related in an ordered way to magnetic fields. But, that the ordered array of experimental results are solved by enumerating them, and attributing them to a particle's rotation, and then asserting the rotation of that particle to be the cause of the results, is not good science. Hypotheses that solve what "spin" was supposed to address should come from what must be necessary, in order to fulfill the properties observed in life.

Unknown Radiations?

Let us look at another series of experiments, which aim at the discovery of new principles, while laying open the space-time character of life.

Frank Brown and his collaborators built an apparatus to measure the metabolic cycles of a variety of organisms. The apparatus consisted of a big Erlenmeyer flask, into the which the subject organism could be placed. The flask could then be closed, and the oxygen input and output measured via chemical reactions within another vessel, connected by a tube. The changes would then be translated into the mechanical motions of a pen on a rotating drum of paper.

The apparatus was also designed to be able to maintain constant levels of illumination, pressure, and temperature within the flask. The researchers measured the oxygen consumption from a potato, for example, for several months under constant conditions, and found that the potato retained its response to atmospheric pressure, even though it was shielded from any variations in pressure: Its oxygen consumption went up when the pressure outside the chamber rose, and vice versa (**Figures 4-5**). There was not just a response to pressure, but the response also appeared to correlate with pressure events that occurred, on average, two days into the future.[27]

To be precise, Brown noted that local pressure variations are largely affected by local weather shifts.

FIGURE 4
Study of the Potato's Metabolic Rate

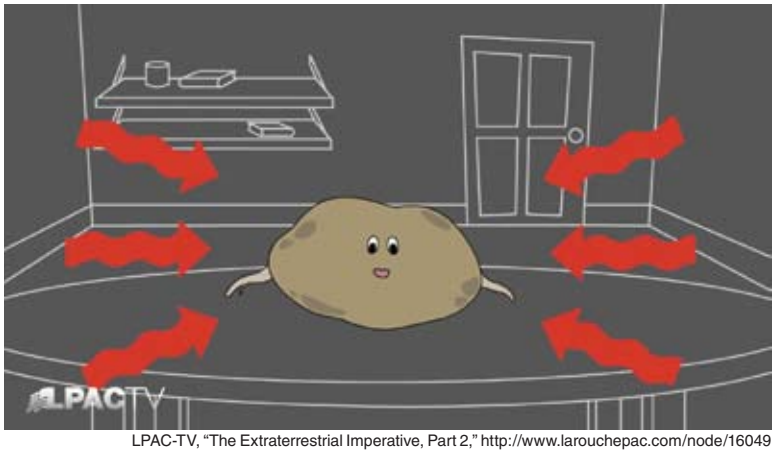


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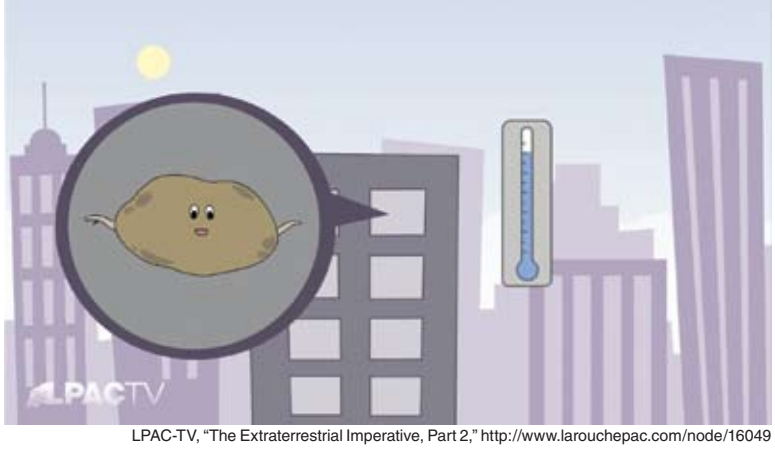
FIGURE 5
Potato's Metabolism Varies with Barometric Pressure



LPAC-TV, "The Extraterrestrial Imperative, Part 2," http://www.larouchepac.com/node/16049

The potato did not respond, minute to minute, to these changes. But, if the metabolic response of the organism was measured from about 4-7:00 a.m. every day, those changes would correlate with the average pressure over a three-day period, usually centered on two days into the future. Since Brown knew that this seemed pretty outlandish, he repeated the experiment with almost a dozen other unrelated organisms. Each one demonstrated the same ability to "forecast" what the average temperature would be sometime in the future. The rat demonstrated the best ability, correlating with an astounding seven days into the future. In other words, the rat's metabolic changes were virtually identical with three-day averages of the outside

27. F. Brown, H.M. Webb, E. Macey, "Lag-Lead Correlations of Barometric Pressure and Biological Activity," *Biological Bulletin*, Vol. 113, No. 1, pp. 112-119 (1957).

barometric pressure, centered on seven days ahead.

Brown did not know what the potatoes, or the other organisms, could be responding to, since the cycles were not purely circadian or lunar, and therefore not endogenous, yet the potatoes were being held in pressure-constant chambers. And, it couldn't be simply an annual cycle, because the responses at corresponding months over two years were inverted. In other words, in May 1955, O_2 consumption went up around 6:00 a.m., but in May 1956, O_2 consumption went down at the same time. What accounted for this pattern? He and his collaborators recognized that the cycles appeared to coincide with an unlikely cosmic cycle—the ebbs and flows of cosmic-ray flux into the Earth's atmosphere.[28]

Brown was cautious here, though. He did not say that the cosmic rays were causing the pattern in the potatoes and other organisms, but that they coincided. Perhaps, what was causing the fluctuation in the potatoes was also causing the fluctuation in cosmic rays. He proposed that variations in the geomagnetic field could account for some of what was observed, since cosmic-ray flux is mediated in part by such changes. It should be that cosmic-ray flux is affected by many things, including the activity of sunspots, the Solar wind, and other galactic phenomena, with the Sun's activity appearing to dominate.

Brown embarked on a series of experiments to determine whether organisms can sense weak magnetic and electric fields.[29] Remember that this was in 1960, before magnetonavigation had been demonstrated! Brown placed a variety of organisms into special corrals, such that they could begin traveling in a specified compass direction, but then be free to turn in any direction after exiting the corral. Brown could then measure the direction of turn. His apparatus could also be equipped with an electrostatic field, oriented at right angles to the corral path, and with a magnet that could be oriented however he wished, within the plane of travel of the organism. Over a period of more than a year, he tested several organisms, from the paramecium up to the snail, in all four compass directions, and found definite patterns that varied over time, and could be modified with the artificial electric and magnetic fields.

His results proved, conclusively, that all organisms tested were quite sensitive to both weak magnetic and

Planarian

weak electrostatic fields, but that their response to the fields depended on the time of year. For example, if a planarian is initially oriented north during the late morning, between September and March, it will turn left around new Moon, and right near full Moon. During March and April, however, the response becomes somewhat random, and by the end of April, the planarian begins turning right around new Moon, and left near full Moon. This persists until about July, when the patterns become somewhat random again, and reverses by September. Brown showed that he could easily alter these results with very weak (0.17-4 Gauss), artificial magnetic fields. At the same time, the pattern goes through about a 360° oscillation during a 24-hour period.

What this means, is not just that organisms are sensitive to magnetic fields. It also means that the magnetic field interacts not only with the sense of direction for the organisms, but also with the clock-sense. Recall the experiments of Aschoff and Wever, where removing the influence of all known magnetic and electric fields radically changed the sleep-timings of the subjects, but that creating a varying magnetic field immediately put them back on circadian rhythms. Hence, we are dealing with a space-time phenomenon in organisms, not simply time or orientation.

At issue here are both the space-time organization of life, and the potential that organisms, already demonstrated to be extremely sensitive to very weak fields, are responding to as-yet-unknown radiations, or un-

28. F. Brown, "Response of a Living Organism, under 'Constant Conditions' Including Pressure, to a Barometric-Pressure-Correlated, Cyclic, External Variable," *Biological Bulletin*, Vol. 112, No. 3, pp. 288-304 (1957).

29. F. Brown, "Response of the Planarian, Dugesia, to Very Weak Horizontal Electrostatic Fields," *Biological Bulletin*, Vol. 123, No. 2, pp. 282-294 (1962).

known aspects of already recognized fields. Thus, it should be very likely that oscillations in motion, and timings within organisms, would coincide with things like cosmic-ray flux, which also is very sensitive to changes in the geomagnetic and interplanetary magnetic fields.

Brown went further, and showed that organisms also respond to the influence of gamma radiation. Here again, an extremely weak source of radiation was used (~6 times the background radiation), which cannot be construed to be "hurting" the organism (no animals were harmed in the experiments). Brown tested the organisms with his special corral, placing the gamma source first on their right side, then on their left side, to see how they would orient with respect to it. He found that, when initially oriented towards the north or west, the organisms would turn away from the gamma source, while if initially oriented south or east, they would turn toward the source. These responses also exhibited daily and monthly periodic variations.

Again, a response to extremely weak radiation, which is exhibited not only in spatial orientation relative to the weak geomagnetic field, but also temporal oscillations on the order of one Solar day and one lunar month.

What can be concluded from this series of experiments? From Brown:

> The primary value of this study lies in its description of some of the intricacy of the organism's relationship to its subtle environment. The study provides further experimental evidence for an almost incredible "time-space organization" of terrestrial creatures. Within the organism it seems probable that the mechanisms of the biological clocks and compasses merge into a single functional system.[30]

All of these phenomena demonstrate the high sensitivity to very weak fields, in both direction and intensity, of a variety of organisms. Only a limited number of radiations have been tested, which leaves open, and in fact demands, that the organism be sensitive to numerous other cues in the environment.

30. F. Brown, H.M. Webb, "Some Temporal and Geographic Relations of Snail Response to Very Weak Gamma Radiation," *Physiological Zoology*, Vol. 41, No. 4, pp. 385-400 (1968).

The Space-Time of Life

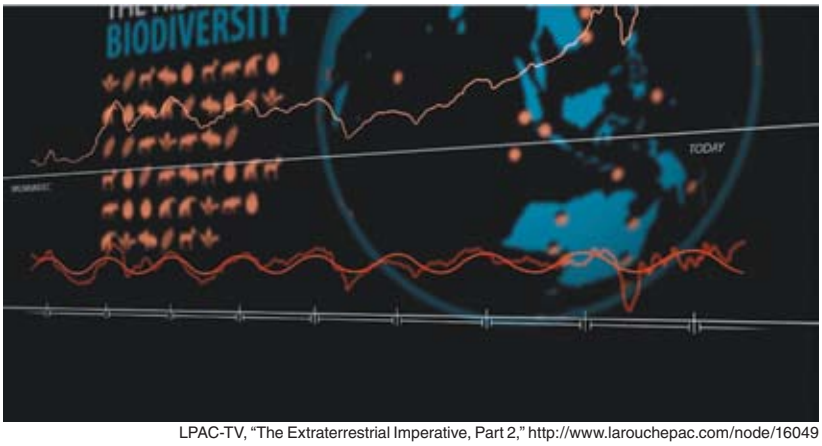
Another way to look at this, is that life in the Biosphere is not separate from its radiative environment. Instead, the Biosphere should be thought of as a "filled space-time." If organisms can sense and respond to very weak fields, such as less than half the geomagnetic field of 0.3-0.5 Gauss, or as little as 6 times the background gamma radiation, then we are awash in a sea of influential radiations from numerous sources.[31] Considering that these radiations apparently govern the majority of not only basic biological timings, but also spatial motions and orientations of organisms, these incredibly weak radiation fields are also incredibly well structured, such that animals such as pigeons and monarch butterflies are able to migrate, accurately and on time.

Recall how Kepler thought. In his world, the rays of light from the planets, intersecting at the Earth to form the aspects, carry absolutely no motive force within them. It is through a process of reason, while regarding those aspects, that corresponding actions within life occur. Discard any notion that organisms are being pushed or pulled by radiations, including gravitation. Response occurs in a non-kinetic fashion. The organisms on the Earth, the geological and atmospheric motions, and cycles of the cosmos, exist within an harmonic universe. Organisms act in correspondence with those other processes through the medium of harmony, not through a thermodynamic, ricochet accident.

This also opens up another area of research, already referenced elsewhere in this report: the long-term development of life on the planet, as related to long-term cycles of changes in geological activity, climate, atmospheric composition, geomagnetic field strength and orientation, radioactive decay rates, cosmic-ray flux, changes within the Solar System and the Sun, the motion of the Solar System through the Milky Way galaxy, and the changing relationships between our galaxy, the local group, and local supercluster of intergalactic space-time. As has already been noted, there is a marked cycle of biodiversity of about

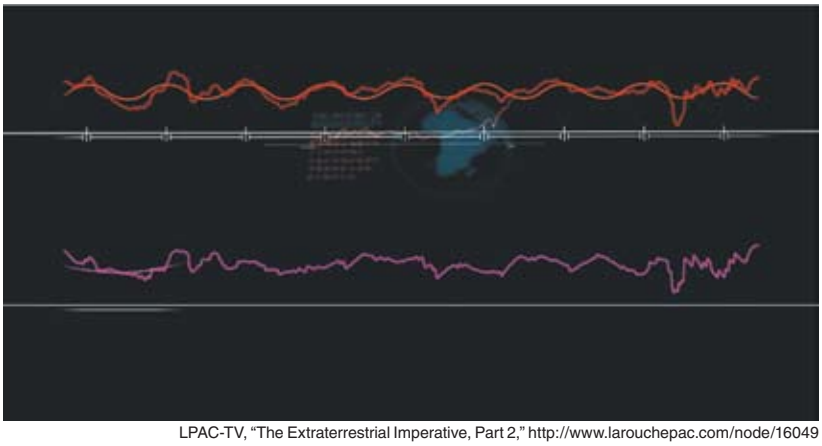
31. Recently, scientists working with NASA's Fermi Gamma-Ray Space Telescope, have detected flashes of gamma-rays produced by terrestrial thunderstorms, which apparently generate streams of antimatter. They estimate that at least 500 terrestrial gamma-ray flashes occur per day, worldwide. http://www.nasa.gov/mission_pages/GLAST/news/fermi-thunderstorms.html

FIGURE 6
Long-Wave Patterns of Biodiversity



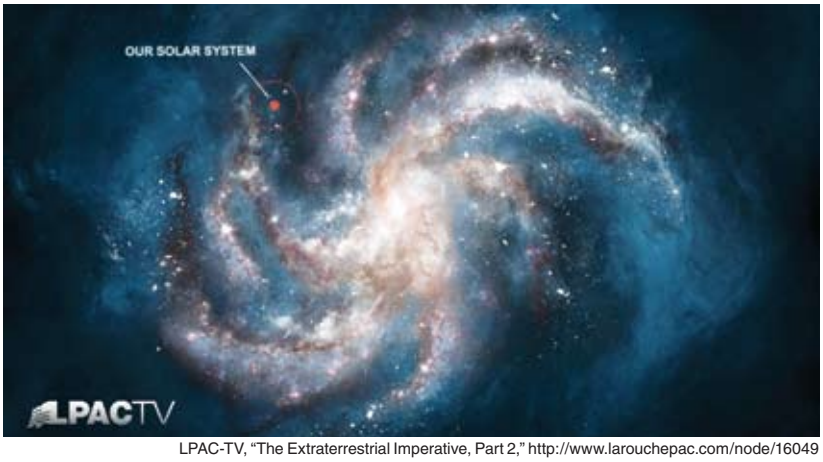
LPAC-TV, "The Extraterrestrial Imperative, Part 2," http://www.larouchepac.com/node/16049

FIGURE 7
Biodiversity: Long and Even Longer Waves
(Top, 62-Million-Year Cycle; Bottom, 140-Million-Year Cycle)



LPAC-TV, "The Extraterrestrial Imperative, Part 2," http://www.larouchepac.com/node/16049

FIGURE 8
Our Solar System Travels Through the Galaxy



LPAC-TV, "The Extraterrestrial Imperative, Part 2," http://www.larouchepac.com/node/16049

62 million years on this planet (**Figures 6-8**).[32] The emergence of recognizably human cognition appeared roughly 62 million years after the last great transformation of the Biosphere's life (the "K-T Extinction"). This cycle of changes includes shorter cycles that have similar relations to biospheric changes, such as the periodic magnetic pole reversals.

The apparently much shorter cycles of biological rhythms reviewed here are properly recognized as subsumed aspects of much longer cycles. Responsible scientists involved with studies related to what has just been described, will be open to the discovery of new types of cosmic radiations, but also new properties of known radiations.

For just a small example: If organisms are so sensitive, in such a quantized space-time manner, to radioactive decay radiations, would such a sensitive dependence be observable in the fossil record? If so, would such an observation establish variable rates of decay, over long periods of time? If so, since recent studies have suggested that decay rates have some dependence on distance to the Sun, would long-observations through such a fossil telescope reveal echoes of ancient interplanetary perturbations, including perhaps dating the explosion of the missing planet between Mars and Jupiter?[33]

On the other hand, introducing Man onto the stage of space travel opens yet another possibility, which demands yet more study of the relation between the long and short biological cycles. Soon, after construction of the North American Water and Power Alliance (NAWAPA) has become a reality, we

32. LaRouchePAC video, "The Extraterrestrial Imperative, Part 2," at http://www.larouchepac.com/node/16049. Transcript in *EIR*, Oct. 41, 2010, p. 5.

33. See video, "Decay Rates and Time," at http://www.larouchepac.com/node/16224

will begin moving masses of people into both Arctic and Antarctic regions. Both of these areas will become robust biological research laboratories, certainly because of the unique radiative environments, but also because of the long periods of constant daylight.[34]

Let us keep in mind that NAWAPA, as LaRouche has discussed it, is the true launchpad back into space. We are already in a position to observe the effects on organisms in our orbiting International Space Station, of rapid travel through our magnetosphere, and of exposure to cosmic radiation impossible to synthesize on the Earth's surface. Once we take the Biosphere with us, once again to the Moon, and then beyond the lunar orbit, we will enter a domain that is apparently free of the typical diurnal, lunar, and annual cycles. How will organisms respond to such conditions? Up to now, we have only been able to shield organisms from known forms of radiation, but we are still prisoner to other radiations that exist for the orbiting Earth. From deep in interplanetary space, we will not only be able to create novel radiative conditions, but also be in a position to delve deeper into how organisms interact with the cosmos, and vice versa.

For example, from the perspective of a colony of NAWAPA-graduated scientists and engineers on the surface of Mars, the typical Martian day is closer to what has been observed as the terrestrial "free-run" of the human daily sleep cycle, around 24.5 hours. However, the Solar year will be almost twice as long; the two tiny moons orbit the planet within a day; and there is only a faint signature of an apparently fossil magnetic field. How will the persistent rhythms of organisms respond to such cues? Will we find that some of what we had considered purely terrestrial cues, are actually not bound to the Earth's regular periods? We will certainly discover more about how the biological timings and motions function, and perhaps discover new forms of cosmic radiation, which will in turn enrich our understanding of how life functions as an integral part of our intergalactic system.

34. See Sky Shields, "Unheard Melodies: Electric and Magnetic Senses in Humans," in this issue, for more on the radiative environment of the Arctic. Also, watch the LaRouchePAC video "The Extended NAWAPA, Arctic Development," at http://www.larouchepac.com/infrastructure

Polarization Sensitivity

A Strong and Weak Sense

by Meghan Rouillard

Bows and Bees

Our eyes are able to distinguish polarized from non-polarized light[1] only very faintly without the aid of other visual devices. When visible, this appears as a small yellow and blue bowtie image in the center of the visual field, called Haidinger's brush—try staring at the white screen of your laptop, while tilting your head slowly to the side, to see it. Otherwise, our eyes require polarized filters to distinguish it. That is not to say that we don't see polarized light without them; we just typically don't see it as something that stands out against light that is not polarized. We will return to the human biological polarization sense later, but for now, let us compare the first known cases of human and animal navigation using polarized light.

Many years ago, it is thought that the Vikings used a crystalline "sunstone" to determine the location of the Sun on very cloudy days, for navigational purposes. Crystals are known to polarize light, and to produced polarized light of different colors. Surely this could have been used to infer the position of a light source, but it is thought that certain kinds of crystals, such as quartz, tourmaline, or cordeirite, which could have served the purpose of a sunstone, could also have indicated the angle of incoming sunlight through changing color and brightness, to perhaps indicate the position of the Sun, even indirectly, through polarized sunlight patterns in the sky.[2]

Animals have been found to operate based on a similar principle, though, of course, they do not use crystals as supplemental instruments. The capability to dis-

1. See accompanying piece by Jason Ross, "What Is Circularly Polarized Light?" Also see video, Louis Pasteur: the Science of Life," http://www.larouchepac.com/node/13732

2. http://www.livescience.com/history/070302_viking_navigation.html or http://www.polarization.com, a very useful website for this and other references from this report.

Courtesy of J. Tautz and M. Kleinhenz, Beegroup Wurzburg

LPAC/Chris Jadatz

The honeybees' waggle waggle dance. In the diagram, s indicates the time during which the waggle part of the dance takes place, and the distance to the food source. The angle alpha, an angle on the honeycombs between the vertical direction and the waggle part of the dance, indicates the angle between the Sun's position and the direction of flight to be taken. Another variation of the dance occurs when it is done on a horizontal plane, but the orientation towards the Sun is still necessary.

tinguish polarized light by some birds, insects,[3] and a few sea creatures, is more developed than our own. Early in this study, the polarization sense was surmised to be used by bees, which can additionally sense the Earth's magnetic field, and are known to dance based on gravitational cues, and the position of the Sun.[4] The Sun sense and the polarization sense were found to be closely related. The bees' dance, based on knowing the location of the Sun, is used to give directions to other bees, to indicate where a distant food source may lie, and they have been found to use this dance when a food source is 100 or more meters away from the hive. In this dance, the Sun's position is the key reference point. This dance is called the "waggle waggle dance" (by humans, of course).

These dances were studied by an Austrian ethologist (student of animal behavior), Karl von Frisch. He says his main discoveries were made in 1944, but were not accepted until decades later. He noticed that when he prevented the bees from seeing the Sun's light, or when they were exposed to diffuse light, their dance became disoriented, but when exposed to even only a very small portion of the blue sky, they would resume the dance as though the Sun were in view. This led him to assume that the bees were responding to the polarization of light from the Sun.[5] Here we quote von Frisch's account of his discovery in his 1973 Nobel Lecture:[6]

> There can be no doubt that the Sun's position is decisive for the direction of their dancing.... But there was one big puzzle. To prevent excessive heating during most of the experiments, a protective roof was installed over the observation hive. The dancers were unable to see the Sun. Nevertheless their dance was usually correct. Orientation by heat rays, by penetrating radiation, as well as other explanations that seemed possible had to be discarded—until I noticed

3. Polarized vision of many insects, such as dragonflies, can be deadly when they are tricked into laying their eggs on murderous solar panels, which they mistake for water because of the reflected polarized light. Let us be rid of these killer panels!

