Article

Birds, Bees, and Electromagnetic Pollution

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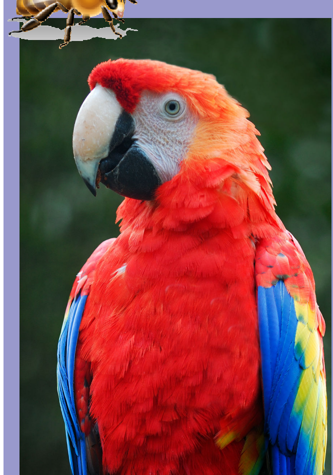
"Birds are very sensitive to electromagnetic fields."



Many of our birds are disappearing mysteriously from the urban environment and our bees are now under serious threat. There is increasing evidence that at least some of this is due to electromagnetic pollution such as that from cell towers, cell phones, DECT cordless phones, and Wifi. It appears capable of interfering with their navigation systems and also their circadian rhythms, which in turn reduces their resistance to disease. The most probable reason is that these animals use a group of magnetically-sensitive substances called *cryptochromes* for magnetic and solar navigation and also to control the activity of their immune systems.

Birds are very sensitive to electromagnetic fields and some may find the electromagnetically polluted urban environment no longer tolerable. Migratory birds may also lose their sense of direction and never reach their intended destination, perhaps just falling into the sea on the way. Bees are even more under threat and are extremely important to us. Without bee pollination, there would be very few brightly colored or scented flowers in the countryside or in our gardens and many of our crops would be devastated. We would be left just with crops that are wind pollinated (mostly cereals) that do not on their own provide a healthy balanced diet, nor do they act as host to the friendly nitrogen fixing bacteria that are essential to the sustainable fertility of our soil. This may be a very heavy price to pay for our unrestricted use of cell phones and other forms of wireless communication.

What are cryptochromes?

The cryptochromes are a group of pigments found in virtually all animals, plants, and many bacteria. They consist of a flavin (a derivative of vitamin B_{2}.), folic acid, and protein. Like all pigments, they get their colour by absorbing light at specific wavelengths. The cryptochromes absorb blue-green and ultra-violet light and use its energy to drive *photochemical reactions* where light energy is converted to chemical energy. The earliest cryptochromes used this energy to repair damaged DNA. However, more modern ones have evolved in both animals and plants where they measure light to reset their biological clocks.

In some animals, they also sense the direction of the Earth's magnetic field. Unfortunately, cryptochromes are very badly affected by weak oscillating electromagnetic fields that are orders of magnitude weaker than the Earth's steady magnetic field. This can disrupt both solar and magnetic navigation, which may account for colony collapse disorder in bees, the loss of some migratory birds and butterflies and a weakening of the immune system in many more organisms.

How cryptochrome measures light

The energy of light is used to transfer an electron from one part of the cryptochrome molecule to another to form a pair of what chemists call *free radicals*. The electron finds its way back of its own accord to restore the *status quo*, but this takes longer and results in an accumulation of cryptochrome in the free radical form. It soon reaches equilibrium when the rate of free radical formation equals its rate of destruction, at which point the proportion in the free radical form is a measure of the current brightness of the light.

How cryptochrome senses magnetic fields

This depends on the fact that free radicals are affected by magnetic fields. Steady magnetic fields delay the return of the displaced electron so that there is an even greater accumulation of cryptochrome in the free radical form. This can be sensed by the cell in the same way as it senses the effect of light. The direction of the field can be found by having an array of cryptochrome molecules oriented in different directions, as they would be in the compound eye of an insect or in the retina of a vertebrate's eye. Most of the cryptochrome is found in the eyes, but it is quite distinct from the regular visual pigments (rhodopsins) that are used in normal vision. However, their combined effect gives the animal the potential to "see" the direction of the magnetic field, possibly as an extra colour superimposed on its field of vision.

Oscillating magnetic fields severely disrupt cryptochrome function.

