The Extended Sensorium

Following the Beat of a Different Drummer

by Peter Martinson

Part 2 of 2

Cryptic chemistry

As was seen in the case of bird migration, it is clear that birds somehow sense the geomagnetic field, but 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. It was proposed by Thorsten Ritz and Kurt Schulten that some chemical could be involved, which becomes magnetically sensitive after activation by the blue light. [19] The chemical he 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, all the 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 include 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 get green from chlorophyll. This is called "de-etiolation," or just "greening."

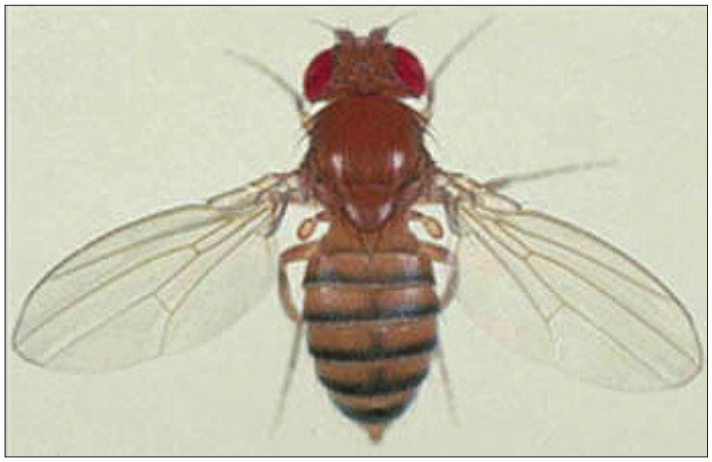
Arabidopsis thaliana

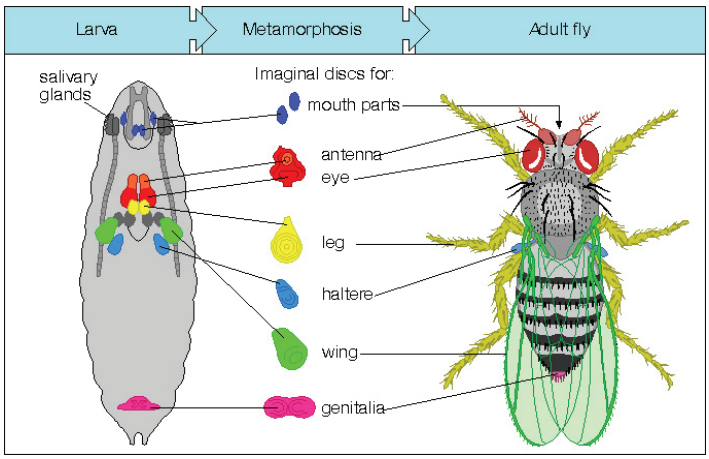
It was found that de-etiolation doesn't require the entire spectrum of light. Normal plants will green under either blue or red light, or both. Scientists believed that this meant there were two pathways, initated by two distinct sets of photoreceptors, that led to the same result. The photoreceptors 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, but not blue. In 1993, Ahmad and Cashmore determined the section of DNA that differed between one of these blue-immune strains, and normal *Arabidopsis*. [21] They found that the protein which corresponds to this DNA section bore heavy resemblance to a protein called photolyase, which can be induced to repair UV-damaged DNA, but only after being activated by violet/UV light. [22] They argued that they had found the elusive cryptochrome pigment's gene, which was then found in many other organisms.

In a fascinating 2007 experiment, Margaret Ahmad and others (including the Wiltschkos of bird-migration fame) 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. They 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 insect. Cryptochrome had already been found in a variety of animals and insects, 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. In the experiment, they presented a travel tube for the flies, one end of which had a 5 Gauss magnetic field, the other being magnetically neutral, and watched what 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 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 they 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 fruit fly's locomotor activity 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. It had been shown by Jürgen Aschoff 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., got a bunch of 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 like 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, respectively), aligned with the local geomagnetic field. Under red light, nothing special happened, while under blue light, they found the wild-type flies staying awake even longer, while





Drosophila Melanogaster

the cryptochrome-lacking flies went back to sleep. They also found that, in the flies affected by the field, the periods got longer, the stronger the magnetic field.