4. As Karl von Frisch said of the bees, "thus the language of the bee, which was initially brought to our attention by the physiology of sense perception ... led to general questions of orientation in time and space." See Peter Martinson, "Following the Beat of a Different Drummer," Ben Deniston, "Magnetoreception," and Oyang Teng, "Insects and Infrared," in this issue.

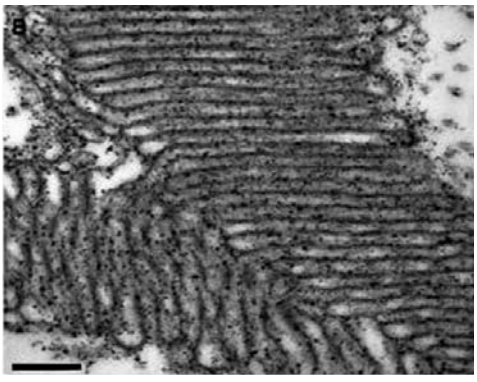
5. The polarization of the Sun's light is greatest 90° from the Sun, something you can test with polarized sunglasses. If the bee can so precisely indicate the location of the food based on this kind of reading, it is not hard to imagine that the polarization pattern seen by the bees has more resolution than this.

6. http://nobelprize.org/nobel_prizes/medicine/laureates/1973/frisch-lecture.pdf

that a view of the blue sky is the same as a view of the Sun. When clouds passed over the section of the sky visible to the bees, disoriented dances immediately resulted. Therefore they must have been able to read the Sun's position from the blue sky. The direction of vibration of polarized blue light[7] differs in relation to the Sun's position across the entire vault of the sky, thus, to one that is able to perceive the direction of vibration, even a spot of blue sky can disclose the Sun's position by its polarization patterns. Are bees endowed with this capacity?

FIGURE 1

a) *Close-up of cuttlefish eye*



Courtesy of Nadav Shashar

b) *Orthogonal microvilli*

To give further weight to the hypothesis that they were responding to polarization, Frisch performed an additional experiment :

> The following test furnished an answer. The observation hive was set horizontally in a dark tent from which the dancers had a lateral view of a small area of blue sky. They danced correctly toward the west where their feeding place was located 200m away. When a round, rotatable polarizing foil was placed over the comb in a way as not to change the direction of the vibration of the polarized light from that part of the sky, they continued to dance correctly. If, however, I turned the foil right or left, the direction of the bees' dance changed to the right or the left by corresponding angle values.

Von Frisch went on to conclude that for the bees, the sky revealed a pattern of polarized light from the Sun. He acknowledged that other creatures were known to see it, but that human beings and other vertebrates remained unendowed with this sense. We will revisit the admittedly more weak, but interesting case of the human ability to detect polarized light after exploring the visual world of some polarization-sensitive sea creatures, where this sense appears to be the most honed.

Cephalopods

The cephalopods seem to share a relatively unique capability to respond to, and to reflect, patterns of polarized light. Cephalopods, with only one kind of squid as an exception, are colorblind, but their eyes serve them well, through an enhanced ability to selectively perceive linearly polarized light. The cephalopod eye has photoreceptors and corresponding hair-like microvilli which expand their surface area, and appear to be oriented orthogonally to adjacent ones, as seen in **Figure 1b**.

The common explanation for the polarization perception in cephalopods is that, since it is said that a specific population of retinal cells would be activated by polarized light in a specific plane, it is due to the orthogonal orientation of photoreceptors in the cephalopod, as in this case there would be a high population of retinal cells oriented in two different directions. It is said that human photoreceptors are less well organized, and that we humans barely perceive polarized light because the orientation of our visual pigment cells is "semi-random." In the arthropods, and also the stomatopods which we will look at next, the visual pigments have a radial arrangement. Here is a common description of how polarized light interacts with visual

7. Von Frisch alludes to polarization in a particular color of light, an indication that the eyes' pigments themselves are contributing to the polarization sensitivity. As it turns out, bees, and many insects, perceive polarized light distinctly in the UV range. Other experiments have shown that the perception of polarized light by bees can still be somewhat efficient in a partially cloudy sky, which would support this idea. There are conflicting accounts about whether bees see polarized blue light, to which von Frisch alluded. We will further examine what this means and how it is determined a bit later in this report.

pigments, which we will show to be rather too simple:

> Visual pigment molecules are based on a single type of chromophore, whose highest absorption occurs when the molecule's dipole is aligned with the e-vector axis of the light, making visual pigment molecules naturally polarization sensitive. In vertebrate rods and cones, the visual pigment is arranged in a semi-random array of axes, which makes the photoreceptor equally sensitive to any e-vector orientation when the light arrives parallel to the photoreceptor's long axis.[8]

In this statement, there are a few problems which we should keep in mind. One, is that we don't know exactly what causes the highest absorption of the light polarized in a given plane when aligned with the pigment, let alone how phototransduction occurs in eye, converting light into electrical signals. We know of the association, but polarization is a tricky phenomenon, because light itself is. But two, it would appear that it is the *macro-organization* of the pigments that matters, contrary to what this statement implies.

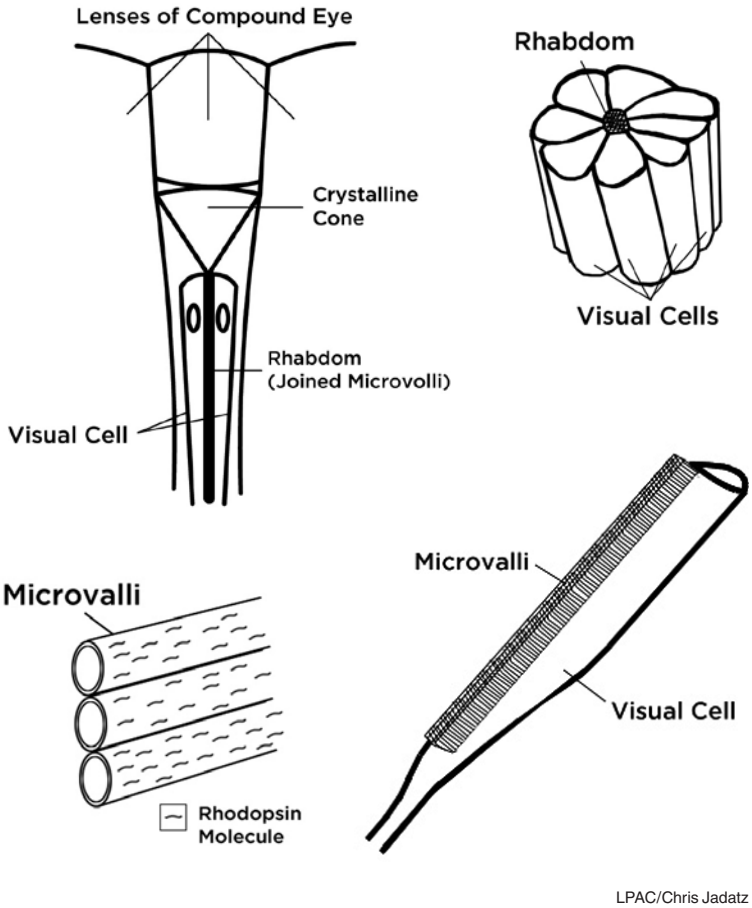
The so-called randomly organized pigments of the human eye do not appear to be as highly organized as they are in the eyes of these other creatures, if we consider the macro-organization of these pigments—but wouldn't the same polarized light activate a portion of our retinal cells oriented in a parallel fashion, just not close-packed together, if the orientation of the pigments were the simple requirement? Perhaps the sheer number of pigments oriented in the same plane is simply not comparable to what the cephalopods have.

The fact that we do perceive some polarized light should mean that the organization of the pigments is not in fact random—assuming this has something to do with polarization sensitivity. This is besides the fact that claiming that any feature of human anatomy is semi-random, usually means something more like, "We don't know how it is organized." Accounts of the polarization sensitivity of humans, arthropods, stomotopods, and cephalopods all hinge on a particular arrangement of the visual pigments, but, as we have indicated, in each of these cases, each class represents a different arrangement.

Another paradox: The polarization-sensitive bees can perceive the colors white, yellow, blue, violet, and ultraviolet, but the polarization sensitivity of bees and other insects seems to correspond only to the ultraviolet wavelengths of light. But if the bees see five different colors, why would they only see polarized light in one of them? The simple radial arrangement of all visual pigments, as it is typically presented, does not account for this.

One explanation, is that in the region which is not sensitive to polarized light, there is a 180° rotation of

FIGURE 2



LPAC/Chris Jadatz

Several images of cuttlefish eye, from top left to bottom right with increasing resolution.

8. Lydia M. Mathger, Nadav Shashar, Roger T. Hanlon, "Do Cephalopods Communicate Using Polarized Light Reflections from Their Skin?" *Journal of Experimental Biology*, 212, 2,133-2,140, Doi:10.1242/jeb.020800 (2009).

the pigments along the length of the photoreceptor, canceling out the polarization. But even in the area receptive to UV light, there is a 40° rotation of the pigment.[9] This account does not quite match up with the descriptions of how polarized light interacts with visual pigments based on their perfect alignment, since high sensitivity to polarized light is apparently otherwise achieved with a 40° rotation of pigments through a twisting of the rhabdoms, a rod-shaped part of the insect's eye (**Figure 2**). It seems as though the pigments in our human eye, though they be randomly arranged, should have an array of pigments spanning at least 40° in their orientation with respect to one another. But our polarized vision is clearly less acute, which means that this simple explanation of how "polarized vision" works doesn't quite make it.

The cuttlefish, in one of its camouflages.

In discussion of the polarization sensitivity of animals, there is heavy emphasis on the orientation of visual pigments, but this alone does not account for the phenomenon of polarization perception. It is not simply the organization of a substance which allows it to be sensitive to polarized light; the material itself determines the interaction with polarized light. It can also polarize light itself, in addition to simply being sensitive to it. In the human eye, it is thought that our ability to weakly perceive polarized light is additionally influenced by a crystal-like property of the cornea, which has its own slight polarizing effect on light. For the mantis shrimp, as we will see, the crystalline structure of the microvilli is said to affect the polarization. All we know is that the material and organization together seem to correspond to the ability to polarize light, and to selectively perceive it. The mechanism remains unclear, although it may have seemed somewhat intuitive at first; but it is the activity of the cephalopods and a handful of other creatures in response to the polarized light that we *do* know.

This capability has been tested more extensively with the cuttlefish, which has a camouflage capability that includes a polarization variable. This ability of the skin to polarize light seems to be especially prominent in the blue-green light range, a range in which the animal is colorblind. When placed in front of a blue, yellow, or a blue and yellow checkerboard background, the cuttlefish never changes its camouflage in response, when these colors are of the same intensity.[10] Despite lacking one aspect of a visual sense, they can respond to changes in the polarization of light much more efficiently than other creatures.

For example, a cuttlefish will respond differently to its own reflection, if seen through different polarized filters, and will change polarization patterns around other cuttlefish in displays of aggression or when attacking prey. Their skin demonstrates distinct patterns when seen though a polarized filter, which are otherwise not visible, and there are indications that the polarization of their skin is physiologically controlled. In one experiment, changing the chemical environment of the skin changed the polarization characteristic of the light reflected off of the skin**.** These examples indicate that cuttlefish may communicate with each other through induced polarization patterns in their skin, taken in addition to what it known about their orthogonal visual pigments.

The polarization is achieved through reflective cells called iridophores, which lie underneath a layer of chromatophore skin pigments. The chromatophores have small pigment sacs which expand, contract, and

9. To what extent this is based on observation, or just a model, was not clear from the account.

10. Lydia M. Mathger et al., "Color blindness and contrast perception in cuttlefish determined by a visual sensorimotor assay," *Vision Research*, 46 (2006) 1,746-1,753, doi: 10.1016/j.vires.2005.09.035

change shape to create the cuttlefish's camouflage. The iridophores, or guanophores, are crystalline plates made of guanine, among other things, and are also used to produce colors in the cuttlefish's camouflage. For example, purple can be created by a red chromatophore and an iridophore. The cuttlefish can also use an iridophore and a yellow chromatophore to produce a brighter green.

As for using these iridophores to create the polarization patterns, do the cuttlefish achieve this by the iridophores themselves changing in orientation with respect to the incident light, while being present over all of the skin? Or, are there special patterns of iridophores that have this induced polarization capability? In squid, it seems that the latter may be the case. But the change in polarization patterns is able to occur so quickly, that it is thought by researchers to be neurological (as opposed to hormonal), and researchers are currently puzzled as to how the changes in polarization can be induced within less than a second. Only very recently have nerve fibers been found in the vicinity of the iridophores. Prior to this, no squid had been known to have iridophores that are under neural control, and even this is still unproven, since the nerve fibers have only been found near the iridophores—no actual connection has yet been established.[11]

Another paradox about cuttlefish vision was communicated in a 2007 study which tested the "optomotor response" of cuttlefish, in response to moving patterns of contrasting stripes, and moving patterns of polarized stripes. In the optomotor response, the cuttlefish, in a tank surrounded by one of these backgrounds, should rotate around its center to follow the image that is circling around the tank. The cuttlefish did just this in response to the patterns of contrasting stripes (of different intensities), but not for polarized stripes. While this experiment was only done with one rare species of cuttlefish, it still puzzled researchers. The orthogonal structure of the eye's pigments was present. Are polarization and intensity perceived differently by this cuttlefish, they asked? Are only certain kinds of visual cues involved in an OMR (Optical Mark Recognition) test? Or is the fish possibly not seeing polarized light, despite having the eye structure to account for it?[12]

How can insight into the control over the biological polarization mechanism, and the mechanism accounting for its perception, give us more insight into the still not-well-understood phenomenon of polarization? Is it achieved biologically by means which do not fully reconcile with our current explanations? This will be suggested even more in the case of the mantis shrimp.

An additional puzzling question for researchers is how the cuttlefish, who are colorblind, can match colors in their camouflage. They can perceive brightness and intensity, and patterns based on these contrasts, but how they are able to match colors, even in complete darkness, is puzzling to researchers. Using night-vision video, scientists at Woods Hole Marine Lab discovered that cuttlefish even match their background at night, when there isn't enough light for color vision. Claims by some that this is explained by passively reflective cells called leucophores, do not seem to account for the sharp changes in patterns which they can induce. Dr. Roger Hanlon, who has written many research papers on the cuttlefish, and has done a lot of field work with them, was asked how the cuttlefish's skin changes to any hue in the rainbow, although the animal has only one visual pigment which is sensitive to colored light at 492 nanometer (nm). He replied, "That's a vexing question. We don't know how it works."[13] In the case of the cephalopods, we have a creature which discerns polarized light, and has the ability to induce changes in its skin polarization patterns in less than a second, by an unknown mechanism, which then appears to be seen by other cephalopods, who are colorblind, but can clearly perceive color in some way, as their camouflage demonstrates. Vision more generally seems to be quite perplexing!

However, even the polarized vision and communication capability of the cephalopods is not nearly as well developed as the capability of a specific kind of crustacean called the stomatopod, or mantis shrimp.

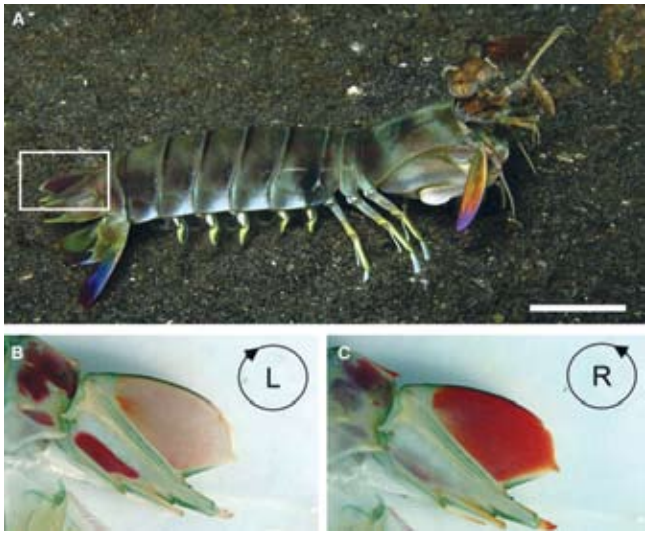
11. Nadav Shashar et al., "Polarization reflecting iridophores in the arms of the squid Loligo pealeii," *Biological Bulletin*, 201:267-268 (2001).

12. Nadav Shashar and Anne-Sophie Darmaillacq, "Lack of polarization optomotor response in the cuttlefish Sepia elongata," *Physiology & Behavior* (2008), doi:10.1016/j.physbeh.2008.01.018

13. http://www.nytimes.com/2008/02/19/science/19camo.html

Mantis Shrimp

Not only does the mantis shrimp pack a serious punch, so fast that it can produce killer sonoluminescing bubbles, but these guys blow everyone out of the water in terms of a functional polarization-sensitive visual apparatus. The hyperspectral eyes of mantis shrimp, which perceive from the infrared to ultraviolet range (to 300 nm),[14] can also perceive linearly and circularly polarized light.



Courtesy of T. Chiou

Mantis shrimp tail seen through left and right circularly polarized filters.

The tail of the male mantis shrimp, as well as other parts of their bodies, seem to emit circularly polarized light. When seen through a filter for either left-circularly polarized light or right-circularly polarized light, only one of these images of the tail will be illuminated.

It is unclear whether this is a kind of bioluminescence, a controlled reflection as in the case of the cephalopods, or simply the reflective nature of the material, although several articles imply that the males use this ability to "signal" others, implying that it is more than passive reflectivity.

The shrimp have 12 primary color pigments to our 3, and 4 which aid in polarization sensitivity. Each eye has three distinct parts, the two hemispheres and the midband, and is capable on its own of trinocular vision.

This midband is where most of the action occurs, being composed of many ommatidia, or "simple eyes," each of which has long visual cells called rhabdoms, arranged and close-packed in a star pattern, pressing up against the ommatidia, similar to the insect eye. Here also, as in the cephalopods, we have tube-like microvilli, the light-sensitive part of the rhabdom, each of which points radially towards the center of the ommatidia, and which contains the pigment. Interestingly, more detailed studies reveal that the "small four lobed UV sensitive photoreceptor," R-8, in the midband, is also said to be the one responsible for the circular polarization perception—two super-senses in one! "Circular polarization sensitivity is not innate to the R1-7 cells, but arises from the quarter-wave retardance of the overlying four-lobed R-8 cell."[15] In some fish, and in bees and other insects, UV perception and polarization sensitivity are related, but only for linearly polarized light.

Seeing the circularly polarized light is thought to be unique to several species of mantis shrimp, although fireflies and scarab beetles can generate it; scarab beetles reflect it off of their liquid-crystal-like exoskeleton. One of several experiments used to detect the mantis shrimp's sensitivity was done by giving them food with a flashing left circularly polarized light signal above it. Next to this station, would be a flashing right, circularly polarized light signal, but no food.[16] This would be repeated, and the positions of the two stations alternated, one with food, one without, but the light signals kept the same—the left circularly polarized light always at the station with food. When the food was removed, unbeknownst to the mantis shrimp, after having repeated this exercise many times, the mantis shrimp invariably went for the flashing left circularly polarized light signal. If this experiment were repeated with humans, our choice about which station to go to would have been arbitrary (or we might have a slight chance of making an informed guess, as we will soon see), whereas for the mantis shrimp, it would be informed by sensing some

14. For cell perception of UV below this frequency, see Cody Jones, "Cosmic Bio-Radiation: Casting Gurwitsch in the Light of Vernadsky," http://www.larouchepac.com/files/CodyJones-BioCosmo_0.pdf

15. S. Kleinlogel and A.G. White, "The Secret World of Shrimps: Polarization Vision at Its Best." PloS ONE 3(5): e2190. Doi:10.1371/journal.pone.0002190 (2008).

16. "How Mantis Shrimp see circularly polarized light," Aug. 16, 2010, http://arthropoda.southernfriedscience.com/?p=2964

distinction between the left and right polarized light, though we don't know exactly how this looks to them. How they sense the light is usually compared to the function of a quarter wave-plate, the non-biological mechanism we use to convert circularly polarized light to linearly polarized light. Accounting for the perceptive ability is based on this kind of quarter wave-plate being literally in the eye, in the R-8 cell overlaying the other rhabdom. It would be interesting to compare how the non-biological quarter-wave retarder in our labs is different from that in the mantis shrimp's eye—and they do appear to be different. Is it a unique kind of crystalline structure, as is the case for our wave plates, which are made of calcite, quartz, or magnesium fluoride? It appears to be the case, but they are still quite different. The efficiency of their "wave plate" is said to be greater than even our own quarter-wave plates by a factor of 3. What accounts for this is unclear. As these researchers from *Nature Photonics* admit, the optical capabilities of the mantis shrimp's eyes may be more advanced than some of our best noëtic instrumentation:

> We have discovered a novel microvillar mechanism that acts as a remarkable achromatic optical device. Man-made retarders are among the most important and commonly used optical components, and the cellular structure we describe [of the mantis shrimp] significantly outperforms these current optics.[17]

This is aside from the fact that our optics are not also used to perceive linearly polarized UV light! The question of how alike, in fact, are the means by which humans with our instruments, and animals with their bodies, receive and produce polarized light, is forcefully posed by the case of the mantis shrimp. We can ask ourselves, what does the world look like to this creature? And although the circular polarized vision seems the most exotic, it is also interesting to ask how this creature perceives color. What does it look like to see based on the blending of 12 color pigments? Would you see "different colors," or would variations be more striking? Would they blend differently? For a mantis shrimp, which colors would combine to make green? Blue and yellow, or completely different colors? What "color" is infrared or UV light for this creature? What does the visual field of an animal which can see all kinds of polarized light look like? Or what does it look like to have one eye with trinocular vision? Two? As we extend our concept of the sensorium, there seems to be a gap between the supposed impressions of these super-senses, their actual perceptions, and the actions of the creature, although these senses are not used for creativity. Some of what is unexplained lies within the "technology" itself. Although these creatures lack mind, untangling the problem of how these biological senses actually work, is a problem which continues to puzzle us, a problem of which these sea creatures, for example, are unaware, though they operate based on them to near perfection. Clearly a mantis shrimp and a human being do not see the same thing; the visual impressions received are thus not real objects, but different, contrasting impressions received from different sets of instruments. In the next case, we will show that our human visual map may have more resolution to it than we may assume from the most obvious impressions.

