Protein Choreography of the Molecular Compass

Supervisory team:
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Host institution: University of Exeter (Streatham/St Luke's)

Project description:

Birds, fruit flies and many other animals are equipped with the remarkable ability to sense the Earth's magnetic field by means of a biochemical reaction in cryptochrome proteins. Surprisingly, this protein molecular compass utilises truly quantum effects to respond to changes in the magnetic field as the animal navigates. The molecular basis of how these proteins structurally reconfigure in response to planetary magnetic fields, transduced by quantum effects on single electrons, is unknown. In migratory songbirds, such as the European robin, Cryptochrome 4 (Cry4) is the protein identified to correlate with magnetosensation. Photoreduction of Cry4 has been shown to be sensitive to magnetic fields in vitro. Yet, little is known about the structure of Cry4 and which conformational changes transduce the geomagnetic field.

Here, we will aim to decipher the inner workings of Cry4 protein as the molecular transducer of our planet's magnetic field by migratory birds. You will learn a variety of cutting-edge and highly transferable biophysical and computational tools and techniques. This studentship will provide a rare opportunity to become an expert in hydrogen/deuterium-exchange mass spectrometry (HDX-MS), using novel prototype instrumentation developed by the Phillips lab at The Living Systems Institute, Univ. Exeter. You will make millisecond time-resolved measurements of the protein structural dynamics under magnetic stimulation. You will then use these experimental results to seed molecular dynamics simulations (Mulholland Group, Univ. Bristol) and combine this with quantum mechanics calculations (Kattnig Group, Univ. Exeter). As a result, you will produce an experimentally driven molecular movie of the process of Cry4 functional switching with atomistic resolution.

In addition, we will provide you with full training in mass spectrometry, molecular dynamics simulation, fluorescence spectroscopy, molecular biology, and recombinant protein expression. To study Cry4's magnetosensitivity, you will employ these techniques in combination with magneto- and photo-stimulation.

This project is open to students with experience in natural sciences (chemistry; biosciences; physical sciences and engineering degrees). As this is a highly interdisciplinary project, we anticipate the successful candidate will not have prior experience in all relevant areas of research and we are fully committed to supporting you to succeed, regardless of your background. This project will involve joint working between Exeter and Bristol and may involve collaboration visits to our collaborators at The University of Lund (avian cognition and ecology), The University of Oxford (optical spectroscopy) and The National Physical Laboratory (cellular magnetic field effects).