Ritz and co-workers (Nature Vol. 429 13th May 2004 pp 177-180) showed that, provided they were given light of the wavelengths absorbed by cryptochrome , robins could orient themselves for navigation in the Earth's magnetic field. However, this was severely disrupted by the application of extremely weak alternating electromagnetic fields. Frequencies between 0.1-10MHz at field strengths as little as 0.085 microtesla (about 500 times weaker than the Earth's field) made the birds completely unable to respond to the Earth's field! The irregular pulsations of information-carrying digital transmissions give a broad spectrum of frequency components within this range. These will occur in most mobile telecommunications, including cell phones, DECT cordless phones and Wifi. It is therefore reasonable to conclude that the use of these devices may be a major factor in some animals losing their ability to navigate using the Earth's magnetic field.

Cryptochrome and solar navigation

Many animals, including birds and bees, can also navigate by using the position of the sun. But in order to do this, they must have an internal clock to compensate for its changing position throughout the day. The mechanism of this clock has been extensively studied in mutants of the fruit fly *Drosophila.* It uses cryptochrome to sense the light-dark transitions at dawn and dusk to reset its clock and also to keep it running at the correct speed. Unfortunately, the use of cryptochrome also makes the clock sensitive to magnetic fields.

Yoshii *et al*. found that a 300 microtesla steady field could alter the speed of the clock or even stop it altogether. (http://tinyurl.com/cx7xaa) They didn't test weak alternating fields, but given the findings of Ritz *et al*. and the fact the sensing of light and magnetic fields by cryptochrome uses the same basic mechanism, it is likely that these too would disrupt the clock's normal functions. The consequence of this would be that electromagnetic fields of this sort would render the animal unable to compensate accurately for the changing position of the sun. This means that both solar and magnetic navigation would fail together and, if there were no landmarks to guide it, the animal would be completely lost. This could explain colony collapse disorder when bees do not return to the hive, why it is so prevalent in the featureless almond plantations of the USA, and why there are increasing losses of animals that have the option to use both.

Circadian rhythms are affected too

Circadian rhythms are natural metabolic rhythms that occur in virtually all higher organisms. They too are driven by the biological clock so that the organism can *anticipate* the coming of dawn and dusk and modify its metabolism to be ready for the new conditions. Many metabolic functions are controlled in this way. These include the rhythmic production of melatonin (a sleep hormone) and the diversion of metabolic resources from physical activity during the day, to repair and the immune system at night.

Consequences of losing the circadian rhythm

If the rhythm were to be lost or become weaker due to a failure of the clock as a result of electromagnetic exposure, it would have serious consequences. In humans it would result in tiredness during the day, poor sleep at night, and a reduced nightly production of the sleep hormone melatonin. All of these effects have been reported in people exposed to the radiation from cell towers and other sources of continuous weak electromagnetic radiation such DECT phone base stations and Wifi routers.

Also, any weakening of the amplitude of these rhythms means that **at no time will any process controlled by them ever function at maximum power.** In particular, the immune system may never be able to summon up the overwhelming power that is sometimes needed to overcome pathogens or to destroy developing cancer cells before they get out of control. This could in part explain the increased risk of cancer often found in epidemiological studies of people living near mobile phone base stations. It may also be a contributory factor in the continuing reduction in the health of our bee population and its apparently reduced ability to resist pathogens.

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Andrew Goldsworthy was born in 1939. After a conventional Grammar School education he obtained a First Class Honours Degree in Botany followed by a PhD for research into plant physiology and biochemistry at the University of Wales. He went on to lecture at Imperial College London, where he spent the rest of his career. He has had many teaching and research interests, ranging from the biochemistry of photorespiration to the biology of space flight. He retired in 2004 but remains as an honorary lecturer, and still gives occasional lectures on specialized subjects. He was also a scientific advisor to the European Space Agency and is currently a scientific advisor to several European charities concerned with the environment and electromagnetic fields, including the h.e.s.e - project, the Radiation Research Trust and Electrosensitivity-UK. He has always had a strong interest in how living organisms use internally-generated electric currents to control their growth and metabolism and in their disruption by externally-applied currents and fields. In his retirement, he pieced together nuggets of information from a wide range of scientific journals and created a simple layperson's explanation of how weak electromagnetic fields affect us all. This can be found on the h.e.s.e. - project website at:
http://tinyurl.com/28lo82,
which corresponds to:
http://www.hese-project.org/hese-uk/en/niemr/resonance1.php.