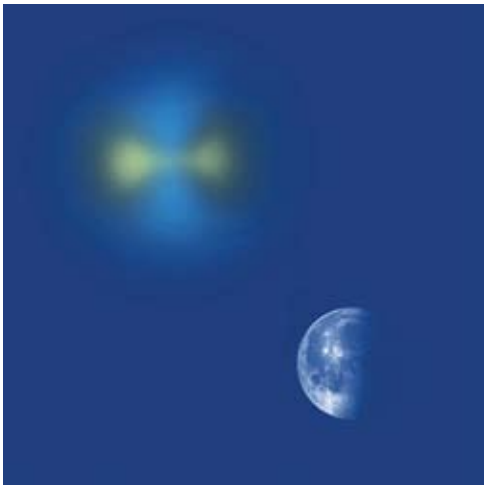
Humans and Haidinger's Brush

After reviewing some cases of super polarized vision, the human capability to perceive polarized light may seem rather lame: a faint blue and yellow bow which you may or may not be able to see on your laptop screen or on a blue patch of sunny sky close to the horizon. You probably think that seeing circularly polarized light is out of the question—but seeing a diagonal brush which maintains its orientation as your head tilts, indicates that the light is circularly polarized, left or right, depending on the tilt! But surely this isn't as useful as being able to communicate with other members of our species through secret polarization channels.

Haidinger's brush is what is called an entoptic phenomena, and was discovered in 1844 by German physicist, geologist, and mineralogist Wilhelm Karl von Haidinger. Similar to the floaters you may see "on your eye," Haidinger's brush is also not something external. After all this discussion about the highly structured pigments in animal eyes, and our "practically random arrangement," how is this faint polarization perception achieved? The matter is not completely

17. N.W. Roberts, T-H Chiou, M.J. Marshall, T.W. Cronin, "A biological quarter wave retarder with excellent achromaticity in the visible wave length region," Nature Photonics, Doi:10.1038/NPhoton/2009.189 (2009).

settled. An article published in 2010 points out the flaws in a couple of theories, and posits the researchers' own, which they tested through creating an artificial eye and camera. The reasons for being able to see the funny pattern of polarized light here also trace back to an organization of the eye's pigments. But as you see in this brief summary, completely different models were said to be able to account for its perception. The 2010 study references previous theories:



LPAC/Chris Jadatz

An exaggerated view of Haidinger's brush.

> Most models are based on either a possible radial or tangential arrangement of absorbing elongated yellow pigments in the macula. Unfortunately, a radial alignment of anisotropically absorbing molecules along the nerve fibers which may be expected for highly elongated pigments would lead to reverse brush colors. Tangential alignment of the molecules orthogonally to the fibers would lead to the correct colors, but are unexpected and has never been experimentally observed.[18]

The researchers who wrote this critique say that they can produce the correct brush colors and orientation based on a particular cylindrical organization of a small population of blue cones in the fovea, a small section of the macula. They claim to have mimicked this organization in an artificial eye-like device, and say that they were able to photograph an image generated by this device which produced the blue brush when blue light was shown, and the yellow brush when red and green light was shown. However, accounts of people seem to indicate that the brush is not perceived at all with red light, but that specifically blue light is required. The cause of the particular faint colors of the brushes is not clearly related causally to the color of the perceived light, nor how or whether it depends on the organization of the eye's pigments—for example, radial or tangential, as implied above, where both could be used to explain the perception. Does it depend on yellow or blue pigments? Both explanations have been given. Another account suggests that it may be a birefringence in the eye itself which accounts for the particular colors. As we can see, there are and have been many theories put forward. Many models claim to account for some aspect of the perception, but none claim to have reproduced it completely in the same way as the human eye does.

It is nonetheless interesting that this last model should rely on a specific arrangement of the eye's blue cones, which are relatively sparse in the human eye anyway— only 2% of our cones are blue cones, but they are highly sensitive for yet unexplained reasons. Most of us would not consider ourselves to be blue colorblind, despite having so few blue cones. In the area of the fovea, the percentage of blue cones is even less than 2%. Blue light has proved important for other phenomena referenced in this report, including bird magnetoreception, etiolation, and certain biological rhythms. But at least one account claims that the fovea is too small to account for the perception based on the size of the brush.

The above apparatus as described, a simple machine involving not much more than a lens, a glass cylinder, and a "blue mosaic on a screen," cannot be seriously treated as an analogue to the human eye. And also, the unique arrangement of a very small number of blue cones, which this model relied on, does not, on the surface, account for other phenomena associated with Haidinger's brush. You may want to understand why you can see Haidinger's brush, or why you can't, because it may have to do with your overall visual health, as researchers are finding out.

The ability to sharply perceive Haidinger's brush in a particular eye, has been linked in many people to the "dominant eye," which is also a puzzling phenomenon. But those functions which we associate with eye dominance, dealing with perception much more generally, do not on the surface to account for why the dominant eye would be able to perceive a sharper Haidinger's

18. Albert Le Floch, Guy Ropars, et al. "The polarization sense in human vision," *Vision Research*, 50, 2,048-2,054, doi:10.1016/j.visres.2010.07.007 (2010).

brush. Apparently, the ability or lack thereof to see Haidinger's brush is even used to diagnose some degenerative conditions in the eye:

> The absence of a photographically visible polarization pattern is an indication of macular dysfunction due to senior macular degeneration, angioid streaks, or diabetic retinoplasty, and thus the phenomenon can be useful for diagnosing diseases affecting the macula.... Perception of Haidinger's brushes may indicate a healthy eye, and the inability of perception of these brushes indicates certain visual dysfunctions.[19]

Additionally, patients with certain kinds of strabismus, or "turning eye," can be trained to view objects with the correct part of their eye by lining up the Haidinger's brush with the object they are trying to look at.

We have, with Haidinger's brush, a perception much less stark than those used by the bee, cephalopod, or mantis shrimp to function day to day, but which may be just that significant for our own vision all the time, despite the fact that we aren't consciously seeing it all the time. However useful the ability to perceive Haidinger's brush may be for making the above diagnoses, it is only correlated with these various degenerative eye conditions—there is not a demonstrable causal connection between the them.

Perhaps we could refer to it as a kind of visual "weak force." That is, something barely perceived or sensed by us, as, for example, in the case of various low-intensity kinds of radiation which play some critical role in the optimal functioning of an organism. Here, we have a faint, or low-intensity perception, which seems to play some more critical role for the function of vision. Perhaps the true cause for it would redefine our notion of vision itself—but with various and completely different models claiming to explain it, we are not there yet.

Let us, as Bernhard Riemann did for the investigation of the ear, start our investigations of vision based on taking into account what the animal and human visual apparatuses *do*, and allow that to shake up our models of how vision must function.[20] It does seem to be clear, that based on the function of the human eye generally (and the very intentional role of human beings!), claims that anything about its organization are random, as compared to the eyes of animals, seem more dishonest than anything. Such statements should be reformulated to state that we don't fully understand the reasons behind the particular organization of the eye. Then again, the eye itself exists and functions based on its own relationship to cosmic radiation, polarized, unpolarized, and of varying intensities. Is there a cause which lies completely outside the domain of the rods and cones of the eye, as might also be the case for distinct closed-eye visual noise, colors, and patterns, or those you see when pressing or rubbing a closed eye? Or the lights seen by numerous astronauts, which appear when they close their eyes?[21] In addition, auroral "hearing," bird magnetoreception, the phenomenon of synesthesia, and the case of someone like Helen Keller, can all cause us to wonder if there is not more to vision as a sense, than we might have assumed from the most obvious impressions.[22]

And despite the greater intensity and clear utility of the animal polarization sense, our own seemingly weaker visual perceptions do not leave us weaker as a species. But, could we further increase our power over nature through honing our own polarization sense, through our man-made instruments and even our own biological instrument? Based on how much time most of us spend on a given day staring at an LCD screen on our laptop, it may be that we have been subconsciously training ourselves to block out the perception of Haidinger's brush, as a kind of unwanted visual background noise. For Vikings who navigated the seas using pieces of Iceland spar to locate the Sun on a cloudy day, the polarization sense was second nature, and a matter of survival. Perhaps some of them were unaware that it was polarization which they were responding to, as you yourself might have been unaware of what generated the faint perception we have now identified as the human biological polarization sense. What other kinds of weak impressions, or phenomena more generally, could you be responding to, unknowingly?

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19. Horvath Gabor and Varju Dezso, "Polarized Light in Animal Vision: Polarization Patterns in Nature," http://www.uni-tuebingen.de/cog/literature/literatur-Dateien/2003/HoVa_bookcontensts03.pdf

20. See Aaron Halevy on Riemann's approach to hearing, "The Sounds of a Cosmic Chorus," this issue, and, http://www.larouchepac.com/files/AaronHalevy-CosmicChorus_0.pdf

21. http://www.space.com/scienceastronomy/mir_lights_030416.html

22. See Oyang Teng, "Synesthesia: Beyond the Five Senses," and Sky Shields, "Unheard Melodies: Electric and Magnetic Senses in Humans," in this issue.

What Is Circularly Polarized Light?

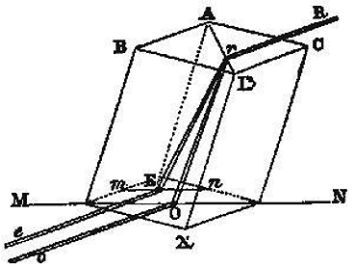
by Jason Ross

Beginnings

When light passes from one substance into another, its direction is perceived to change. This phenomenon, known as refraction, was first understood by Pierre de Fermat as arising from the different speeds of light when moving through different media. These coefficients of resistance were successfully determined for a variety of different materials, but one particular crystal, a type of calcite known as Iceland spar, did not fit neatly into the theory. This crystal has the amazing property of not simply bending light's path, but of splitting it in two! (**Figure 1**)

These two paths of light, known as the "ordinary" and "extraordinary" rays, are always of equal intensity, when usual sources of light are used. This is not the case, however, when rays refracted through Iceland spar, are directed to a second piece of the crystal. If the two pieces are parallel, the rays do not split again, but continue on as either ordinary or extraordinary rays. If the second crystal is rotated by 90°, the once-ordinary light undergoes an extraordinary refraction, and the extraordinary light refracts as an ordinary ray. At 45°, both rays split, giving a total of four rays exiting the second crystal. In between, there are four rays, but of unequal intensities: At zero and 90°, two of the four rays vanish. Thus the rays of light refracted through Iceland spar are not of the same quality, but have additional directions associated with them (not just the direction of propagation), as revealed in their changing interaction with the crystal: They are thus said to be "polar."

FIGURE 1

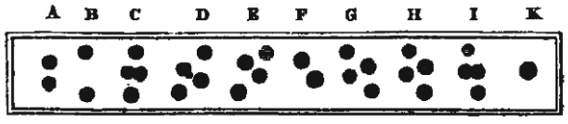


Source: François Arago's *Biographies of Distinguished Scientific Men* (1859), p. 152

Double refraction of Iceland spar

In the early 19th Century, Etienne-Louis Malus was studying Iceland spar, using beams of light reflected off the windows of a nearby building. To his surprise, the ray of light was not doubled, but refracted in the ordinary or extraordinary way, depending on how he held the crystal. Performing a further test with candlelight reflected off the surface of water, he found that at a shallow enough angle, the light reflecting from the water had a polarity, just like the light passing through Iceland spar. Similarly, the extraordinary ray passing through Iceland spar would not reflect at all off water at this shallow angle. He discovered that almost all surfaces (except mirrored metal surfaces) can reflect polarized light (**Figure 2**).

FIGURE 2



Source: Arago, p. 150

Representation of refraction through two pieces of Iceland spar. (A) represents the double-refraction through one piece. (B) represents the result when the two crystals are aligned, moving to 45 degrees at (D), with four equally bright spots. The four coalesce into two at 90 degrees (F), and then continue on, as the crystal is further rotated.

Fresnel's Discoveries

The shimmering colors of soap bubbles or of thin films of oil on water, arise from a phenomenon known as *interference.* Augustin Fresnel brought this phenomenon to a greater level of understanding by demonstrating the complete elimination of a beam of light by shining another upon it. Not just any two rays of light can interfere in this way: Fresnel showed that the two beams had to be of exactly equal color to interfere. If red light is made to interfere with white light, then blue-green light will remain. By setting up two paths of light, differing only slightly in their length, Fresnel could determine the least difference in lengths that could give rise to interference, and determined these characteristic lengths for a variety of colors. Color and distance are not the only factors, however: Two rays of light, having the same origin and color, but being polarized at right angles to each other, *will not interfere* (**Figure 3**).

FIGURE 3

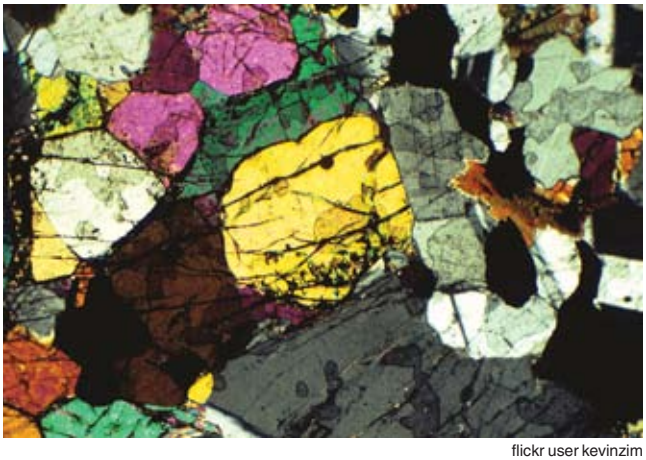
Source: Arago, p. 205

Fresnel's method for producing interference. The two path lengths are very slightly different, and path differences that are multiples of a determined minimum distance result in interference—the brightness is eliminated.

Fresnel, a proponent of the wave theory of light, who composed devastating attacks on the emission theory, conceived of these waves not as Christiaan Huyghens did—as longitudinal waves, compressing and expanding in the direction of propagation, as do sound vibrations—but as transverse waves, having an oscillation perpendicular to the propagation direction. That is, like ocean waves, where water moves up and down as the wave moves horizontally, light has a perpendicular oscillation. This oscillation, having all different directions in a typical source of light, is split into its perpendicular components by passing through Iceland spar or by appropriate reflection. Thus, the rays polarized at right angles did not interfere, since they act in different planes.

Fresnel then created a new kind of polarized light, which he called *circularly polarized light*.[1] Like unpolarized light, this new light would split in two when passed through Iceland spar, but, unlike normal light, would display interference colors if it were passed through substances like mica before passing through Iceland spar. To produce this circularly polarized light, Fresnel used an apparatus that produced two rays, polarized at right angles to each other, and with one retarded by a quarter-wavelength. Together, they act as one ray of light, whose plane of polarization rotates: circular polarization. The secret to this special quality of light, quite useful now in microscopy and a variety of other applications, already existed in the tail of the lowly mantis shrimp! (**Figure 4**)

FIGURE 4



flickr user kevinzim

The colors in this microscope image of olivine and pyroxene appear from the polarized light used in the microscope.

1. This was to distinguish it from the previous, simpler kind, now known as linearly polarized.

Insects and Infrared

by Oyang Teng

Entomologist Philip S. Callahan dedicated his life's work to a field he termed "reverse bionics"—examining the properties of human inventions to understand the means employed by nature for similar ends. In this case, it was his experience as a U.S. Army Air Force radio operator, working with the electronics of antennas and tuned circuits during World War II, that led him to the conclusion that insect antennae sensilla (the tiny micrometer structures covering what we typically call the antennae) were themselves functional electromagnetic antennae, allowing insects to utilize infrared frequencies, and not chemical scents per se, to "find their way around nature."

According to Callahan, the infrared portion of the electromagnetic spectrum, comprising some 17 octaves, and therefore, the largest region, provides fertile ground for study of the regulation of the biosphere:

"In terms of the overall universe, of course, all radiations are natural because they come from the sun and stars. In terms of our living environment, however, the radiation that is natural to our bodies is the huge sea of visible light and infrared radiation in which we begin, live, and end our lives, and which surrounds us day and night alike. Natural night light is just as important to our bodies and to all living things as is daylight, for as we can see from the spectrum of Earthly radiation, nighttime—as well as daytime—is primarily an infrared environment."[1]

Infrared ("below red") radiation was discovered during refraction experiments by the astronomer John Herschel in 1800, establishing for the first time the existence of "invisible light." Any object above absolute zero (0°K), i.e., every object, emits infrared radiation. So, for example, NASA's Spitzer Space Telescope is able to detect the infrared signatures of distant celestial bodies, by peering through dust clouds which trap visible light, but which are transparent to certain bands of infrared.

One of the central features of our unseen environment on Earth, is the stimulation of gas molecules in the atmosphere by ambient infrared, visible, and ultraviolet (UV) radiation. This pervasive environmental radiation "stimulates them to oscillate at many unknown frequencies of colors—not visible colors of red or blue or green,

1. Philip S. Callahan, "Tuning into Nature," *Acres*, 1974

but infrared 'colors' of much longer wavelengths. If we had infrared eyes, we would give names to these colors—these auras of beautifully psychedelic infrared frequencies, as easily tuned to by an antenna as are the visible color by the rods and cones of our eyes."[2]

These subtle fluorescences are a key component of insect communication and navigation, a discovery pioneered by Callahan, through lab experiments in which he irradiated pheromones and other organic gases with low-intensity UV light, and measured the response of insects such as moths (which can also see in the UV spectrum). Insightfully, he remarks that, "It is just such unknown mysteries of nature as these that space research will uncover for us. The entomologist and the space scientist must form a new and firm partnership to study nature's secrets together."

NASA

The Trifid Nebula, as revealed in an infrared photograph from NASA's Spitzer Space Telescope. The nebula is located 5,400 light years away in the constellation Sagittarius.

Airborne molecules can emit unique and subtle electromagnetic infrared "colors" as coherent, low-intensity, laser-like radiation. "The word laser refers to light because visible light lasers are the ones most commonly used by man. It is far easier, however, to lase molecules that have absorption bands in the infrared portion of the spectrum, and, as a matter of fact, there are far more possibilities for lasing infrared than visible radiation. This is true because it is easier to stimulate low-energy wavelengths than high-energy ones. X-ray and UV lasing require extremely high-energy pumping sources, whereas infrared usually requires only visible or near-UV pumping radiation. . . . Scent, in my mind, is a fleeting-floating world of vapors that luminesce in many, many different infrared colors and can be amplified and collected by a scent organ such as the insect antenna. The antenna sensilla are tuned as a resonating system to these infrared frequencies. Accordingly, I coined the term 'maser-like frequencies' for the scent infrared colors that we could not detect until the early 70s."[3]

So, how do insects receive these frequencies? Oscillating gas molecules, be they pheromones or other organic scent molecules, disperse through the atmosphere and accumulate on or near the insect antennae (which have a static electric charge due to their waxy covering), transmitting their specific infrared frequencies down the sensilla antennae/waveguides. The frequency of the emitted infrared changes depending on the concentration and temperature of the gas (which cools as it disperses), thereby giving information about direction and distance to the emitting source, whether that source is a plant, a rotting carcass, or potential mate. Apparently, insects are also able to modulate the incoming frequencies through the beating of their wings and the attendant vibration of their antennae, and their constant rubbing of legs and antennae serves to improve their receptivity to the infrared frequencies, by clearing away debris and water moisture.

The implications of Callahan's work for pest control, especially for agriculturally vulnerable places like Africa, are enormous. But so too the potential for advancing our understanding of the fundamental nature of electromagnetic radiation itself. For, while there is a close analogy between the man-made antennae used in electronic communication and those utilized in the insect world, the direct comparison extends only so far, given that living organisms are not simple tuned circuits. Further work on the interaction of infrared and other radiation with specifically biological processes will revolutionize our understanding of such radiative phenomena, which are currently defined solely according to measurements by abiotic instruments. However, Callahan's discoveries already point to a partial reconciliation of "chemical" and "electromagnetic" effects, showing that the distinction—as in the case of scents—may not be as sharp as normally assumed.

Additional Reference:

Philip S. Callahan, "Insects and the Battle of the Beams," *Fusion*, September-October 1985, pp. 27-37. http://wlym.com/~basement/fusion/fusion/19850910-fusion.pdf

2. Ibid.

3. Philip S. Callahan, "Exploring the Spectrum," *Acres*, 1984

Magnetoreception

by Benjamin Deniston

The impressive migratory and homing ability of birds has long drawn attention. Detailing the wide range of impressive cases has quickly grown from papers to books. The ability to consistently navigate incredible distances (migrating from the Arctic to the Antarctic and back every year, in some cases!) with impressive speed and accuracy has drawn extensive wonder and experimentation as to how exactly they are able to do this.[1] Through the 1950s, '60s, and '70s, tests were performed to determine how homing pigeons, among other birds, were able to do this. It was shown that they are able to use a number of impressive sensory capabilities, from being able to "hear" extremely low frequencies (down to 0.1 Hz for pigeons), to seeing both ultraviolet light and linearly polarized light, to using the positions of the Sun and stars to orient themselves. Pigeons are sensitive to changes in air pressure, with an accuracy of the pressure difference due to altitude changes as small as 10 meters. In fact, the studies of how the birds were able to utilize the position of the Sun were important in building significant interest in "biological clocks"[2] in the late 1950s, because determination of direction based on the location of the Sun requires some ability to "know" the "time of day," another ability demonstrated in these birds.

Even with this impressive array of sensory capabilities, tests indicated that there was more to the birds' sensorium than even this array of abilities. For example, when homing pigeons were conditioned to a day-night light cycle shifted six hours ahead, this shifted their "biological clocks" six hours, such that, when released into normal daylight, their directional sense was correspondingly shifted ~90° (6:00 to 24:00 corresponds to 90° to 360°), because their seeing the position of the Sun was correlated to a shifted sense of time.[3] But, when the same experiment was conducted on overcast days, the pigeons were able to navigate homeward with no problems, despite the light-dark conditioning which had shifted their "biological clock." This was the case even when the birds were released in a location completely unfamiliar to them, such that they had no indication of where they were being taken (at least no "indication" in terms of the traditional five senses).

Other tests with overcast conditions and/or impaired vision (as with frosted goggles which allowed the birds to see no more than a few meters) further indicated that the birds had another dimension of sensory capability. Experiments in the early 1970s, with magnets and magnetic fields, quickly showed an ability expected by some for over a century: that the birds had some sort of magnetic sense. The questions remained, and still remain: "How exactly is this magnetic sense utilized? What are they detecting and how are they detecting it?"

The Geomagnetic Field (What We Know)

To situate the experimental investigations, we have to start with a presentation of what is known about the measurable structure of the geomagnetic field (GMF), even if there might be limitations to what we know. Even in the simplest sense, the GMF is more interesting than can be measured by the polarity compass that we are most accustomed to.

