Radical Pair-Based Magnetoreception

Erin M. Mattern*, Thorsten Ritz
Physics and Astronomy, University of California, Irvine, U.S.A.
*E-mail: emattern@uci.edu

Every season many species of birds migrate due to an endogenous program that is designed to propagate the species through breeding and provision of larger food sources. The mystery of this biological phenomenon is how the birds are able to navigate to their new environment. One source of directional information that is always present is the Earth's dipolar magnetic field. Magnetic field experiments over the course of more than 40 years show that birds can detect the geomagnetic field and use it to determine migratory directions. However, the lack of an obvious site for a magnetic sensor, combined with the ability of magnetic fields to pass through all tissue has prevented the discovery of the mechanism responsible for the detection of Earth-strength fields. Two primary models have risen to the forefront of magnetoreception research: magnetite and radical pairs. In the radical pair model, the magnetic field affects a photochemical reaction step that involves light-induced creation of an intermediate pair of radicals, i.e., molecules with an unpaired electron spin. Recent experiments suggest that the blue-light receptor cryptochrome, which has been discovered in birds, plants, and other animals, is a promising candidate for a photo-magnetoreceptor. Its presence in plants allows one to apply molecular biological and genetic approaches in order to determine the molecular basis of photochemical magnetoreception. Magnetic field effects on cryptochrome-responses, such as hypocotyl growth, have been seen in *Arabidopsis thaliana*. My current goals are to first obtain a dose-response curve explicitly connecting the height of the plants to the strength of the static magnetic field. Experiments with oscillating magnetic fields in the MHz range will then be performed to further identify the chemical nature of the magnetosensitive reaction step through resonance effects. The results from these experiments and collaborative studies at the protein level will be used to establish a conceptual model of the photochemical magnetic detection mechanism in cryptochromes with the goal of explaining how small magnetic effects in one reaction step can lead to stable physiological responses.