The results of 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 spacetime distinction of the biotic phase of the Universe. As will be seen in the following section, this spacetime 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 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 another protein called "photolyase." Matching DNA sections have been found in other organisms, such as *Drosophila* and birds, and has 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 which corresponds to this system was then mass-produced, crystalised, 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, that 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 pheonomena described through these experiments, instead of the causative factor. It is a danger that conclusions be made on the basis of theories of spin chemistry and the crystal structure of cryptochrome, while 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 phenomenon called "spin" really does exist—there are clear chemical and atomic properties that are related in an ordered way with magnetic fields. But, that the ordered array of experimental results are solved by enumerating them and attributing it to a particle's rotation, 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 fulfil the properties observed through the line of experiments leading out of these referred to above, in life.

Unknown radiations?

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

Frank Brown and his collaborators built an apparatus to measure metabolic cycles of a variety of organisms. The apparatus consisted of a big Erlenmeyer flask, into which you could place the subject organism. 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 whole apparatus was also designed to be able to maintain constant levels of illumination, pressure, and temperature within the flask. With this, they measured the oxygen consumption from a potato, for example, for several months in constant conditions, and found that the potato retained its response to atmospheric pressure, even though it was shielded from any variations in pressure, i.e. although the potato physically felt no change in pressure within the chamber, its oxygen consumption went up when the pressure outside the chamber rose, and vice versa. What is more, they found that there was not just a response to pressure, but that the response 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. The potato did not respond, minute to minute, with these changes. But, if the metabolic response to the organism was measured from about 4-7am every morning, 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 was pretty outlandish, he repeated the experiment with almost a dozen other non-related 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 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 he found that the responses at corresponding months of two years were inverted. In other words, in May 1955, O2 consumption went up around 6 am, but in May 1956, O2 consumption headed down at around 6 am. 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 remembered that cosmic ray flux is impacted by many things, including the activity of sunspots, the Solar wind, and other galactic phenomena, with the Sun's activity appearing to dominate.

Thus, Brown embarked on a series of experiments to determine whether or not organisms can sense weak magnetic and electric fields. [29] Remember, that 1960 was 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 once 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 snails, in all four of the 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 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 degree oscillation throughout 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 simply orientation.

At issue here is both the spacetime organisation of life, but also the potential that organisms, already demonstrated to be extremely sensitive to very weak fields, are responding to as-yet unknown radiations, or unknown 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 things like 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 organisation' 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, in both direction and intensity, of a variety of organisms to very weak fields. 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.

The spacetime 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 spacetime." 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 amospheric 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 relation-

ships between our galaxy, the local group and local supercluster of intergalactic spacetime. As has already been noted several times in several places, there is a marked cycle of biodiversity of about 62 million years on this planet. [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 spacetime 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 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 NAWAPA has become a reality, we 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 not forget, that the North American Water and Power Alliance (NAWAPA) 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 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, of course, 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.

Footnotes

[18] See the report on bird magnetoreception by Ben Deniston, elsewhere in this volume.

[19] Ritz T., Adem S., Schulten K. **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, it is 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] Ahmad M. & Cashmore A. **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 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] Ahmad M., Galland P., Ritz T., Wiltschko R., Wiltschko W. **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 or Gauss. One μT equals 10,000 Gauss. The geomagnetic field averages about 0.3-0.5 Gauss, which equals 30-50 micro-Tesla. Therefore, Ahmad's experimental magnetic field was about ten times the background geomagnetic field.

[25] Gegear R., Casselman A., Waddell S., Reppert S. **CRYPTOCHROME Mediates Light-dependent Magnetosensitivity**. *Nature*, Vol. 454, pp. 1014-1028 (2008)

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

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

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

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

[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. www.nasa.gov/mission_pages/GLAST/news/fermi-thunderstorms.html

[32] LaRouche PAC special video, *The Extraterrestrial Imperative, Part 2*, found at www.larouchepac.com/node/16049

[33] See Jason Ross's video on the non-constant rate of radioactive decay at www.larouchepac.com/node/16224

[34] See the report on hearing auroras and meteorites by Sky Shields, elsewhere in this volume, for more on the radiative environment of the arctic. Also, watch the LaRouche PAC video on developing the arctic, at www.larouchepac.com/infrastructure