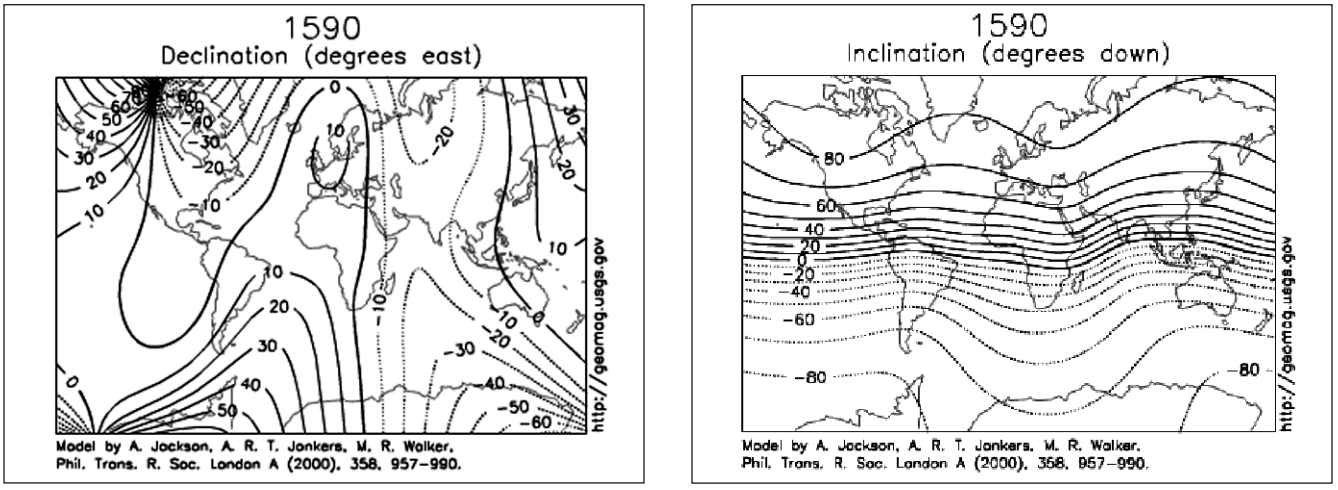
For clarity, we will take the investigation in successive degrees of resolution. In the most basic view, the GMF is a dipole field, having a single north and single south pole, opposite each other (though in the GMF they are not exactly opposite). Here, in the hypothetically uniform dipole magnetic field, every location on the Earth will not only have a polarity (measured as *declination*, the angle between geographic north [or south] and magnetic north [or south]), but also two other components. There will also be a specific *intensity* (because the field is more intense at the poles and becomes less intense as one moves towards the magnetic equator), and an *inclination* (or dip), which measures how many degrees away from parallel (with the

1. It has also drawn man to utilize this capability. The domesticated homing pigeon has been bred to enhance this impressive navigational ability. Entire books have been written documenting the impressive capabilities of these birds, including the fact that the capability was so well trusted, that homing pigeons were used for military purposes up through World War II.

2. See Peter Martinson's contribution in this issue, "Following the Beat of a Different Drummer."

3. For example, if you are in a completely unfamiliar land, and you think it is 7:00 a.m., and you see the Sun just above the horizon, you would determine that direction is east; however, if you, instead, for whatever reason, think that it is 7 p.m., and see the Sun in the same location above horizon, you would be inclined to think that direction is west.

FIGURE 1



Declination and inclination global maps from the USGS. These maps are animated; see http://www.larouchepac.com/node/17191

surface of the Earth) the magnetic vector is (**Figure 1**).

For example, imagine you had a compass needle that could spin freely in three dimensions; at the north magnetic pole, the needle would point straight down to the Earth (90° inclination), but as you moved south, the inclination would gradually change until it pointed parallel with the surface of the Earth at the magnetic equator (0° inclination). Even though the GMF is much more complex than a simple uniform dipole field, these three values can be measured at every location in the GMF.[4]

However, when we increase the resolution, the structure of the GMF is much more intricate than a uniform field. Everywhere on the surface of the Earth there are variations in the structure of the GMF. Some variations are larger, related to the large scale-structure of the GMF as a whole, but there are also uncountable smaller variations of a variety of sizes, typically attributed to different densities of metallic components within the Earth's crust (referred to as magnetic "anomalies"). For example, one of the largest magnetic anomalies is found in Kursk, Russia (450 km south of Moscow), where the intensity jumps four-fold, compared to the expected GMF intensity for that location, and the declination (polarity) varies from +60° to −110°, when 8° should be expected. Another extreme case is found off the southern coast of Finland (near the island of Jussarö), where there is a sharp jump in intensity, and variations in the declination are enough to have caused many shipwrecks in the past, when a magnetic compass was all that could be relied upon.

These, however, are among a limited number of outstanding cases, and most of the anomaly variations are much smaller, though they are everywhere. Because there are at least some magnetic minerals in nearly every rock type, if we increase our resolution of measurement enough, the entire surface of the Earth is blanketed with these small anomalies of low intensity (variations of the expected GMF intensity by +/−0.1% to 2.0%).

Though invisible to us, these magnetic structures are as real and dependable as the minerals and other processes with which they are associated. Consider the geographic topology surrounding your hometown. In your mind's eye, you recall those distinguishing characteristics, its hills and valleys, mountains and cliffs, or, perhaps, the remarkable flatness of its plains. So too, does any location in the GMF have its distinct, memorable, and probably beautiful topography. It surrounds us at all times; we just don't see it. But, other species do.

In addition to these relatively fixed structures,[5] there are regular and irregular variations induced from above. The effects (gravitational and electromagnetic) of the rotational relationship of the Earth with the Sun, along

4. A few simple variations of these three values are also used. The general properties measured are the same, though the metric can be different. Instead of declination (polarity), inclination, and intensity, two other the sets of components are also used: horizontal intensity, vertical intensity, and declination; and x (north-south intensity), y (east-west intensity), and z (vertical intensity).

5. In truth, the magnetic anomalies are only as fixed as are mountains, valleys, and plains. As the crustal structure shifts and changes, so do the magnetic anomalies. Even more interesting, the large-scale structure of the GMF changes, including reversals of the dipole field, where the magnetic poles actually swap their respective locations on the globe, although much of the "how" and "why" is still highly speculative.

with the rotational effects of the Moon (gravitational) induce slight (sometimes unnoticeable), but regular variations in the GMF qualities measured at the surface of the Earth. Much of this is attributed to the effect on, and generation of, electrical currents in the atmosphere, ionosphere, magnetosphere, and related structures which generate magnetic fields which interact with the GMF. Even if, on a relatively weak level of intensity, the class of regular variations in the GMF (daily, lunar, annual, etc.) could provide a temporal landscape, a periodic indicator, for life. Along with these expected influences, much more rapid micro-pulsations add another dimension of variation. Also, irregular activity from the Sun (solar flares, coronal mass ejections, solar wind shutdowns,[6] etc.) and other extraterrestrial interactions[7] sporadically induce fluctuations in the magnetic field at the surface of the Earth.

So, with this known degree of variation in the structure of the GMF, it is no surprise to learn that there is no single quality of the GMF that living organisms respond to; rather, a variety of distinct qualities of the GMF have been shown to influence living organisms. Presently, the magnetoreception ability of birds is the best studied, so that will be both the starting point and the bulk of this present report, with cases from other animals added in where relevant. But don't let that fool you: The wide range of living organisms which respond to the GMF—from single celled bacteria, to plants, to crustaceans and insects, to vertebrates including fish, reptiles, amphibians, mammals and birds—poses the likelihood that some form of magnetic perception is a rule, and not an exception, for life.

Unfortunately, in trying to determine how organisms can do this, the investigations are generally dominated by a "bottom-up" methodological approach, characterized by, first, asking, "How does magnetism act in non-living experiments of physics?" And second, seeking out particular mechanisms with those properties within living organisms. This unjustly constrains the investigation of a living process to the domain of the non-living, whereas the crucial experimental work of Louis Pasteur, especially as elaborated in the unique work of Vladimir Vernadsky, demonstrated that life cannot be reduced to non-living phenomena.[8] This challenge will come up in a specific, more developed context towards the end of this paper.

First, the proper geometry of experimental evidence will have to be created in the mind of the reader.

An 'Inclination Compass'

What follows is not intended to be chronological presentation of the history of the development of our understanding of magnetoreception, nor is it a complete record of the experimentation conducted. Rather, the composition is structured to build to the crucial questions relevant for this report as a whole.

Extensive study has attempted to narrow down exactly what aspects of the GMF are being detected by the animals, usually limited to investigations of the three factors of the GMF discussed above. Animals have shown responses to each of those factors, as well as combinations thereof, indicating that they can sense all of these qualities.[9]

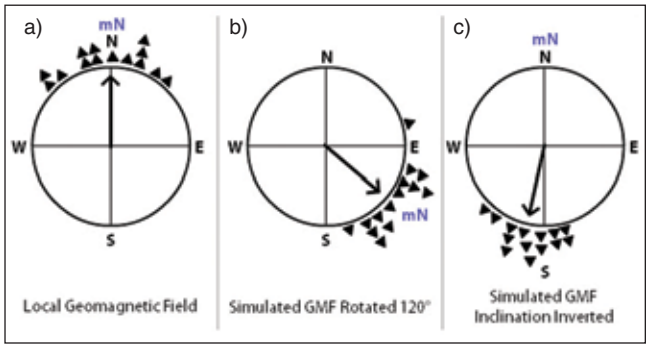
6. For example, for two days in May 1999, the Sun basically stopped emitting solar wind (the constant flow of charged material flowing from the Sun), with output levels falling to less than 2% of normal. This was by far the most extreme reduction ever witnessed, and is, still, a completely anomalous event. See http://science.nasa.gov/science-news/science-at-nasa/1999/ast13dec99_1/.

7. For example, see Sky Shields, "Unheard Melodies," in this issue, where he discusses the large-scale effects of the interaction of meteors with the Earth's ionosphere and atmosphere.

8. For the work of Pasteur referenced here, see the LaRouchePAC-TV video, "Louis Pasteur: The Space of Life" (http://www.larouchepac.com/node/13732), and for the work of Vernadsky, see his "The Physical States of Space" (http://www.21stcenturysciencetech.com/Articles%202008/States_of_Space.pdf), and "The Problems of Biogeochemistry II: On the Fundamental Material-Energetic Distinction Between Living and Nonliving Natural Bodies of the Biosphere" (http://www.21stcenturysciencetech.com/translations/ProblemsBiogeochemistry.pdf).

9. Although the experimental work leans heavily on the ability of animals to detect magnetic fields as such, often using synthetic magnetic fields generated with man-made electromagnetic systems, we cannot simply limit our understanding of animal sensation to this. It cannot be assumed that the laboratory magnetic fields generated for these tests embody all of the characteristics that animals are sensitive to. What we do know is that we can simulate a limited component of the sensorium that animals are responsive to, but we don't know how or in what way that component is limited with respect to their full sensorium, which is interconnected and organized in ways that we don't yet realize. For example, entire classes of organisms have demonstrated abilities to sense (and in some cases produce) electrical currents and fields, which, though notable in itself, also takes a new dimension of interest because of the intimate relation of electrical and magnetic fields (again, noting that extensive investigations of this interrelationship have been limited to abiotic expressions). In that context, consideration must be given to the electrical nature of living organisms, expressed throughout their structure, as well as the sensitivity of living organisms to extremely low-frequency electromagnetic fields. Without fully knowing how the electrical nature of an organism functions, nor exactly how organisms are sensitive to these low-frequency fields, among other considerations,

FIGURE 2



*Orientation behavior of migrating European robins during Spring time. The triangles indicate the direction of individual birds, and the large arrows indicate the averaged direction. Image adapted from Wolfgang and Roswitha Wiltschko, "Magnetic orientation and magnetoreception in birds and other animals," **Journal of Comparative Physiology**, A (2005) 191: pp. 675-693.*

For example, birds have shown the ability to determine compass direction, though not the way you might think.

European robins, under caged test conditions, will consistently show their expected desire to head north in the Springtime. If prevented from seeing the Sun, or any landmarks, the birds are still able to consistently orient themselves northward, suggesting that they are given indications by the natural geomagnetic field. In attempting to determine how they do this, and what specific characteristics they respond to, various experimental conditions were tested.

If an artificial simulation of the local GMF was created, simulating all the same conditions of the GMF (only in terms of the three components discussed above), but rotated 120° to the east, then the birds showed that they wanted to go in that corresponding roughly southeast direction (**Figure 2b**). Initially, it seemed that the birds were determining their direction by a desire to head towards magnetic north, as they following the 120° shift.

However, we get a totally different response when a new artificial simulation is tried. When magnetic north still points towards geographic north, as in the GMF, but the inclination is inverted (pointing above, rather than below the horizon), then the birds go in the exact opposite direction, predominantly heading towards magnetic south (**Figure 2c**).

it is presumptuous to expect that we could grasp the extent of the "magnetoreception" capabilities of living organisms.

This indicates that the Robins don't determine their navigational direction by the magnetically polarity, but rather determine the inclination of the GMF, and use that to determine their migratory direction. For example, the inclination in the Northern Hemisphere points in a downward direction, and the amount it points downward depends on how close you are to magnetic North Pole.

Every species of bird that has been tested for this particular "inclination compass" has shown this specific ability. Sea turtles and salamanders also possess an inclination compass, whereas the only mammals tested for this ability (mole rats), as well as insects and crustaceans, did not respond to the inclination changes, but demonstrated a "*polarity* compass" (orientation based on the direction of magnetic north/south). Further tests were performed to determine how those that did, were able to use this inclination compass.

For example, intensity was tested. For robins that live in a local geomagnetic field of ~46,000 nanotesla (nT), it was shown in experimental tests with artificial geomagnetic fields, that they could not orient to their normal migratory direction if the intensity were either increased or decreased by ~20-30%. This showed that the intensity window at which the birds respond with their inclination compass is rather narrow. But, if the birds were exposed to a higher-intensity magnetic field for three days prior to testing, they could then orient properly at the higher intensity level, as well as at the normal intensity level, though not at an intermediate level, which they had not yet become accustomed to.

It was also shown that the magnetic compass function of birds is dependent on the right eye, specifically. When only the right eye was covered, they could not determine their migratory direction. But with the left eye covered, they could determine their migratory direction by using their right eye.

`Non-Compass Use of the Geomagnetic Field'

As we saw above, there is evidence demonstrating that animals can do much more than detect the inclination of the magnetic field to determine direction. From observations of their ability to navigate and home, it is clear that they need to know more than just a direction. Tests have long shown that birds could be released in locations completely unfamiliar to them, even when they were given no indication of what direction they had been taken in, and they could still find their way directly back home. This clearly requires, in addition to

being able to determine direction (compass), some way for the birds to determine their location. Using a compass to determine which way is north won't do you much good in trying to find your home, if you don't know where you presently are. For birds, among other animals, it has been demonstrated that this ability is also a magnetic sense.

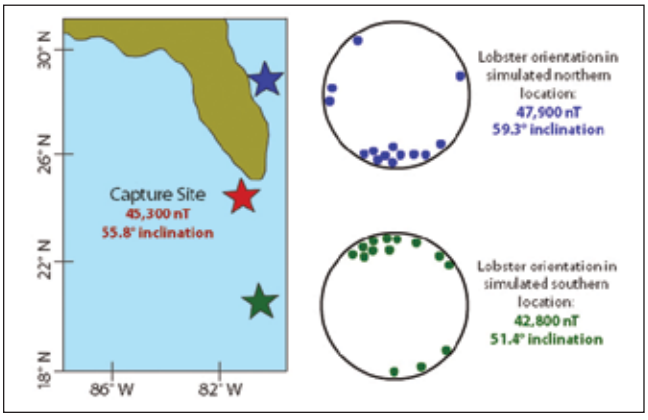
In addition to inclination, the other components of the GFM discussed, intensity and polarity (declination), change continuously as you move throughout the GMF.

To test the ability for animals to utilize these components to determine their position, numerous experiments were set up, including with lobsters. Captured off the tip of Florida, their home location has a specific GMF intensity, inclination, and polarity. They were kept in one location, but two groups were tested in two different magnetic environments generated to simulate the GMF at two different locations. One group was exposed to magnetic conditions which simulated a location directly north of their home, while the other group was exposed to a simulation of the magnetic conditions of a specific location directly south. No other stimuli were provided to simulate any difference in location. In the first group, the lobsters predominantly attempted to head south, which would be the direction of their home, if they were actually at the location indicated by the simulated magnetic conditions. Likewise the second group, exposed to magnetic conditions simulating a location south of their home, attempted to head north, even though they were geographically in the same location as the first group. In both cases, the synthetic magnetic indicators appeared to be enough to trick the lobster into "thinking" they were at the location that would be associated with those magnetic conditions (**Figure 3**).

Some birds have demonstrated an even more sophisticated ability to use the magnetic conditions of the GMF to not only determine their relative location, but also respond to the geographical characteristics associated with that location. They will react as if they had encountered those geographic conditions, even if only provided with the associated magnetic conditions.

The Autumn southerly migratory route of the central European pied flycatchers takes them from central Europe, not directly south, but first southwest, towards the Iberian Peninsula, allowing them to avoid the Alps. Then, after a certain distance, they make a roughly 90° change in direction, heading southeast. This helps to avoid the Sahara Desert. Domestically raised birds of this population were tested in caged environments,

FIGURE 3



The circles indicate the direction of individual lobsters. Image adapted from Wolfgang and Roswitha Wiltschko, op. cit.

where they remained in the same geographic location for the entire test period. During the appropriate migratory time, they showed an orientation to head in the expected southwest direction. They continued the desire to head in this direction only until they were subjected to an artificial magnetic field that simulated the magnetic conditions in Northern Africa. Then they immediately changed their orientation 90°, heading southeast. There was no change in visual or other stimuli, only the magnetic conditions.

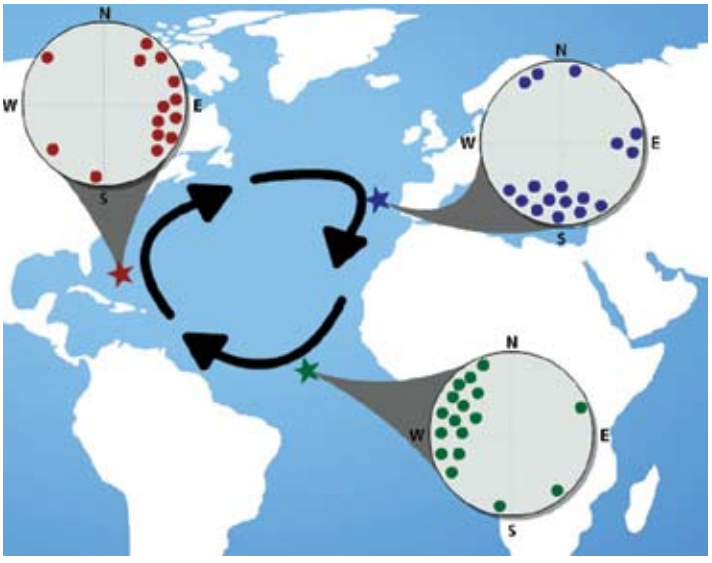
Note that there is nothing universal about the magnetic stimulation and the directional response of different species (i.e., there is nothing in the simulated magnetic environment in itself that indicates a particular direction for every animal). For example, if the lobsters were provided the same Northern African magnetic conditions, they would not have made the same directional change that the flycatchers did, but would have likely chosen the direction that would have brought them back to Florida.

Similar tests were performed with thrush nightingales caught in Sweden. In Autumn, while remaining in one location, they were provided with an artificial magnetic environment that simulated what they would have encountered on their regular migratory route, with no change in any other stimuli. Their eating habits and weight were monitored. They showed a slow, regular weight gain in the beginning period. However when the simulated magnetic environment matched that which would be felt in Egypt, the birds suddenly showed a dramatic increase in weight gain. This corresponds perfectly to their actual migratory trips, where they put on more weight prior to crossing the desert in Egypt, where there is a lack of food. In this experimental case, behav-

ioral responses were induced solely by the magnetic stimuli associated with a geographic location, with particular relevance to their migratory patterns.

This ability to use magnetic conditions as "magnetic markers" or "magnetic signposts," is not limited to birds. Juvenile loggerhead sea turtles from Florida show an interesting characteristic during the first years of their lives: They travel about the Atlantic Ocean, but always stay within the particular region known as the Atlantic gyre. So, hatchling turtles of this grouping were tested to see whether this ability depended upon magnetoreception. As in the cases of birds and lobsters, the turtles were kept in a single location, but were provided with three different artificial magnetic environments, simulating the magnetic conditions of three locations on the edge of the gyre. In each of the cases, the hatchling turtles oriented in the proper direction that would keep them within the gyre, had they actually been at the geographic locations that the simulated magnetic conditions indicated. As hatchlings, they obviously had never experienced the extent of the Atlantic gyre, so, in addition to the ability to navigate by magnetic conditions, they were seemingly born with some form of magnetic map of the Atlantic Ocean (**Figure 4**).

FIGURE 4



The three different locations the artificial magnetic conditions simulated. The circles indicate the direction of individual turtles subjected to the artificial conditions indicated. Image adapted from Wolfgang and Roswitha Wiltschko, op. cit.

Proposed Mechanisms, Exposed Paradoxes

The question remains, how are these animals able to sense the magnetic field?

Certain mechanisms have been proposed and investigated which seem to be involved in the organisms ability to respond to the GMF, though how exactly these function is still unclear. As we will see, it is much more interesting than can be explained by the reaction of a single mechanism to a magnetic field.

Structures of the biogenic mineral magnetite have been found in various organisms, and have been studied as a possible way for organisms to detect the GMF. One report said that various forms of magnetite structures were so diverse that they were found in "species belonging to all major phyla."[10] However, there is still no comprehensive picture of how these structures might operate.

In attempts to test the nature of these magnetite structures, experiments were devised to determine whether disrupting their magnetic polarity would affect the magnetoreception ability of the organism. In tests on birds, a strong, very short magnetic pulse was employed at the beaks of Australian silvereyes, under the hypothesis that this would alter the magnetization of the magnetite (for birds, the magnetite structures are found in the beak). The pulses were 3 to 5 milliseconds in length, and around 10,000 times the strength of the natural magnetic field. As expected, prior to the pulse, the birds oriented to their appropriate northerly migratory direction. After the pulse, their orientations were shifted east 90°. The eastern tendency lasted about three days, followed by about another seven days of general disorientation, after which the birds were able to regain their normal migratory ability.

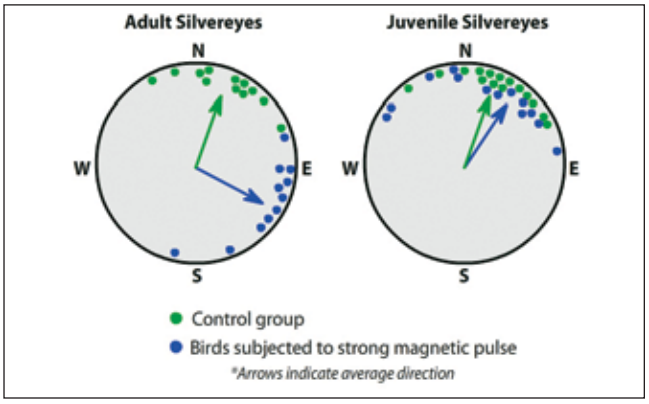
These results were not uniform, however. What was interesting is that only *adult* birds which had migrated before were affected by the pulse. *Juvenile* birds of this species, which had never experienced a migration, were not affected, and most had no difficulty finding their proper migratory direction (**Figure 5**).

