Birds Navigation and Magnetoreception

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Introduction:

Birds are capable of true navigation in which the birds are able to return to a goal after being displaced (even artificially) to an unknown place. The ability of migratory birds to make journeys of thousands of miles, has long fascinated scientists. In this research, the mechanism of magnetoreception in birds' navigation is studied.

Methods:

Computational Simulation Techniques, Applying Artificial Magnetic Field to European Robin and Recording the Results.

Results and discussion:

Cryptochromes which are located in birds' eyes, can form long lived radical pairs on exposure to light. Electron transfer processes which generate radical pairs in coherent electron spin states (singlet or triplet) are affected by weak magnetic fields such as earth magnetic field. This can result in formation of different molecules and therefor control the behaviour of the migratory birds.

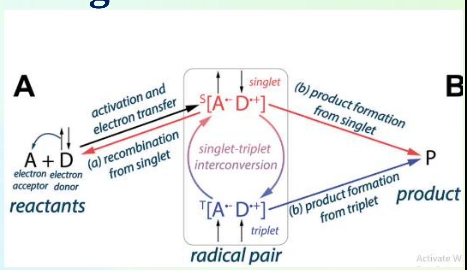
Conclusion:

The ability of migratory birds to navigate accurately using the geomagnetic field for journeys of thousands of kilometers is thought to arise from radical pair reactions inside a protein called cryptochrome.

Keywords:

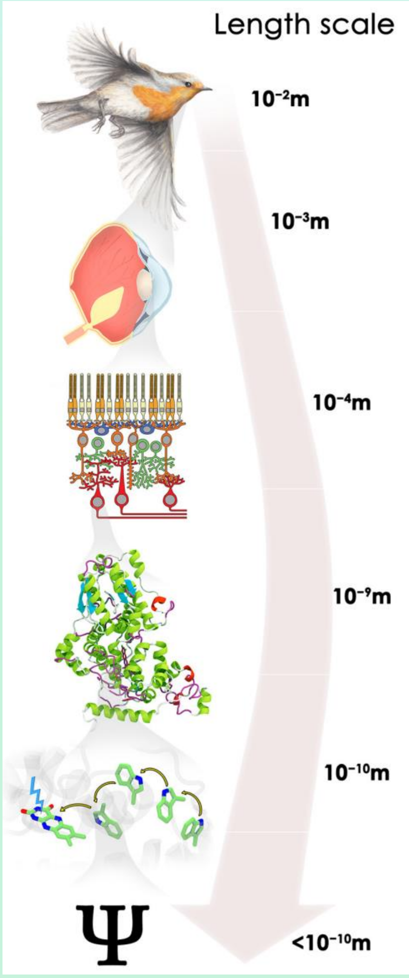
Birds Navigation, Radical Pair Mechanism, Magnetoreception, Quantum Biology, Cryptochrome

A simplified scheme of the radical pair mechanism and birds navigation:



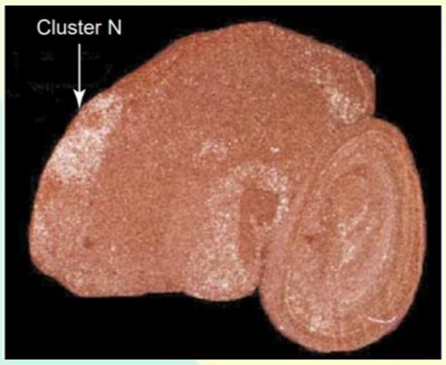
- The radical pair [A•− D•+] is formed from reactants A and D by light-absorption (black arrow) and interconverts between singlet and triplet states (curved red/blue arrows).
- The singlet state can recombine to regenerate the reactants or react to form the product P (red arrows), while the triplet state can only form P (blue arrow).

How birds sense the direction of the Earth's magnetic field.



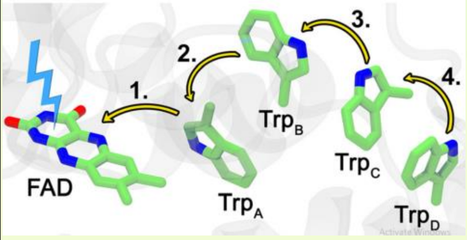
- To sense the magnetic field, the cells must contain molecules that respond to magnetic stimuli having first been activated by light.
- The protein thought to fulfil this role is cryptochrome 4.
- Inside the cryptochrome, light-induced magnetically sensitive radical pairs are formed.

Cluster N integrates specialised visual input at night in night-migratory songbirds



- The whitest area in the top left part of the brain is 'Cluster N'.
- Cluster N is processing seemingly specialized, night-time visual input from the eyes in garden warblers.
- The brain extracts the reference compass direction provided by the geomagnetic field from the visual inputs it receives from the retina.
- If the bird's circannual clock and its hormonal and genetic machinery are in migratory mode, a comparison between the reference direction and the bird's genetically coded migratory direction fixes its magnetic compass orientation.

Electron transfer in Cry4 to FAD along a chain of four tryptophan (Trp) residues:



- The electron transfer occurs after the protein has absorbed a photon of blue light and results in the formation of a radical pair comprising the FAD and the terminal tryptophan.

Key points in birds magnetoreception:

- Magnetodetection senses based on light-dependent radical-pair processes
- Behavioral responses to oscillating magnetic fields
- Having magnetosensory molecules, the cryptochromes, in their eyes.
- Cluster N integrates specialised visual input at night in night-migratory songbirds.

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