The conclusion drawn was that the magnetite structures could play the role of some form of magnetic map, built up over time. The experienced birds seemed to rely upon this map, whereas younger birds had not developed a map, but could still orient to the magnetic field by another mechanism.

In an elaboration of this experiment, adult birds

10. See Wolfgang and Roswitha Wiltschko, "Magnetic orientation and magnetoreception in birds and other animals," *Journal of Comparative Physiology,* A (2005) 191: 675-693.

FIGURE 5



Adult silvereyes were disoriented by the magnetic pulse, but juveniles are not. Image adapted from Wolfgang and Roswitha Wiltschko, op. cit.

were subjected to the same intense magnetic pulse, but then, prior to having their migratory ability tested, they had a local anesthetic applied to their beak (the location of the magnetite structures). In this case, the birds could again orient in their proper migratory direction with no problem, despite the fact that they had been subjected to a strong magnetic pulse.

Thus, evidence indicates that the magnetite structures located in the beak are likely involved in the magnetoreception capabilities of birds, but they cannot account for everything. The birds were clearly able to rely on another aspect of magnetic sense, relating to the "inclination compass" ability discussed above (given its light-dependent nature and relationship with the eye, instead of the beak).

Further tests on other animals have shown that this light dependence is not limited to birds. For example, salamanders. Simply covering either the left eye, or the right eye, or both, did not disrupt the salamander's ability to use its inclination compass ability. It was only when the pineal gland (the so-called "third eye") was covered, even with both eyes open to the light, that the salamanders became disoriented.

In the mid 1970s, experiments with certain chemical reactions in the laboratory showed a sensitivity to low-level magnetic fields. The reactions required light, and the resulting chemical reaction could be changed by the application of an external magnetic field. Such experiments were supposedly explained by certain spin chemistry models.

The question was raised, "Could such chemical reactions be occurring *within living organisms*, enabling them to sense the GMF?"

A few general characteristics of such a process could immediately be tested, to see if this would affect the magnetoreception ability of birds and other animals.

Most obvious was light dependence. As we saw, tests showed that birds required light for their "inclination compass" ability, but, it was also shown that it only worked under specific colors and intensities of the light (this will be discussed in greater detail below).

A second experimental test was devised. Based on the spin chemistry model, it was claimed that an oscillating magnetic field (with rapid variations in its intensity), even if the changes are very slight, should disrupt the process, but only if the oscillation frequency is at just the right value. The idea was that if the low-intensity oscillations in the magnetic field disrupt the magnetoreception of the animals, that would be evidence for this particular mechanism.

This effect of disrupting the magnetic sense was first demonstrated in birds, where magnetic field oscillations of amazingly weak intensity, variations as low as 5 to 15 nT (0.01% of the average normal intensity of the GMF), but at just the right frequencies (in the range of 0.1 to 10 MHz), did disrupt their magnetoreception, and lead to general disorientation.[11] This was also demonstrated with tests on cockroaches (yes, they have magnetoreception too), where extremely low-intensity, but precise-frequency oscillating magnetic fields disrupted their inclination compass ability, leading to general disorientation.

The interaction of the low-level oscillations with some process relating to the magnetoreception ability of the animals provides a useful piece of evidence. The disruption indicates a resonance, which means that the question can be inverted, and we can ask, "*What characteristics can we know about the quality of the affected process, based upon the characteristics of the low-intensity oscillation with which it is interacting?*"

At this point there are no definite conclusions that have been made about how this process functions for

11. Imagine if the brightness of the lights in your room was decreased by one ten-thousandth of their current level, and then increased to the same amount above the initial level. If this was done in rapid succession, would you notice? Within a magnetic field, this type of fluctuation in the intensity, even at such a low level of change, is enough to disrupt the magnetic sense under investigation here. This magnetic case falls under a class of "weak force" phenomena, whose significance is not determined by a scalar value of intensity, but by a geometric question of resonance, in which harmonization with the quality of a process is what enables an interaction. Contrast this with the failure of the limited conception that interactions are only determined by quantity levels, a "brute force" approach.

the organism. In fact, only within the last decade has there been evidence for a specific light receptor within the organism which could play this role. Absorbing light in the blue range of the spectrum, cryptochrome was discovered in 1998 (initially for its likely role in circadian rhythms in plants).

Since then, it has been found in a wide range of organisms. To test for its possible involvement in magnetoreception, experiments were performed with plants (*Arabidopsis thaliana*) and fruit flies. Both showed sensitivity to magnetic fields (certain characteristics of the plant's growth were shown to correspond to the magnetic field intensity; and the flies' magnetic sense could be used to train them to seek out a magnetic field, based on associating it with food), and in both cases, the response to the magnetic field required light in the blue range of the spectrum. But, when genetic modifications of the flies and plants without the genetic material associated with cryptochrome were created, they were no longer responsive to the magnetic field at all.

The evidence indicates some relation to magnetoreception, but what exactly is occurring is still unclear, and even the biggest names in support of this model won't claim that anything is proven yet. Still, another potentially interesting point comes up here.

The light-dependent nature, and the characteristic disruption under a low-intensity oscillating magnetic field of the proper frequency, are claimed to support the idea that this light-dependent mechanism could relate to some chemical process (interaction in the small).

However, we do not know whether the quality of such an interaction would be replicable outside of a living process. That is, we cannot assume that the characteristics of abiotic chemistry or physics, as presently understood, will be sufficient to express how the interaction of light and an external magnetic field in the small, *within the process of a living organism,* might provide a reading of the GMF, or at least be involved in doing so. It is important not to limit the investigation to models defined solely by abiotic physics.

Assuming that this aspect of magnetoreception does involve a chemical reaction, the following sets of tests could provide interesting experimental grounds for how the interaction of light and magnetism with chemical processes within living organisms might operate. The results reported below expose some fundamental problems in trying to pin the magnetoreception ability of organisms to a specific mechanism.

Light-Dependence

The experimental work discussed so far led researchers to two distinct mechanisms for magnetoreception, each with distinct characteristics. For example, here is a quote on magnetoreception from a 2008 book on photobiology:

> Animals can detect different parameters of the geomagnetic field by two principal independent magnetoreception mechanisms: (1) a light-dependent process detecting the axial course and the inclination angle of the geomagnetic field lines, providing the animals with magnetic compass information (inclination compass), and (2) a magnetite-mediated process, providing magnetic map information (map sense).[12]

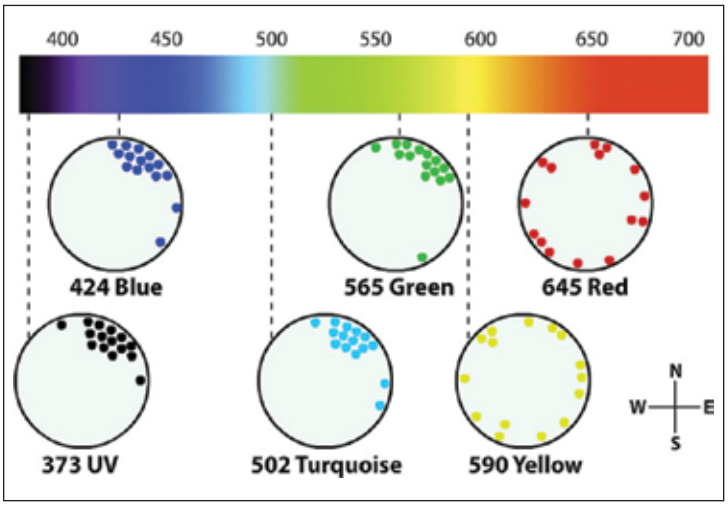
The experimental evidence presented here indicates that the receptive ability associated with the map-like magnetoreception ability of birds is associated with the beak, and is disrupted by a strong magnetic pulse. The "second," supposedly independent, vision-related function (the "inclination compass") has distinct, different characteristics. First of all, it is light-dependent, and limited to the right eye specifically. It is not polar, but determines the inclination of the magnetic field; it operates in a narrow window of intensity levels (unless the bird is conditioned to a different level); it is disoriented by low-intensity MHz-range oscillating magnetic fields; it is not affected by anesthesia of the upper beak, and is not affected by a strong magnetic pulse. However, despite the seeming distinctness, experimentation indicates a complex interaction between the two. To get to that, the nature of the light-dependence of the "inclination compass" has to be examined.

First it was shown that the light-dependent process in the birds' right eye *would only work under certain colors of light*.

If birds were tested in light from the blue-green side of the spectrum, they would be able to orient to their migratory direction without problems. In the extensive tests with European robins in blue or green light, they would orient to the North in the Spring and to the South in the Autumn, just as if they were in the wild. Even in UV light (at 373 nm), the robins were able to find their proper orientation. However, when yellow and red light

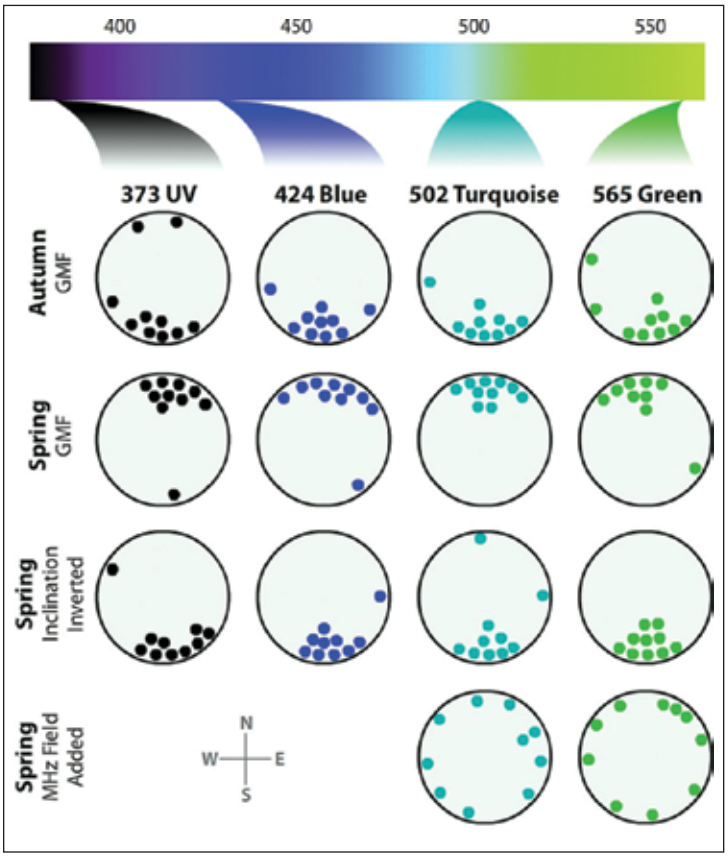
12 *Photobiology: The Science of Life and Light* (Springer Science+Business Media, LLC, 2008)

FIGURE 6



Birds' orientation to different monochromatic colors of light. Image adapted from Wolfgang and Roswitha Wiltschko, op. cit.

FIGURE 7



Birds' orientation to monochromatic colors combined with a very low-intensity oscillating magnetic field. Image adapted from Roswitha Wiltschko, Katrin Stapput, Peter Thalau, and Wolfgang Wiltschko, "Directional orientation of birds by the magnetic field under different light conditions," R. J. Soc. Interface (2010) 7, pp. S163-177.

were used, the birds showed a general chaotic disorientation (**Figure 6**).

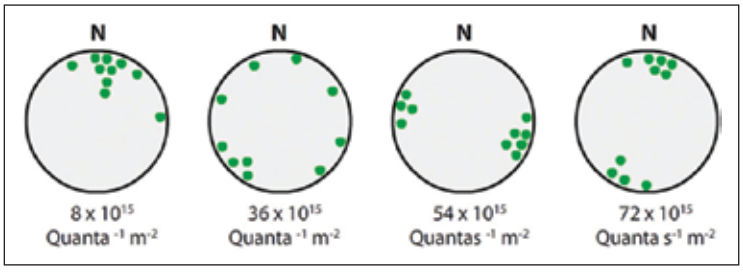
In each of these cases, single color (monochromatic) light was used.

This indicates that the light-dependent magnetoreception is only activated by the UV to green part of the spectrum, and fails to operate properly in the yellow to red range. As we saw above, this light-dependent response is related to the inclination compass, where the birds use the inclination of the magnetic field to determine direction (e.g., if the inclination of the field is inverted, the birds will go in the opposite direction, even though the directions of the north and south components of the magnetic field remain the same). Also, recall that this light-dependent magnetoreception is disrupted by a very low-intensity oscillating magnetic field of the proper frequency. These characteristics were tested, and demonstrated for monochromatic UV, blue, turquoise, and green light tests (**Figure 7**).

However, these monochromatic tests were all performed at rather low light intensities. For each of the tests using monochromatic light, the intensity level was roughly equivalent to the brightness experienced around half an hour before sunrise, or after sunset. Tests with birds in bright daylight, where they experience the entire visible spectrum at the same time, showed that they have no trouble using this light-dependent magnetic sense in the bright daylight. But, using the narrow ranges of the monochromatic lights, they showed interesting problems with increased light intensity.

Still, at intensity levels far below that experienced on a sunny day, using monochromatic light, the birds started showing peculiar responses. In tests with robins under green light, at a low intensity ("$8*10^{15}$ quanta/s/m^2"), they oriented in their proper migratory direction, north in this case. When the intensity of the green light was increased ("$36*10^{15}$ quanta/s/^{2}") they showed general disorientation. When increased further ("$54*10^{15}$ quanta/s/m^2") a curious response emerged, they showed a tendency to orient either east or west specifically. When the intensity of the green light was increased more ("$72*10^{15}$ quanta/s/m^2"), they now preferred either north or south. Even with the highest intensity tested here ("$72*10^{15}$ quanta/s/m^2"), it is still only the level of brightness experienced around sunrise or sunset. This new phenomenon was iden-

FIGURE 8



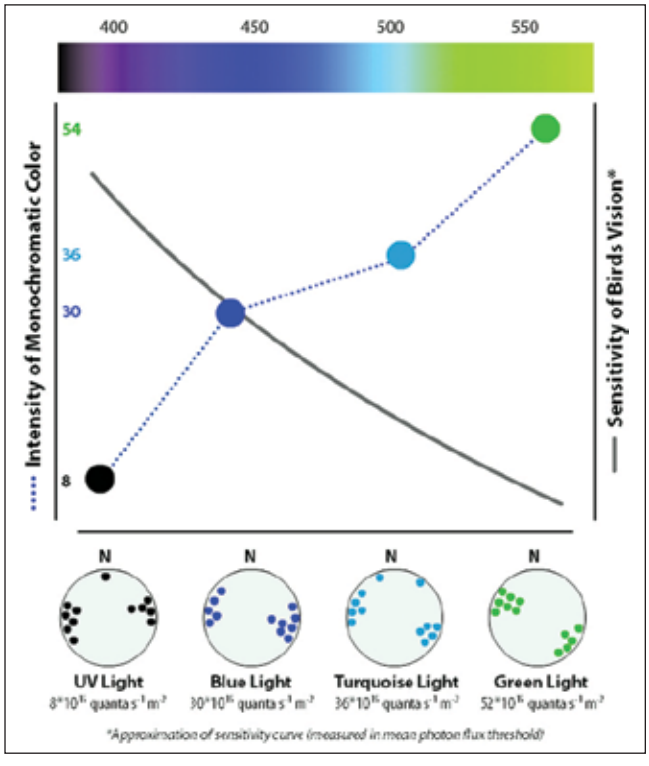
Direction of birds at successively higher levels of intensity of green light. Image adapted from Roswitha Wiltschko et al. (2010), op. cit.

tified as an "axial preference" (**Figure 8**).

Because the intensity was still far below that of noon on a normal day (where the birds have no trouble orienting), this could not be just an over-saturation of the birds' vision. At least, not in a simple sense. And this is more than general confusion, because the birds were not just generally disoriented, but predominately chose a certain axial direction, one different than their expected migratory direction. Again, the axial direction changed with different intensities, and it was found that to obtain the same axial direction at different colors (e.g., east-west under green light and then under blue light), the intensity level had to be different. It was shown to get a general east-west directional response in successive colors (UV, blue, turquoise, and then green, in that order), the respective intensity had to be higher in a corresponding manner (**Figure 9**).

It is worth noting that this relationship of the intensity and color roughly corresponds to the sensitivity of the different light cones of the birds' eyes. That is, the intensity level at which a certain fixed-axis response is induced gets lower, as you move from green towards UV light, just as the sensitivity of the birds' receptor cones is said to increase as you move from green to UV light.

FIGURE 9



Comparison of the general change in the sensitivity of birds' vision at different colors of light, with the intensity at which the same fixed-direction response is induced at different colors. Image adapted from Roswitha Wiltschko et al. (2010), op. cit.

Mixing Colors

A last set of tests pushes the understanding of the nature of the magnetoreception capability in birds to an unexpected paradox.

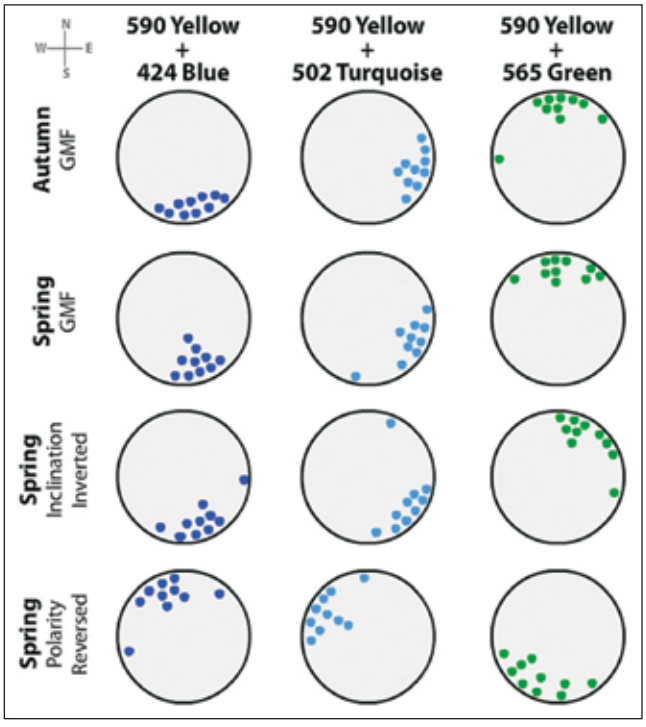
What we have seen is that under low-level monochromatic light from the UV to green range, the light-dependent magnetic response of birds functions; but it does not function under yellow-red light, under which the birds orient randomly. Now, in a new set of tests, when low-level turquoise light is added to low-level yellow light, a new response appears. The birds do not choose their natural migratory direction, as under the turquoise alone (or under normal daylight), but they are not simply in a general disorientation, as occurs under the yellow light alone. Rather, they *all* choose to orient in one specific direction that is not the expected migratory direction. They all tend to a southeast direction, in both the Spring and Autumn, whereas under normal light conditions, they orient south in the Autumn and north in the Spring. Because of this same direction in both Spring and Autumn, this was identified as a "fixed-direction response."

First of all, this indicates that yellow light dose not simply have a null effect for the birds, but does interact with the magnetic reception process in some way. Next it was demonstrated that the actual direction of the "fixed-direction response" depended upon what colors are mixed with the yellow. For example, yellow-blue induces south, yellow-green north, and yellow-turquoise east-southeast.

Now things get strange.

So the fixed-direction response is light-dependent, because the light quality determines its direction. How-

FIGURE 10



Under each respective color pair, the birds choose different fixed directions, but in each color pair, they choose the same fixed-direction in both Spring and Autumn. When the vertical component of the magnetic field was inverted, the birds did not respond differently, as is the case under normal light conditions. But, when the polarity direction is rotated 180°, then the birds shift their fixed direction by the same 180°, even though they did not do this under normal light conditions. Image adapted from Roswitha Wiltschko et al. (2010), op. cit.

ever, the following set of tests demonstrates that it shows characteristics *opposite* to the normal light-dependent magnetic orientation of birds discussed above. Recall that normal light-dependent magnetic orientation was shown to be dependent on the inclination of the magnetic field and not the polarity (declination). However, this fixed-direction response was shown to be the same when the inclination was inverted, but reversed when the polarity was reversed. That is, showing the opposite characteristics of the normal light-dependent response (**Figure 10**).

Again, it might be tempting to dismiss this by saying that the birds are just confused. But what is interesting is that there is an order to their confusion, in that they are still consistently choosing certain directions.

In fact, the fixed-direction response, though clearly light-dependent, seems to lose all the characteristics that were found to correspond to the birds' normal light-dependent magnetic sense. What follows are the results of another series of experiments.

- The normal light-dependent function was dependent upon the inclination of the magnetic field, but not the polarity; the fixed-direction light-dependent response is polar and not sensitive to the inclination.
- The normal light-dependent function was disrupted by low-intensity oscillations in the magnetic field intensity; the fixed-direction light-dependent response is not disrupted by those effects.
- The normal light-dependent function functioned in a narrow intensity window (roughly +/–20-50% of the local GMF intensity); the fixed-direction light-dependent response does not have a limited intensity window, but occurs over a wide range of intensities.
- The normal light-dependent function is not disrupted when anesthesia is applied to the upper beak—that is, the location of the magnetite structures associated with the "other" ability of the birds to perceive the magnetic field. But when anesthesia is applied to the beak, the fixed-direction light-dependent response ceases to function, and there is a general disorientation, as opposed to a fixed direction.

So even though it is clearly demonstrated that the fixed-direction response is, in some way, light-dependent, it also seems to rely on this other mechanism of the magnetite structures in the beak, which had no indication that it was light-dependent in any way (there is no light-dependence in any of the theories of how the magnetite structures might function).

Magnetoreception in the Sensorium

An immediate implication from the preceding evidence is that there is some form of complex interaction between two magnetic reception abilities—or at least what had been presented as two distinct abilities. Perhaps it is wrong to view these as distinct. Rather, they may be aspects of one system. For example, the human eye uses three different cones to detect different wavelengths of light, but you see the three different cone readings as one sense. Taking this into view, perhaps there are other mechanisms involved in magnetoreception as well, ones that we are not yet aware of, all of which could become integrated into one sense for the bird.

This also appears to go beyond just a magnetic sense as such. These sets of experiments with intensity of monochromatic light and mixing of different color lights, indicate some form of interaction between the bird's magnetoreception and its visual system. Recall two indications of this.

First, in tests with various intensities of light, certain

fixed axis responses were induced, whereby the birds consistently chose to go in a specific direction, even though it was different than their expected migration. Recall, that direction changed with the different intensity levels of the light, and the different color mixtures of light. When comparing the different colors and intensity levels at which a specific direction of fixed-axis response was induced (for example the desire to head east or west), there was a similar relationship between that intensity-color relationship, and the general sensitivity of the bird's normal vision to different colors. That is, as the light source moves from green to UV light, the intensity level of light required to induce the same fixed-axis response (e.g., east or west) becomes less and less—which generally corresponds to the fact that the receptor cones of birds are supposed to become more sensitive as you move from green to UV light (see Figure 10, above).

In the second case, under low-intensity monochromatic light, the birds could properly orient to their migratory direction under light from UV to green, but under yellow and beyond, they became generally disoriented, choosing no specific direction. The simple interpretation would be that magnetoreception requires light from the UV to green range to function, and it does not function under other wavelengths, implying that under yellow light, the birds' magnetic sense is simply not activated. However, it does not appear to be that simple. When two colors were mixed, for example green and yellow, the yellow no longer appeared to have a null effect, as the birds chose a particular fixed direction (which was different than their expected migratory direction), whereas, if the yellow did simply have a null effect, then it would be expected that the bids would still orient to their proper migratory direction under a green and yellow mixture.

It is worth noting that the molecule proposed to be the one reacting to the magnetic field, cryptochrome, is responsive to light in the blue range, and not the yellow to red range. This leaves presently no mechanical explanation for why the addition of the yellow light would have any effect at all.

These results indicate that there is possibly some interaction between the birds' "vision" (as we tend to understand vision) and their magnetic sense. Perhaps they are not two distinct senses for the birds? Perhaps it is more of a mixture, maybe similar to what we call synesthesia in people, which we identify as seemingly unexpected mixtures between our senses.

The other useful point of departure for future investigation based on what has been presented here, is a potential basis for the study of light-field-chemical interactions within a living process.

If we leave behind the assumption that the reactions occurring within a living process can be reduced to the characteristics of the non-living, the evidence for some form of reactions in the very small being involved in magnetoreception can been seen in a new light. Perhaps the tests involving different colors and intensities could provide new grounds for experimentation on interactions in the small, within a living process.

However they are able to do it, this remarkable ability of the widest variety of living organisms to sense the invisible and changing landscape of the GMF surrounding us at all times, when taken to the extreme of present knowledge, presents questions which are likely more universal across all aspects of what we consider "senses."

When the exact mechanisms and processes by which different living beings are able to detect and utilize the magnetic field are sought out, the investigation leads to some of the same standing questions regarding what sense perception really is. The demonstrated paradoxical interaction between what are said to be different mechanisms for magnetic perception in birds, and the likely general interaction of vision, indicates that the senses are not self-evident and distinct "data readings," as one might be led to believe.

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Electric and Magnetic Senses in Humans

by Sky Shields

…Heard melodies are sweet, but those unheard
Are sweeter; therefore, ye soft pipes, play on;…
—from John Keats, "Ode on a Grecian Urn."

With a number of elements now in mind—the recognition of the impossibility of attributing "five senses" to the human individual, and the deep connection which exists between various forms of animal life and the incredibly complex network of electromagnetic and other phenomena which we have referred to collectively in this report as "cosmic radiation"—we now turn to some of the very interesting topics which we will face over the course of the next several decades of human development.

As mentioned elsewhere in this report, mankind's successful expansion into the Solar System will require a very different concept of the relationship between biological processes and their electromagnetic environment. It will require a better understanding of the biological aspects of electromagnetism, and the recognition that, among the bodies of our Solar System and beyond, there is no "empty space." There is, rather, an intricate, ever-changing, anti-entropically evolving, dynamic system of cosmic radiation, which might be likened in its character to cell cytoplasm, whose dynamic character is equally difficult to account for, and which is likewise often ignored in favor of an examination of the easier to characterize organelles which it contains. Our first brush with this, however, will come very clearly as a result of the first steps which humanity will take in connection with the North American Water and Power Alliance (NAWAPA), and its further migration poleward.

Sensing the Cosmos

There are reports going back hundreds of years, of people "hearing" the Aurora Borealis, including studies by Benjamin Franklin, and a discussion by Alexander von Humboldt in his *Cosmos*. Usually, they describe either a rustling sound, or static, or "dry leaves," and this is usually combined with specific other conditions: especially bright auroras, and usually exceptionally cold days. Only certain people report being able to hear these, however, and *no recording device picks up the sounds as described*, which has occasionally led to people being ridiculed, whenever they bring up the subject. The effect has now, however, been verified by repeated experiments, using human test subjects, instead of recording devices, and it is no longer questioned as to its veracity. The cause, however, is unknown.

There are physical reasons that the aurorae *should not* be able to produce what is typically (erroneously) described as sound—i.e., the vibration of the air—considering that the portion of the atmosphere where they occur is much too thin to be able to transmit sound waves. This implies both that something other than air vibrations is being transmitted as a result of the Sun's interaction with the Earth's poles, as well as that, what human beings experience as sound, includes more than the vibrations which are picked up by recording devices. The implications for recorded versus live music are obvious. It would also be interesting to investigate whether the sound produced by the human singing voice contains similar non-vibrational, possibly elec-

NASA

There are numerous reports, going back thousands of years, of people "hearing" the aurorae and also, meteors, including those in ancient Chinese chronicles, which describe the sounds, poetically, as "like a flock of cranes." Yet, there is no empirical confirmation of these reports. What is it that accounts for such "extrasensory" phenomena?

tromagnetic aspects.

Related to this, and likewise unexplained, is the fact that people can "hear" meteors. There are observations going back over a thousand years,[1] such as those recorded in ancient Chinese chronicles, which describe sounds "like a flock of cranes," simultaneous with a meteor's passage.

Edmund Halley reported, in 1719, that multiple observers claimed to have heard a meteor "hiss as it went along, as though it had been very near at hand." However, the location of the observers, combined with the angle at which they reported seeing the meteors, required that the meteor be much too high for the sound to arrive simultaneously with the visual appearance of the meteor. In fact, the altitude of the meteor, at the point at which such sounds are heard, is between 80-100 miles, roughly where they would be passing through the Earth's ionosphere. If sound were capable of being transmitted through such a thin atmosphere, it would still require upwards of five minutes to reach an observer on the ground, long after the meteor had faded from sight. That is, the sound of meteors does not follow the lightning-thunder rule, which most people use to estimate the distance of a lightning strike, where the time between seeing a lightning flash, and hearing thunder, is a result of the fact that light travels faster than sound. In the case of meteors, although there is often a more traditional sonic boom which is heard several minutes after the meteor's passage, there is another sound which is heard simultaneously with the observation. This means that the "sound" is traveling at the same speed as the light, suggesting that this could be another case of the direct perception of electromagnetic radiation, similar to what occurs with the aurorae and microwave hearing.

Because of the paradoxes involved, a number of prominent figures, including Halley, sought to dismiss such sounds as imaginary. As with the aurorae, many people claimed that the sheer impressiveness of such a sight—a heavenly fireball, since the loudest sounds seemed to be associated with the brightest of them—should be enough to provoke an imaginary sensation of sound. Further, said Halley, "Others imagin'd they felt the Warmth of its Beams, and some there were that thought, at least wrote, that they were scalded by it." This latter was enough for Halley to dismiss the sensation as fictitious.

Along with the reported sounds, however, those physical sensations connected to meteor passage continued until the present day, with a 1977 account describing a warm "puff of wind . . . towards the end of the duration of the sound," and others describing similar tactile phenomena, such as perceived changes in air pressure and vibrations of the air,[2] or "a slight electric shock."[3] Further, and probably even more inexplicable to Halley, there are several reports of the sensation of specific smells—sulfur and ozone—occurring simultaneously with bright meteors. This smell, and the fact that it occurs simultaneously with the appearance of the meteorites about a 100 miles away, points to the likelihood of an electrical disturbance which propagates through the atmosphere at the speed of light, in the form of electromagnetic waves. The smell of ozone is possibly the effect of intense ionization of the atmosphere in the vicinity of the observer. These electromagnetic effects within the atmosphere, far from being accidental, may play a very important role in the organization and evolution of the entire Biosphere, as will be discussed below.

The specific characteristics of such sounds also make clear the impossibility of their being imagined. Observers have repeatedly described being prompted to look up at a meteor, after first hearing it. Other observers have described hearing the sound of the passing meteor from within their houses. One observer describes being "compelled" to rise from his bed and look out of a window in time to see and hear several meteors, and this report is not the only one of its kind.[4] Chickens and dogs have also been known to exhibit alarm prior to a meteor strike, despite not having observed the meteor directly.[5] This fits with the known behavior of both chickens and dogs with regard to lightning strikes, where both become alarmed shortly before a strike, including at least one case in which a researcher observed a dog barking at the location of a strike before it occurred.[6] This indicates again that the meteor strike must be having an electromagnetic effect similar to that of a lightning strike.

1. http://www.gefsproject.org/electrophones/index_history.html

2. D.Vinkovic et al., "Global Electronic Fireball Survey: a review of witness reports—I." WGN, *Journal of the International Meteor Organization,* 2002.

3. M. Romig, D. Lamar, "Anomalous Sounds and Electromagnetic Effects Associated with Fireball Entry," ARPA Memorandum RM-3724-ARPA, 1963.

4. D. Vinkovic et al., op. cit.

5. Romig, op. cit.

6. A. McAdie, "Phenomena Preceding Lightning," *Monthly Weather Review*, 1928.

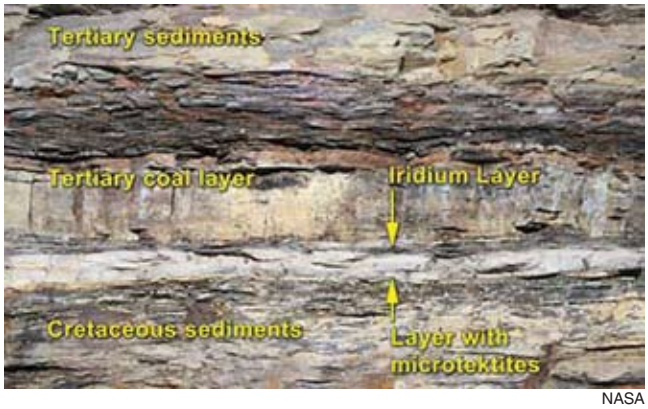
That the sounds observed by meteors also have such an electromagnetic character is supported by the fact that in the case of lightning strikes, a small "vit" or "click" sound can often be heard simultaneously with the strike, much earlier than the time it eventually takes the peal of thunder to reach the listener. One explanation being put forward for this phenomenon, besides a direct perception on the part of the observer, is called electromagnetic transduction, and states that objects in the hearer's immediate environment may be resonating with the electromagnetic disturbance created by the meteor or aurora, and converting the disturbance into sound waves via their own vibrations. This would be somewhat different than directly "hearing" the electromagnetic effect, but might be even more interesting from the standpoint of the ability of the Biosphere to resonate with these sorts of phenomena.

There are several problems with the specifics of this theory, however. As in the case of the aurora, actual audio from a meteor has yet to be recorded. Because of this, it cannot be said that the sound produced is of the "traditional" sort, carried by vibrations in the air. Also, as with the aurora, in groups of several observers, it is often the case that only some of them will hear the associated sound, though there is always great qualitative agreement among those who do report hearing it, even when they are spaced as far apart as opposite sides of a city or small country.

Either way, it is clear that what is being sensed as sound by the listeners in all of these cases—fireballs, the aurora, lightning, earthquakes, etc.—is connected to major disturbances involving large sections, and perhaps the entirety, of the Earth's electromagnetic environment. Colin Keay's theory involves a very interesting description of the turbulent plasma generated in the wake of a meteor as it passes through the extremely active plasma of the Earth's ionosphere. This is the height—70 to 110 miles above the ground—where the meteors are observed at the same time that anomalous sounds are perceived, and it is the same region where the ionized particles which are supposed to be driven into the Earth's atmosphere, due to its interaction with the Sun, produce the effect seen and heard as the aurora.

Meteors as Organizing Agents

Interesting in connection with this, is the extinction event which "killed off the dinosaurs," and which constitutes the transition between the Cretaceous and Tertiary periods—the K-T boundary. Evidence from the fossil records shows a "sudden" increase in the element iridium, typically found on incoming meteorites. For this, and other reasons, the extinction of the dinosaurs is now generally agreed to have been at least partially the result of a major asteroid impact. However, the increase and decrease of iridium in the fossil records, though sudden, on geological timescales (a period of 100,000 years), is actually much more gradual than one would expect for a single large impact, and other evidence points to the possibility of an extended interaction with an extraterrestrial source.[7] Likewise, the patterns of extinction and emergence of new species indicate that something more unusual may have taken place during that entire span.[8]



NASA

The geological transformation at the boundary between the Cretaceous and Tertiary periods (K-T boundary) is very sharp, and it is marked by a layer of iridium, thought to be extraterrestrial in origin.

For us, it is also interesting to note that the K-T boundary falls neatly within the 62My (million-year) cycle discovered by Rohde and Muller (within 2My of the center of the cycle, which may correspond to the passage of our Solar System through the galactic plane).[9] This implies that whatever event caused the massive change at the K-T boundary was not a random collision, but rather part of a much larger process of

7. M. Wallis, "Exotic Amino Acids Across the K/T Boundary—Cometary Origin and Relevance for Species Extinction," *International Journal of Astrobiology*, 2007. Wallis is not presenting the argument I am making here, but his paper is very interesting in this context, and in the context of what follows.

8. For an interesting survey of the disputed details around the K/T mass extinction, see N. MacLeod, "K/T Redux" *Paleobiology,* 1996.

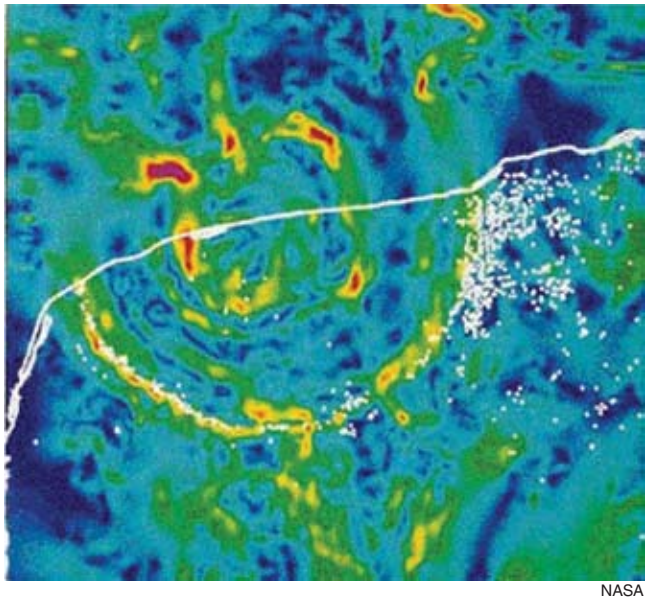
9. Sky Shields, "Kesha Rogers' Victory Signals the Rebirth of a Mars Colonization Policy," *EIR*, March 19, 2010.

On June 30, 1908, a mysterious object—producing the same anomalous sounds as heard from meteors—detonated, felling trees in a 40 km radius, in Siberia. From its effects, the energy released in the blast is believed to have been several orders of magnitude greater than the atomic bomb dropped on Hiroshima. Unusual growth patterns have been observed near the blast epicenter, and along the observed flight path of the object. Shown: The "Tunguska event," which flattened a Siberian forest.

creative evolution.

Given the sensitivity of living processes to electromagnetic effects of the sort connected to meteor impacts, what would be the effect of a long-term interaction such as that which bridges the K-T boundary? An interesting discussion of the potential biological ramifications of the electromagnetic phenomena connected to a meteor impact was carried out during the decades that followed the mysterious Tunguska event in Siberia.[10]

Although the evidence there is not conclusive, there is much other evidence that rapid growth, such as that observed at the Tunguska site, is positively related to exposure to the same sort of low-frequency electromagnetic phenomena as those hypothesized to be generated by electrophonic meteors (although at higher intensities),[11] and has been theorized to account for the gigantism observed during the Cretaceous period, and which ended abruptly (in geological terms) at the K-T boundary.[12]



NASA

Like most major craters on Earth, the Chicxulub crater (shown here) cannot be seen, because it has been covered over by Earth's incredibly active biosphere, but it can be viewed as a gravitational anomaly, as in this gravity map. The crater underneath the Chesapeake Bay, near Washington, D.C., is likewise invisible, though it may be responsible for the much later formation of the Bay, 18,000 years ago.

It is very interesting to note, in this context, that continuing the cycle another 62My from the K-T boundary finds another major evolutionary change—the appearance of *Homo habilis*, or tool-making man. This coordinates with the first evidence of the emergence of the Noösphere—the subjection of the Biosphere to the dominance of willful creativity, in the form of the creative human individual—within major intergalactic processes. Further investigation will have to determine whether or not this is coincidental.[13]

In general, this should not come as a surprise. As reflected in the central theme in this report, animal navigation and physiological function, in general, are closely tied to such long-term cycles and electromagnetic effects. Also, the Biosphere is not a passive player in these effects. There is reason to believe that a signifi-

10. Z.K. Silgadze, "Tunguska Genetic Anomaly and Electrophonic Meteors," *Acta Physica Polonica B,* 2005.

11. Anomalous, electrophonic sounds were reported by observers up to 100 km from the flight path of the Tunguska object. Cf. Romig, op. cit., p. 13.

12. T. Nishimura, K. Mohri, M. Fukushima, "The Mystery of the Dinosaurs: The Earth's Electromagnetic Field May Explain Their Giantism and Extinction," *Viva Origino,* 2009.

13. If you'd like something else interesting, take the two events—the K-T extinction and the appearance of *Homo habilis*—which are roughly 62My apart, and then look at their half-way point, which should correspond to another mid-plane crossing. There, we find a sharp singularity which corresponds to the sudden appearance of an ice sheet in Antarctica, the mass extinction of most species on that continent, and the beginning of the Oligocene. This correlates likewise to a meteor bombardment which included the giant bolide which created the impact crater that now lies deep beneath the Chesapeake Bay, just east of Washington, D.C.

cant portion of the perturbations in the Earth's magnetic field is attributable to long-distance flows within the Earth's oceans.[14]

Further, there is also reason to believe that up to one-third of the motion within the Earth's oceans is attributable not to wind, or simple heat convection, but rather to the motion of large masses of various sea creatures.[15] The more significant of these creatures may also follow migratory patterns, which themselves are already determined by the Earth's magnetic field (whose source is still unknown), such as the sharks and sea turtles mentioned elsewhere in this report. Apart from that, it is enough to note that the Earth's oceans and atmosphere are entirely the creation of life, and their composition is far from accidental. The result is that we are driven to recognize that the Biosphere is largely an electromagnetic phenomenon, more so than has heretofore been recognized.

The atmosphere whose charge differentials create the stunning phenomenon of lightning is entirely a creation of living processes. Likewise, this same atmosphere, produced by life, is the active player in auroral displays and the meteor effects we have discussed so far. Without the action of life, there would be no large-scale electromagnetic effects of meteorite collisions with the Earth, and the Earth's visible aurorae would not exist. It is even plausible to hypothesize that, without life, the Earth's peculiar and active magnetic field—whose source is still entirely unknown—would not exist.

We must consider that these electromagnetic effects are at least as intentional as, say, the creation of mammals, which depended upon the complex series of evolutionary events leading up to the development of a nitrogen- and oxygen-rich atmosphere on Earth.

Sensing the Cosmos

But now, in that context, think of the relationship Vernadsky identified among the abiotic, the Biosphere, and the Noösphere. As the Noösphere gradually increases its conscious control over the Biosphere, the entire domain of activity which once belonged to the Biosphere must become subject to the anti-entropic, willfully creative activity of the human mind. This means that the conscious control of electromagnetic effects on exactly this intergalactic scale is part and parcel of mankind's destiny: It is human nature. The beginnings of such a process are only hinted at by the recognition that the same electrophonic effects which we have been discussing, and which were once only the product of meteor impacts, have been observed in connection with the re-entry of man-made satellites into Earth's atmosphere.[16]

The aurorae are more evidently connected with these large-scale atmospheric electromagnetic phenomena, and the similarity of the two reported types of electrophonic hearing, as well as the other similarities among the anomalous sounds connected with aurorae, lightning, and meteors, prompt us to recognize similar electromagnetic perturbations of the Earth's atmosphere and magnetic field in each of these cases.

There are also plenty of other similar phenomena which have the exact same characteristics, and which ultimately require us to redefine what we consider to be our sense perceptions. That is, we have to rethink the idea that we come with a fixed set of five, distinct senses, whose operation are fundamentally understood. In all of these cases, there is plenty of reason for us to think that what we commonly call "hearing" is much more than the detection of vibrations in air.

For instance, workers near microwave towers frequently have described "hearing" clicking and popping sounds, which could not be recorded by any mechanical device designed to record the vibrations of air waves. This effect—called the microwave auditory effect—has been well studied, although its cause is still not understood. (It is usually claimed that it is the effect of thermal expansion of tissues in the head, though this does not seem to be a certain conclusion.) It was heavily researched by both the U.S. and Soviet militaries, as part of attempts to develop non-lethal (or "less than lethal") weapon systems. In particular, it was thought that it could be used as a form of communication, or simulated telepathy, in which sounds were produced directly within a target's head from afar.

One option that was looked into extensively was the possibility of inducing some of the effects of schizophrenia, and causing a person (possibly a high-ranking

14. G. Ryskin, "Secular variation of the Earth's magnetic field: induced by the ocean flow?" *New Journal of Physics,* 2009.

15. LPAC-TV, "The Cosmic Implications of NAWAPA," http://larouchepac.com/node/16848

16. A. Verveer, P.A. Bland, A.W.R. Bevan, "Electrophonic Sounds from the Reentry of the Molniya 1-67 Satellite Over Australia: Confirmation of the Electromagnetic Link," *Meteoritics & Planetary Science*, 2000.

figure in an enemy country) to believe that they were constantly hearing voices. Officially, though, there was only success at getting targets to hear poorly enunciated individual words. The official conclusion is that you would actually microwave the targets (in the colloquial, kitchen appliance sense), killing them, or causing serious damage, long before they were able to hear detailed sentences.

This may be a cover story, and, in any event, it does not exclude the possibility that there are more subtle auditory effects of this kind of radiation, which may even already play a fundamental role in human perception. Likewise, humans, when exposed to certain static electric fields, are able to hear sounds of various frequencies, and experience sensations on the skin.[17]

Individuals with defective hearing in high frequency ranges are apparently not susceptible to experiencing a radio-frequency auditory effect. There seems to be only one experiment detailing this, and it is found on a personal website. The experimenter admirably thought to attempt to recreate the perceived sound by normal sound-generation methods, and reports that the listener noticed that this sound, in comparison with the equivalent tone generated by electromagnet stimulation, "seemed to lack something in the high frequency region."[18] He notes that it is difficult to devise an experiment to detect whether the nervous system is directly stimulated by this sort of radiation, because all of the measuring devices used to detect nervous system activity are electromagnetic in nature, and thus affected by the electromagnetic stimulus used, making it difficult to separate out any stimulated nervous system activity that might occur.

In general, the cases of the conscious perception of these sorts of effects seem much less interesting than the unconscious aspects of this sort of sensation. The case of the microwave hearing indicates that inaudible sensations must be being produced constantly at low power levels, and whatever causes the sound of the aurora is probably occurring for all observers, though on a lower than perceptible level. Could this shape our perception constantly, without us realizing it?[19]

This again points up the serious fallacy involved in defining uniquely cognitive phenomena, such as communication via sound, on the basis of abiotic measurement and instrumentation. This involves a tacit reductionism which is ultimately untenable.

Unheard Melodies

The cultural implications of this investigation are not to be ignored. The organization of human society depends upon its ability to transmit profound moral, scientific, and cultural ideas. There is no physical structure that can be identified as a "nation-state" or a "culture." The boundaries of a nation or society do not exist physically, but rather as an idea in the minds of the citizens. If this idea is destroyed, so is the nation, and human society, more generally. The ability to achieve such a national idea depends on the maintenance of a coherent language culture, and the tools which help to maintain it—public education, but most importantly the arts, and artistic composition generally. A collapse in the artistic and cultural level of a society will always express itself as a collapse in the physical and economic conditions of that society. A study of this relationship is the particular expertise of the economist Lyndon LaRouche.

If a language loses its capability to express ironies, or the population loses its ability to recognize them, science suffers, because it is just such an ability to recognize and respond creatively to the ironies and paradoxes presented by the universe—as opposed to dry, logical deduction—that represents the basis for true scientific creativity. But such an ability depends upon a recognition of the subtle ironies of human sense perception which, as we have seen, are much more nuanced than they would at first appear.

For instance, if hearing has (as the above investigation would seem to clearly indicate) an electromagnetic component, to which people are able to respond both consciously and unconsciously, what might be lost as a result of digital recordings (or perhaps any recordings) of Classical musical compositions? It has been demonstrated repeatedly that even the mere exposure to Classical musical composition beginning in childhood has a

17. H.C. Sommer, H.E von Gierke, "Hearing Sensations in Electric Fields," *Aerospace Medicine,* 1964; and T. Moore, "Vibratory Stimulation of the Skin by Electrostatic Field: Effects of Size of Electrode and Site of Stimulation on Thresholds," *American Journal of Psychology,* 1968.

18. http://www.bibliotecapleyades.net/scalar_tech/the_hum/ingalls.htm

19. Even traditional sound waves, at inaudible frequencies, are capable of generating visceral effects, despite not being consciously sensed. Infrasound of 18 Hz is just below the threshold of human haring, but has been demonstrated to cause feelings of anxiety and foreboding in test subjects, despite their being unable to "hear" it.

dramatic effect on the cognitive capabilities of the human individual, and history has demonstrated, without question, that active participation in Classical musical performance is a necessity for true scientific and political genius.

But the characteristic of such composition is centuries of scientific work on the creation of instruments which physically mimic the human singing apparatus. This apparatus itself may even have an electromagnetic component to the sounds produced.[20] How much of this nuance is lost in the recording of such composition? This is to say nothing of music that is entirely composed on digital instruments, and thus incapable of even approximating the effect of an actual human singing apparatus.

Even the cases where a human singing voice is involved in modern music, all nuance is digitally reduced by the fact that a modern singer, as opposed to a singer trained in the *bel canto* Classical singing method, requires his or her voice to be transmitted to a crowd via microphone.[21] This is a step above the ridiculously comical recent development of "auto-tuning," which takes performers who sing out of tune, and digitally adjusts their voices to match the desired digitally correct pitch.

One RAND Corporation report[22] on the human hearing of electrophonic meteors noted that the reports of such sounds have decreased in the modern period. They astutely cite three reasons:

1. Popular opinion. As people become more "educated" about the dominant textbook descriptions of physical science, they are less apt to trust their own observations, and instead, explain away any phenomena that may seem anomalous, or potentially subject them to ridicule. This is a side-effect of textbook learning methods.

2. As humans are exposed to more and more noise in certain aspects of perception, they lose the ability to note subtle distinctions, and likely become deaf to certain more subtle sounds.

3. People today will typically find themselves indoors on the computer or watching television, at times when past generations might have been outside taking a stroll.

That said, the idea that all sound, but not only sound, has an electromagnetic component is not so strange. But, further, if the electromagnetic effects do not register as sounds, due to their subtlety, what do we experience them as? A hunch? A bad mood? A depressed state? An intuition of danger? A feeling of anxiety? A deep sense that massive change of some sort is in the air? A pressing desire to fly South for the Winter, and mate on another landmass?

What would be the effect of losing these sensitivities?

Helen Keller is an interesting illustration in this context. That she was able to develop a concept of her own identity as distinct from her sense perception is, without a doubt, attributable to her own creative capabilities. It is also, however, attributable to the action of organized human society, and the work of her teacher Anne Sullivan, who managed to impart certain socially maintained concepts to Keller, starting at a very young age.[23] What would happen if everyone at that time lacked both vision and hearing, as well as Sullivan's Platonic sense of the soul? We risk entering a comparable situation today.

NAWAPA: Man as a Creature of the Cosmos

The migration of humanity that will be involved in NAWAPA—approaching both poles, via bridging both the Bering Strait and the Darien Gap—will, lawfully, permit us to consider some of these questions much, much more deeply. If nothing else, this whole investigation points out the necessity of a human presence in the most diverse areas to be studied. The validity of the various types of sounds discussed here was only confirmed by the observation of a dense population of educated observers. This is the same sort of population density and level of economic development which we require in unexplored regions such as the Arctic and, ultimately, interstellar space.

Unless we are especially lucky, our constructed measuring apparatuses will only return to us what we think to ask them, and this will frequently appear to have the effect of a confirmation of the theory that went into the construction of the device in the first place. Asking the question, "What sort of a rock is this child?" may return an answer, but what will be its significance?

20. See Aaron Halevy's contribution in this issue.

21. A humorous example of this modern dependence on a microphone, even for live performances, can be seen in video recordings of the *bel canto*-trained tenor Luciano Pavarotti singing alongside "modern" singers, such as Bryan Adams, available online.

22. M.F. Romig, D.L. Lamar, "Strange Sounds from the Sky," *Sky and Telescope*, 1964.

23. See the contribution by Meghan Rouillard, "Helen Keller: Mind Over Instrumentation," in this issue.

The Sounds of A Cosmic Chorus

by Aaron Halevy

As we listen to the faint whispers which come to us from the shimmering aurorae and passing meteors, we reflect upon that possibility that humans can "hear" events extra-terrestrial.[1] Now we must ask ourselves, can we take any of our assumptions about hearing any further? Must we agree that the modern understanding of what "hearing" is, and what the ear's functions are, is a closed subject? And, if not, as these phenomena suggest, then what are the implications? If recording devices cannot yet record these cosmic sounds, yet living human beings can hear them, then what is possibly going on in our ears? Is sound just a frequency of vibrating airwaves? Take a more complex example: What might we actually be listening to when we hear a live string quartet or a chorus of *bel canto*-trained singers? And, inversely, what could our mp3s, and even vinyl records, not be allowing us to hear?

1. See paper on Auroral Hearing by Sky Shields, in this issue.

We have looked into the cosmos for some new clues for our senses; we've looked at the animals and their extra-powers; now let us look back, where all good scientists must look, into ourselves. A fresh study of hearing and of making music, from a standpoint less weighed down by common assumptions, could bring us closer to a freer understanding of what is actually happening in the real, unsensed universe. This investigation could bring what we call sound, nearer to the domain of light and magnetism, and reveal what a galactic impression Classical music can have.

Human Singing

U.S. researchers, in discussion with Lyndon LaRouche, by the 1980s, had possibly rediscovered the human singing voice in the realm of cosmic radiation.

More specific studies into the human voice, during the 1950s, from the communications branch of the U.S. military, and from civilian communications, like telephone companies, found some new questions from the study of what seemed to be a straightforward subject. Early on in this period, researchers in vocal physiology assumed a very simple system for the production of sound by the human voice; this model is referred to as the "linear model."

Essentially, the vocal chords produce simple acoustical soundwaves, which are then propagated in the air, which flows linearly through the throat and out of the

Helmholtz's 'Perfect' Musical Chords

Hermann Helmholtz (1821-94), a German scientist and contemporary of Bernhard Riemann, published *On the Sensations of Tone as a Physiological Basis for the Theory of Music,* in 1863. Helmholtz's view of sound and its laws, as established in this book, have become the dominant view of today's professionals in all related fields. Helmholtz arrives at the conclusion in his book, that Mozart's Trio Minuet, in the opera *Don Giovanni,* is always sung in too dissonant a manner. "The chords," Helmholtz writes, "almost always sound a little sharp or uncertain, so that they disturb a musical hearer." He suggests that perhaps performers should learn to sing in "perfect musical chords," to satisfy him.

mouth. Microphones measure the pressure of the speech signal to some accuracy. The futility of this model was admitted by some. One researcher from Bell Laboratories, about whom we will say more later, Dr. James Kaiser, said of this linear model: "It's totally irrelevant whether or not that model bears any resemblance to the physics of production. It only has to be a computationally efficient and adjustable model. That's it: computationally efficient and economically viable, so as to allow one to build the hardware to generate the speech signal as part of the system."[2] That is, those promoting the linear theory only cared about what happens outside the mouth.

Questions about what the ear hears, and what else could be going on in the voice, are irrelevant in such a model. Why? "Because," as Dr. Kaiser said, "Almost all this work on modeling was done by electrical engineers; they like to look at things as filters, as block diagrams that have 'input,' 'system,' and 'output.' The 'source,' or input is the vocal fold oscillation. The filter is represented by the cross-section area of the acoustic tube, and the 'output' is the pressure wave at the mouth. That's the filter model and its many variations. That's the approach that was used."[3] The equations were written. The models required many computers to calculate the equations, and if these models were criticized, the heartless mathematician would lurch from his table of equations to say, "These questions are not a problem, because the model works."

From this perspective, with no horizon, these researchers ran into several "anomalies." Vocal *formants*, as they are studied today, are regions in the human voice, where harmonics have stronger amplitudes. The principal vocal formants are formed at generally 500, 1,500, 2,500, 3,500 Hz, and so on. When lighter gasses are introduced to vocal production, such as helium, the calculations based on the linear model should force the pitches of all the sound, including the vocal formants to rise by a factor proportional to the difference in the velocity of the gas. Yet when the tests were done, the change was far less than expected and the irregularity was astonishing—each of the formants is unpredictably changed in different ways with the faster gas.

Other questions were raised, but were not important to explain in the linear model, such as: dealing with the surface of the vocal tract, its characteristic tissue was considered uninteresting; the lubrication essential to speaking was neither here nor there in the standard model; the similarity to speech that birds can achieve[4] was not accounted for; the changes that take place in the space of the vocal tract,[5] i.e., the tract's geometry while vocalizing, was relatively simplified in the standard theory. "Where does the voice comes from?"—although a silly question to some, anyone who sings, knows from experience, that the voice does not emanate from the throat alone. But this too is explained away as a *passive* feeling: "nothing really going on here."

Most interestingly, the energy-input measured at the glottis is only 0.1-1.0% of the energy which is measured in the acoustical soundwaves as the end result. In other words, 99-99.9% of the energy put into use when someone is speaking, or even singing, is accounted for again as *passive* resonance in the linear assumptions of the vocal apparatus.

The work to understand the vocal apparatus from what it does, and not backwards, from its assumed construction to its effects, came first from the curiosity of Dr. Herb M. Teager, a communications man who served in the U.S. Navy. Teager took the hints from some of the anomalies mentioned above, and began to play with the effects present in the voice first, without assuming what it was made of, and what it was doing.

Eventually Teager was led to investigate the voice from a totally new standpoint, as he told his colleague Dr. Kaiser, an electrical engineer and an amateur singer. "There was a lot more going on inside the vocal tract that contributes to the production of the signal outside than was included in the [accepted] models," he concluded. This led them in their work to something which would make Leonardo da Vinci smile—the investigation of fluid dynamics.[6]

Teager discovered by the use of a hot wire anemometer, an apparatus generally used by aerodynamicists to make measurements of the amplitude of the flow, that the airflow within the vocal tract varies wildly from

2. From an interview with Dr. James F. Kaiser in 1997: http://www.ieeeghn.org/wiki/index.php/Oral-History:James_Kaiser

3. Ibid.

4. Talking Myrhy Birds: 1. http://www.youtube.com/watch?v=anyBbiljocA&feature=related
or see "Einstein Bird" http://www.youtube.com/watch?v=gr2vt0CekKA&feature=related

5. See this video of human singing recorded while in an x-ray machine: http://vimeo.com/12251154

6. Leonardo da Vinci, "The voice impresses itself through the air without displacement of air, and strikes upon the objects…." (*Codex Atlanticus,* 360 r.a.).

FIGURE 1a

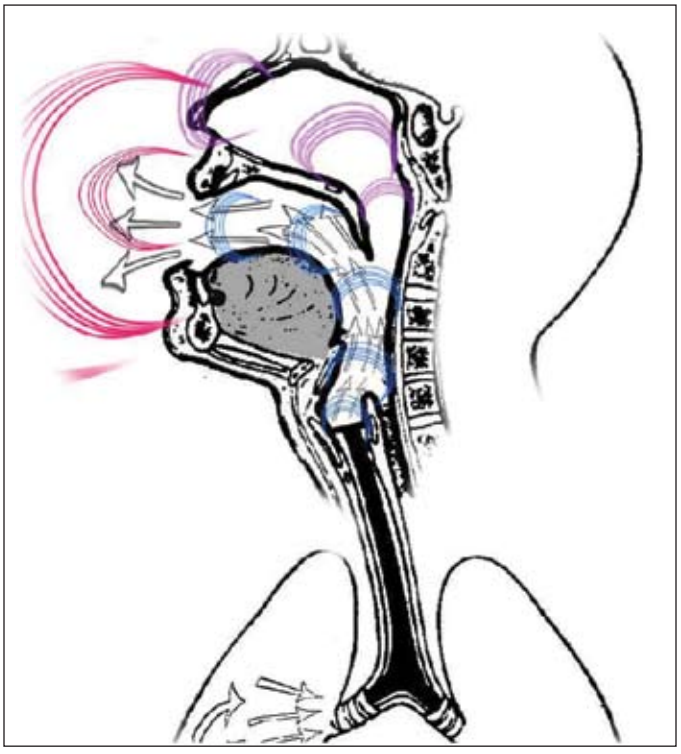
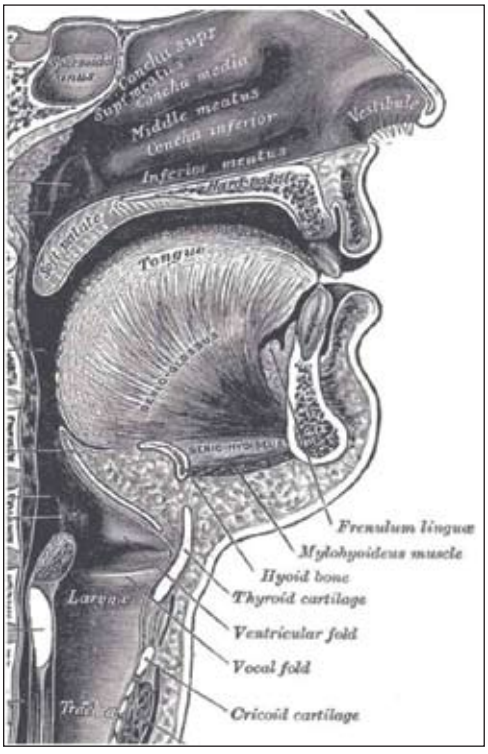


FIGURE 1b

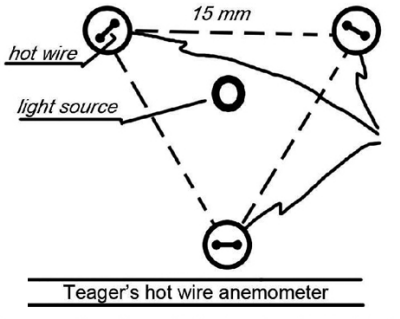


The vocal chords produce simple acoustical soundwaves, that are then propagated in the air, which flows linearly through the throat and out of the mouth.

place to place; from the beginning of the glottis, for the same vowel at the same pitch, the airflow inside the mouth was different in every location of the readings. Teager was struck by the fact that a simple, uniform airflow in the voice was impossible.

To summarize the findings, as Teager describes in his paper, "Active Fluid Dynamic Voice Production Models, or There Is a Unicorn in the Garden,"[7] after thousands of tests, and a perfection of the apparatus, he concluded that the airflow is not uniform, but is more a combination of several separate jet flows at very high speeds. These jet flows utilize the walls of the vocal tract aerodynamically to constantly create nonlinear effects by means of the high-speed pressure changes. These jet streams create a whole family of observable vortices along the walls and in the few cavities, even including toroidal-shaped vortices formed along the volume of the tract.[8]

FIGURE 2



Air passing around a wire cools it, changing its electrical resistance properties, which can be detected by the same attached wire that is electrically heating it, measuring the amount of air flow passing through the apparatus.

The action of these vortices alone is surprising, in that they are found to be pulsating in and out in phase, and modulating the formants of the voice.[9] As Teager wrote, "The pulsatile jet proceeds through the vocal tract and drives or excites everything downstream from it. If you think of it another way, what do you remember most about going over the Niagara

7. H.M. Teager & S.M. Teager, "Active Fluid Dynamic Voice Production Models, or There Is a Unicorn in the Garden," *Vocal Fold Physiology* (Denver Center for performing Arts, 1983).

8. H.M. Teager, "Evidence for Nonlinear Sound Production Mechanisms in the Vocal Tract" (1989 Presentation in France).

9. James F. Kaiser, "Some observations on vocal tract operation from a fluid flow point of view," in *Vocal Fold Physiology: Biomechanics, Acoustics, and Phonatory Control,* I.R. Titze and R.C. Scherer, eds. (Denver Center for the Performing Arts, Colo., 1983, pp. 358-386).

Falls, the froth, or the falling water? The sound generated from the second order process is the froth; the main source of energy is the glottal jet."[10] So the sound which we mostly hear is the effect which is generated by this entire process.

There was a very intense battle that Teager and Kaiser had to wage, against those who would force them to abandon their new model, and to take the advice, as it was told to Prometheus, to "kick not against the pricks." Kaiser describes Teager's frustration with the other agenda which he had to fight against in doing the research: "Look, let me get the physics right first. Then once I understand what's physically going on in this generation, then I will worry about the mathematical modeling after that, because then I will have much better guidelines as to how to do the modeling and which approximations are meaningful and which ones are not meaningful."

And so he worked, he wrote, and the papers were shot down, again and again. Kaiser: "I think he [Teager] had been beaten on so much by the establishment that he had just retreated into his little shell—or his big shell—and said to himself, 'Look, I'm going to solve this problem once and for all so completely and get so much evidence that there's no way these fellows are going to say, 'Herb, you blew it.'… He had a tremendous amount of integrity."

They both eventually left Bell Labs, and in 1989, Teager died of lung cancer.

In their view, this largely unobserved activity in the vocal tract, which makes up the very small action taking place (i.e., "fine structure"), is responsible for much of the volume of the voice, and most all of the higher frequencies, or formants. The tract itself then becomes very active, to say the least; it is not a *passive*, linear system. By this view of the vocal apparatus, the anomalies listed above can become more understandable.

For example, Kaiser, in an interview conducted in 1997, said, on the subject of the efficiency of the vocal action: "So now, let's look at this whole system from an energy point of view. For example, my speech now: I am putting maybe about a quarter of a watt into this system. Only less than one percent of that comes out as sound. So it's like I've got this tremendous reservoir of continuous energy and only a very small part of it comes out as acoustical energy. That leaves a great potential there. The opera singer stands up there on the stage at the Met singing with no microphone, with fifty or sixty pieces of orchestra in the pit, but yet that voice clearly fills that whole hall up. How do they do it with the same set of lungs and vocal chords that you and I carry around? They've learned to get that efficiency up from the order of half a percent up to seven or eight percent."

Kaiser further discusses speaking and singing in what can be seen as a negentropic process: "This is a wind-driven instrument, and the energy in this system is in the moving air. And with moving air, any time you have a time-rate-of-change of flow, you have the potential for the generation of an acoustic wave."[11]

Lyndon LaRouche, a founding member of the Fusion Energy Foundation, upon hearing of the results of this research in the mid-1980s, suggested that this evidence should lead to an electrodynamic view of the human singing voice. This discussion coincided with a strong drive within the fighting part of the scientific community at that time to promote nuclear fusion research, and the discussion was how to confine the fusion process enough to create and contain the reactions, similar to those that occur in the Sun. This, at the time, dovetailed with the work of Phillip S. Callahan on the communication of moths, which emanate a sort of double propagation: one as the "lasing" or shaping of the space, and the other as the communication (or information) wave.[12] LaRouche suggested, based on this and other evidence, some specific experiments to be conducted to extend the discussion of the singing apparatus in this regard.

LaRouche wrote, "The essential thing here, is that the *bel canto* tone is an approximation of a lased tone, as distinct from the raw tone generated in the lower portions of the human apparatus."[13] "The implication is, that the state of the macro-system in this respect, relative to the induced transparency, is more comparable to the relevant physics of propagation in water, and to certain aspects of solid state physics, than any popular, 'gas theory' notion of the air medium." He went on to define the relevant experiments to be performed to test this hypothesis: "What is implied is some form of our

10. Teager, "Evidence…" op. cit.

11. This reveals the use of microphones in more and more major opera halls across the world as a fraud similar to the stupid environmentalist's protest against the use of nuclear power.

12. by Philip Callahan, "Insects and the Battle of the Beams," (*Fusion* magazine, September-October 1985)

13. Lyndon LaRouche, unpublished memo.

dyeing of the prepared air molecules in a drift-tube-centered, ultra-quiet room sort of experimental configuration. What is suggested as instrumentation, is a combination of appropriate stroboscopic and stroboscopic-like NMR [nuclear magnetic resonance] observations. We wish to observe the condensation of the air molecules and the magnetic orientation in the cross-sectional volumes of condensation and rarefaction."[14]

Unfortunately, these tests have not yet been done, and deeper study of this phenomenon still lies beyond our grasp. The evidence already is astonishing, but much more must be done to further this work.

When thought of in the context of our more recent discussion with LaRouche on the phenomena of a space-time made of cosmic rays, one can imagine the analogy of this unseen cosmic ray space which has a mutability, which the galaxy and solar systems act on, and respond to, in their evolutionary development.

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The Italian bel canto *tenor, Luciano Pavarotti, wrote of the* passaggio *(vocal register shift), "It is a little like breaking through the sound barrier. If you do it in the right way, it affects what happens on the other side."*

Now that we have broken into the discussion of what is beyond the soundwaves themselves, what about ideas? How do ideas manifest in the voice, and then out into this space, and into the mind of the audience? What else is at play here? Is this communicated through the ears? Or can it possibly pass to your ears through your iPod?

Registration, Please…

Let us look at the human voice in practice, not as a mechanical device, but at what we need it to accomplish. This reflects Wolfgang Köhler's discussion of *isomorphism:* What is the nature of matter as it relates to cognition, and further, what is the nature of the voice that allows it to produce musical ideas—as opposed to the throat making sounds for no reason? That which is called a register shift, or *passaggio*, by singers trained in the *bel canto* method, has some very interesting implications which are worth touching upon, at least briefly, here.[15]

Kaiser, as a singer, knew intuitively that his discussion with Teager had implications which could help him in his own singing, "Certain things became much more clear to me about certain problems that I had (problems that had come up through my singing, which I was doing very actively)." Similarly, we find a functional understanding, albeit not in these terms, of the processes that Teager and Kaiser found, in some of the best teachers of *bel canto*.

The *passaggio* is described, by the best teachers, as a conscious modification of the vocal tract, by "thinking of a new shape," "shifting gears," or "going through a doorway." One can imagine that this changing of the geometry of the voice, affects all the resonances and the vortices downstream. Every voice has several such shifts. In the *bel canto* tenor or soprano, the main shift is found from the middle voice (second register) to the "head voice" (third register) and is located, at strict C=256 tuning, in the region of the F#. One can imagine that bringing the vocal apparatus into a different configuration, brings a higher efficiency of the throughput discussed by Kaiser, and this reconfiguration gives the singer the capacity to produce notes which otherwise would not be possible to sing before the change (a new degree of freedom).

As a way to think about how this is achieved in the mind of a singer, take Luciano Pavarotti, who wrote of the *passaggio*, in his biography: "It is a little like break-

14. Lyndon LaRouche, 1980s memo, "Conjugate, Schrödinger-like Helices as the hypothetical form of propagation of induced transparency for electromagnetic transmission of coherent sound in the air medium."

15. See the Schiller Institute's *A Manual on the Rudiments of Tuning and Registration, Volume I*, "Introduction" (1992).

ing through the sound barrier. If you do it in the right way, it affects what happens on the other side."

This is very important for a singer to know, for an improper shift can throw off the ability to sing into the higher registers of the soprano and tenor voice, past the high B, into the *do di petto*, in the "fourth register." Pavarotti again: "The *passaggio* is also very important in connection with singing the highest notes. If the shift-over from the middle to the upper register is done correctly, it opens up the top much more effectively and those high B's and C's have a better chance of being hit solidly and well."

What else could be happening as one moves into this higher efficiency? And similarly, what could be taking place in the Basso voice, in the shift which seems to be an *inverted* fourth register found in the lowest range of the voice species? Think then, what could be the effects of arbitrarily raising the pitch of orchestras and choruses beyond the natural, Verdi-promoted tuning of C=256, even if by "just a little bit"?

Given this delicacy of the work accomplished by this jet flow, in its negentropic action on the whole vocal tract, which is unified by the geometry of the tract, the *bel canto* register shift has some very interesting implications in communicating subtleties in performance of music by a composer who knows how to use this higher dimensional power, such as Bach, Mozart, Beethoven, or Verdi.

To "play" the human voice, which every human being has been given "in the box," so to speak, the singer has the challenge of using a living process to make music, and this is what is reflected in the fluid dynamics of vocal production and the use of register shifts. Not only can the voice expand its otherwise small range by this action, which exists in the *bel canto* voice, but it brings a higher, willful organization of the whole geometry of the action taking place, which must be thought of as received, even if "ever so slightly," by the conscious, non-sleeping members of the audience.[16]

Riemann's Posthumous Hearing

The possibility of human hearing going beyond the simple assumptions of sound, was not discounted by Bernhard Riemann in the last researches of his life. Riemann begins, in his posthumously published paper, "The Mechanism of the Ear," very generally on the question of investigating any sense organs, and only after he lays out the method of proper inquiry for himself does he go "into the ear," so to speak. Keeping in mind what's been said up until now in our reports, both tasks are relevant for us here.

In this late work, Riemann takes the same creative approach which he had developed going back to his 1854 *Habilitation Dissertation*, and other work. That is: Don't trust your assumptions, ever! For the universe is creative everywhere, even when you are not watching it. In investigating what we sense, we should keep in mind that there must be things which we cannot discount, even though we don't know they exist yet.

Riemann writes that, to study the physiology of a sense organ, there are, "aside from the universal laws of nature," two necessary elements: one, the empirical determination of what the organ accomplishes, and two, the investigation of its construction. From the need to understand the organ's function, there are two possible ways of acquiring this knowledge: either one can look at the parts of the organ, and then impose an assumed interaction on these parts as a result of the external stimulus, "or we can begin with what the organ accomplishes and then attempt to account for this.... By the first route, we infer the effects from the causes, whereas by the second route we seek causes of given effects." He calls the first route the synthetic route, and the second, the analytic route.

Senses can receive unimaginably small details. As we have discussed above, and in several other papers in this report, very fine details often go unnoticed; therefore, this first route of synthesis is too difficult to use. Riemann writes that the determination of the finer characteristics from observation of microscopic objects, "is always more or less uncertain." And therefore, by following the second route, we shall "seek to account for what the organ accomplishes."

"We must, as it were, reinvent the organ, and insofar as we consider what the organ accomplishes to be its purpose, we must also consider its creation as a means to that purpose. But this purpose is not open to speculation, but rather, given by its experience, and so long as we disregard how the organ was produced, we need not bring into play the concept of final cause."

This is the exact same methodological approach Johannes Kepler used, when he asked of the eyes, over 200 years before Riemann, in his *Harmonies of the Worlds*, "Certainly the mind itself, if it never had the

16. Just as Dante suggests, in his epic poem, the *Commedia*, the person sitting next to you may look alive, but their soul might already be suffering in Hell.

Kepler (left) asked of the eyes, in his Harmonies of the Worlds*, "Certainly the mind itself, if it never had the use of an eye at all, would demand an eye for itself for the comprehension of things which are placed outside it, and would lay down laws for its structure which were drawn from itself. For, recognition of quantities, which is innate in the mind, dictates what the nature of the eye must be; and therefore, the eye has been made as it is, because the mind is as it is, and not the other way round." Riemann, 200 years later, asks the ear, "What do you accomplish?" The ear answers, "several things, such as a extremely precise discrimination of sound, sensitivity, fidelity of transformation."*

use of an eye at all, would demand an eye for itself for the comprehension of things which are placed outside it, and would lay down laws for its structure which were drawn from itself. For, recognition of quantities, which is innate in the mind, dictates what the nature of the eye must be; and therefore, the eye has been made as it is, because the mind is as it is, and not the other way round."

So Riemann asks the ear, "What do you accomplish?" The ear answers, and tells him, "several things, such as an extremely precise discrimination of sound, sensitivity, fidelity of transformation." Riemann includes descriptions of "timbre, intensity, tone and direction," as the parameters for the effects received by hearing. He later describes these each in with their own properties, and judges the ear's fidelity and sensitivity to such things, from experiments done before him, and also, from personal experience found in the subtleties in both poetry and live music.

Riemann's critique of Helmholtz's book, *On the Sensations of Tone*, is that the work improves upon the empirical data then existing, but nothing else, and Riemann himself is "frequently compelled to oppose the conclusions that Helmholtz draws from his experiments and observations." So, what could Riemann have been looking for?

Recall the investigations of Kaiser and Teager. They were led to understand that the voice is not what it was assumed to be, and they found that the ear is responding to this process of complexity in speaking and singing as well, mostly without us consciously knowing it. Kaiser said: "[I]f you listen to somebody talk on the telephone, it only takes a second or so of conversation for you to know who is talking, in addition to what was said. If you try to do that analysis spectrum-wise, you'll find that you can't. But this approach is doing it just fine. Why? Because one's ear is looking at the modulations. It's a modulation detector. It's a transient detector. It's not simply a spectrum analyzer. It's a lot more."[17]

For further evidence of what Riemann might be looking into the ear for, we shall revisit his earlier "Philosophical Fragments."[18]

"With each simple act of thought, something enduring, substantial, enters into our soul. This substantial thing appears to us, indeed, as a unity, it appears, however (insofar as it is the expression of a spacial and temporal extension), to contain an inner manifoldness; hence, I call this a *"thought object"* [*"Geistesmasse"*]. All thought is, according to this, the formation of new thought-objects.

"The thought-objects entering into the soul, appear to us as conceptual representations; the distinct inner state of each conceptual representation determines the unique quality of them.... All beginning, generation, all formation of new thought-objects, and all unification of the same, require a material carrier. Hence, all thinking comes to pass at a determined place."

And later he writes, "In order to explain our soul-life, we must assume that the thought-objects produced in our nervous system endure as a part of our soul, that their interconnections continue unchanged, and they are subjected to a change only insofar as they enter into a connection with other thought-objects."

These ideas, along with what Kepler wrote, form a

17. See note 1.

18. A translation of Riemann's *Philosophical Fragments* can be found in the Winter 1995-1996 edition of *21st Century Science & Technology* magazine.

good place to understand the mind's use of the senses.

Now go back for a moment, and think about what the voice is doing for the mind in using register shifts. Why do register shifts exist, but to communicate to the mind? The resonance within the ear must ascend to the subjective resonance within the mind which re-forms the idea. This presupposes that the mind is tuned to the reception of such slight indications. That puts the performer and the audience at a much higher responsibility and attention than anyone is wont to do these days, and that brings us to the next part of this study.

MP3s Versus Your Ears

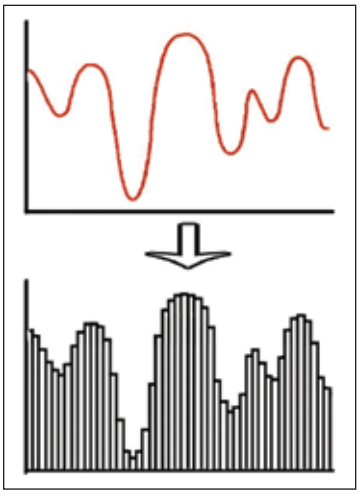
To get into the implications of this discussion on the subject of digitized music, the following recap is necessary.[19]

When a recording is made, the assumptions embedded in the method of sound production are the same as those which come from Helmholtz. And if we make assumptions about what sound is, then our recording devices will take the parameters associated with sound, and strive to recreate those effects. When recording was first developed in the late 1800s and early 1900s, the method was straightforward: A device must receive the effects of the sound vibrations in the air, and those vibrations had to be transferred into a medium—wax or a soft plastic; when the sound is reproduced, those vibrations are sent backwards, via a needle, to a device to recreate the recorded vibrations. This was good enough, assuming that that is all that must be captured.

Technology advanced from wax to vinyl records, and also to magnetic tape, all the while, remaining "analog." The step to "digital" recordings was taken, as in Laserdisc, CD, mp3, WAV, etc. Whatever the reasons given, it was a most dangerous step. The data played back was shrunk, "to the limits of human perception," and the sound emitted is only an approximation of the original sound.

Keep in mind, that the unimportant "extraneous noises," which are cut out of digital recordings, are the signals that are "too high" or "too low," for human hearing. It is assumed that young people can hear up to 22,000 Hz, while most adults can't hear frequencies higher than 15,000 Hz. "So," the typical audio engineer says, "provided that the sample is sufficiently in-depth, there is no audible difference between an analog original and a digital transfer of it. Our ears cannot tell the difference."

FIGURE 3



The transfer of the original sound into digital information can be seen in these curves and rectangles shown above. In the digital recording: X = the sample rate, i.e., samples per second (measured in Hz), and Y = the resolution, i.e., the amount of divisions of the unit (measured in bits). X and Y give you the bit rate, i.e., the amount of data taken per second.

The question now posed is, "Is the mind which uses those ears listening?"

In a digital recording, what can be thought of as the "living-noëtic sound" of the performed music is assumed to be reducible. It is as if your dog were cut into a thousand parts, those parts were then frozen in ice-cube-like chunks, and then your dog was reassembled of these chunks in the shape of the dog. Playing fetch would be a difficult task.

Remember, the electromagnetic component of "unheard melodies," as from an aurora, have not yet been recorded by any device, analog or digital, yet people are able to respond both consciously and unconsciously to these "sounds." What then might be lost as a result of digital recordings (or perhaps any recordings) of Classical musical compositions? How much of the nuance is lost in the forced digitalization of such performances which utilize the slight changes, as the register shifts imply, as discussed above?

Taking the approach of Riemann, while thinking about these phenomena, taking the implications of the complicated process in human singing and register shifts, the assumptions of regular sound mechanics really do "confine" what we could be hearing, and therefore, should be thrown out the window, along with your collection of mp3s.

With this process in mind, think of another interesting aspect of the Classical musician's power to communicate: silence. Silence is very important in composing and performing Classical music. It is the apparent *nothing* that causes that which follows it. The greatest performers speak of a unique musical silence as something

19. See Sky Shields, "What, Exactly, Is a Human Being? Analog, Digital, and Transcendental," *EIR*, Jan. 4, 2008.

which could not be reduced to just a "lack of sound." A deeper study of a Beethoven piece, where one might find a *fermata*, also known as a *corona*,[20] over a rest, would reveal an entire world of "unheard" substance.

To hint at the idea, a very accomplished pianist once told me, "For Beethoven, silence becomes the most beautiful music. He provides you with a dense moment, which, in performance, must be defined by many factors.... This pause must reflect a total change in the idea, of the overall space. It is much more difficult to play silence, because it must be determined by the conditions of the whole concert, by the state of the audience, the way the entire night has gone, in other performances, and by the way you've shaped the whole performance until that moment. This expression of musical silence must be determined by all this, and you have to be aware of all of it in this instant when you create it." Any reconstruction of so-called "silence" must necessarily discount this idea; it could only be read as, "no information = empty space." Would you really want to put that into your head through your earphones?

When human beings communicate, is it only information? In speaking, saying one thing, with the raising of an eyebrow, and then, saying the same thing, without the facial gesture (and thus, expressing something beyond both), is not something that can be reduced to "information." Imagine a population which has lost its access to these ironies, through a degeneration of music and of speaking. Imagine after decades that this population would lose the ability to recognize these ironies. Their science suffers, their art suffers, and ultimately their humanity suffers. Morality becomes only an opinion, and chaos rules, until they can no longer economically care for themselves.

Such were the intended results wrought upon our own society beginning at the turn of the 19th Century into the 20th Century by such scoundrels as Bertrand Russell, C.K. Ogden, and Sidney Hook. That degeneration, which we experience in music and culture today, was the intended effect of the infamous Congress for Cultural Freedom.

Why was this done to us, you ask? "Learn to know thyself," was the advice given to Prometheus, as he fought against the new tyrant Zeus, in Aeschylus' drama, *Prometheus Bound,* of ancient Greece. This was one of the mottoes inscribed at the wall of the temple at Delphi at the time. The other motto which often accompanied it was, "Think as a mortal." This addition gives the first motto a "know your place, and keep in your place," or "don't act or think outside your station in life" kind of command from the Delphic order. This comment, at it comes from Oceanus' mouth in Aeschylus' drama, would resonate among the Greek audience watching the play, for it was a well-known command at the temple. This Delphic control can be seen as a model for the Congress for Cultural Freedom, as they would embrace this dictum in its new form, "Hear as a mortal."[21]

Some Final Considerations

As Shawna Halevy has recently developed the point in the case of Albert Einstein,[22] the scientific mind's ability to passionately investigate the reality of the universe which lies to the other side, so to speak, of our sense perceptions, is developed in Classical expressions of artistic composition. Debating analog or digital is missing the more important point: Participating in a live audience which intently listens to the mind of the composer emanate through the performance, will always be superior to any recording.

Think of the connection of the performer to the audience at those dense moments of thought-filled silence: Is there something more taking place, on a higher level of communication? Could a virtual chorus or virtual symphony ever communicate that?[23] That special power, which exists as a chain of minds singly, magnetically linked in a performance of a great work, from composer to conductor, to musicians, and to the audience, is a special human power which breaches clock time, and unites all participating souls in a moment of heavenly eternity. Such silent power is what Keats reflected upon in the last stanza of his "Ode on a Grecian Urn" (see box). To perceive these finer effects which we've discussed, requires a cultural development, and

20. The difference of terms is important; *fermata*, a more recent name for this notation, means stop, or halt; while *corona*, on the other hand means, "crown," or, as a verb, "to fulfill."

21. It is worth noting, that Aeschylus' Prometheus clearly shows his contempt for this command, and inspires the audience to do the same. Plato took up this command in his *Alcibiades* dialogue, and in the *Apology*. He turns the command on its head, and gives it the significance that civilization attributes to it ever after: "The unexamined life is not worth living."

22. See the video, "The Genius of Albert Einstein." http://www.larouchepac.com/node/15482, and Shawna's unpublished notes on Einstein's connection to his music.

2323> Eric Whitacre's Virtual Choir—"Lux Aurumque": http://www.youtube.com/watch?v=D7o7BrlbaD

to perceive what is beyond those subtle hints, is a result of thousands of years of tuning into these creative processes of art, science, language, and politics.

The tragedy of our contemporary situation is the lack of perception of another sense, a sense of history. The cultural implications of this attack on U.S. and European culture, cannot to be denied. Young people in our time, more and more, go though life assuming that the things that shape their opinions and their actions and emotional reactions, and thoughts, are all a product of their personal experience, their sense experience in their lifetimes. So what could LaRouche be possibly tapping into, when he speaks of being "3,000 years old, in terms of experience"? Do his senses extend to places beyond his life? If you think of senses now being tuned to the finer subtleties of the mind, yes. A sense of history is the finest sense possessed by most historic figures, like an FDR, a Lincoln, a Bismarck, and poets like Shelley, Shakespeare, Dante, or Homer.

Mozart's moral challenge to the audience through his opera "Don Giovanni," Beethoven's commitment to beauty in his combination of voices and instruments in his 9th Symphony, and these pieces worked on from the *bel canto* tradition, in the natural tuning of C=256: This is the mission embarked upon by the LaRouche Movement today. Such challenges are the only gifts by which our destroyed generations may re-tune themselves with human history.

There are many questions which remain to be addressed in the discussion of hearing, singing, and human communication through reliving Classical compositions. What even finer senses still exist in human beings which we deafen and blind ourselves to all the time in our society? To free our minds from the blindness of sense perception, miraculously, as Helen Keller did, will give us the power to create a future for mankind.

Ode on a Grecian Urn (1819)

by John Keats (1795-1821)

Thou still unravish'd bride of quietness,
Thou foster-child of silence and slow time, Sylvan historian, who canst thus express
A flowery tale more sweetly than our rhyme: What leaf-fring'd legend haunt about thy shape
Of deities or mortals, or of both,
In Tempe or the dales of Arcady?
What men or gods are these? What maidens loth?
What mad pursuit? What struggle to escape?
What pipes and timbrels? What wild ecstasy?
Heard melodies are sweet, but those unheard
Are sweeter: therefore, ye soft pipes, play on; Not to the sensual ear, but, more endear'd,
Pipe to the spirit ditties of no tone: Fair youth, beneath the trees, thou canst not leave
Thy song, nor ever can those trees be bare;
Bold lover, never, never canst thou kiss, Though winning near the goal—yet, do not grieve;
She cannot fade, though thou hast not thy bliss,
For ever wilt thou love, and she be fair!
Ah, happy, happy boughs! that cannot shed
Your leaves, nor ever bid the spring adieu; And, happy melodist, unwearied,
For ever piping songs for ever new; More happy love! more happy, happy love!
For ever warm and still to be enjoy'd,
For ever panting, and for ever young; All breathing human passion far above,
That leaves a heart high-sorrowful and cloy'd,
A burning forehead, and a parching tongue.
Who are these coming to the sacrifice?
To what green altar, O mysterious priest, Lead'st thou that heifer lowing at the skies,
And all her silken flanks with garlands drest? What little town by river or sea shore,
Or mountain-built with peaceful citadel,
Is emptied of this folk, this pious morn? And, little town, thy streets for evermore
Will silent be; and not a soul to tell
Why thou art desolate, can e'er return.
O Attic shape! Fair attitude! with brede
Of marble men and maidens overwrought, With forest branches and the trodden weed;
Thou, silent form, dost tease us out of thought As doth eternity: Cold Pastoral!
When old age shall this generation waste,
Thou shalt remain, in midst of other woe
Than ours, a friend to man, to whom thou say'st, "Beauty is truth, truth beauty,"—that is all
Ye know on earth, and all ye need to know.

Editorial

The Revolution Is Underway

Revolution is in the air, but the crucial question is, what kind? Will there be the outbreak of chaos, spreading across the globe, in an orgy of destruction like the French Revolution of 1789, which keeps the global monetarist empire in control, while its subjects kill one another? Or will it be a worldwide revival of the American Revolution, in which sovereign nation-states around the globe begin to cooperate on missions worthy of mankind—from NAWAPA, to the colonization of space?

We in the LaRouche movement are clearly dedicated to the second kind, which Lyndon LaRouche and his leading collaborators are uniquely prepared to lead. But to accomplish this, in the extremely short window of opportunity in which it must be done, requires action on several different levels.

First and foremost, the American people must get their political representatives to act to remove President Obama from office. Why? Because Obama, who was installed by British financial circles to begin with, is a mentally disturbed narcissist who is psychologically, as well as politically, incapable of bucking the interests of his British masters. And those very masters are determined to destroy the United States, both through implementation of outright fascist measures like the healthcare bill, and the blocking of the necessary radical break with the British bailout monetarist system.

The best way for the nation, to remove Obama would be by the invoking of the 25th Amendment to the U.S. Constitution. It would be the first time that measure was invoked—but it would provide an orderly transition.

The second crucial action is also revolutionary, in the sense of overturning the current bankrupt monetary-financial system. But here, what is required is a return to the United States' original revolution in political economy, the one implemented by our Founding Father Alexander Hamilton, both in his role in bringing about the U.S. Constitution and the establishment of the American System of Political Economy. Hamilton's principles of economy, which define a credit system for economic development and the general welfare, are indispensable for saving the United States, and thus the world, from disintegration. The first steps in their implementation would be restoring FDR's Glass-Steagall, writing off trillions in gambling debts, and pumping out *credit* to save the states, and start reconstruction through projects like NAWAPA.

These two steps, however, are by no means sufficient to dealing with the crisis before us. For, fundamentally, we need a revolution in our whole mode of thought, and our understanding of man's relationship to the universe. We need new conceptions, revolutionary scientific conceptions, which will free us from the pessimism and entropic decay that has increasingly enveloped the earth since FDR's death—and launch a new era of progress for all mankind.

It is to this last revolution that this issue of *EIR* is devoted. Lyndon LaRouche's Basement Scientific Team, the same team that is actively coordinating the NAWAPA taskforce which will shape the Great Projects of the future, has devoted itself to launching the indepth discussion we all need, in order to build the future. These young researchers represent a new generation of leadership, one we so desperately need to come out of today's descent into a New Dark Age.

Don't you think it's time you joined this Revolution?

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