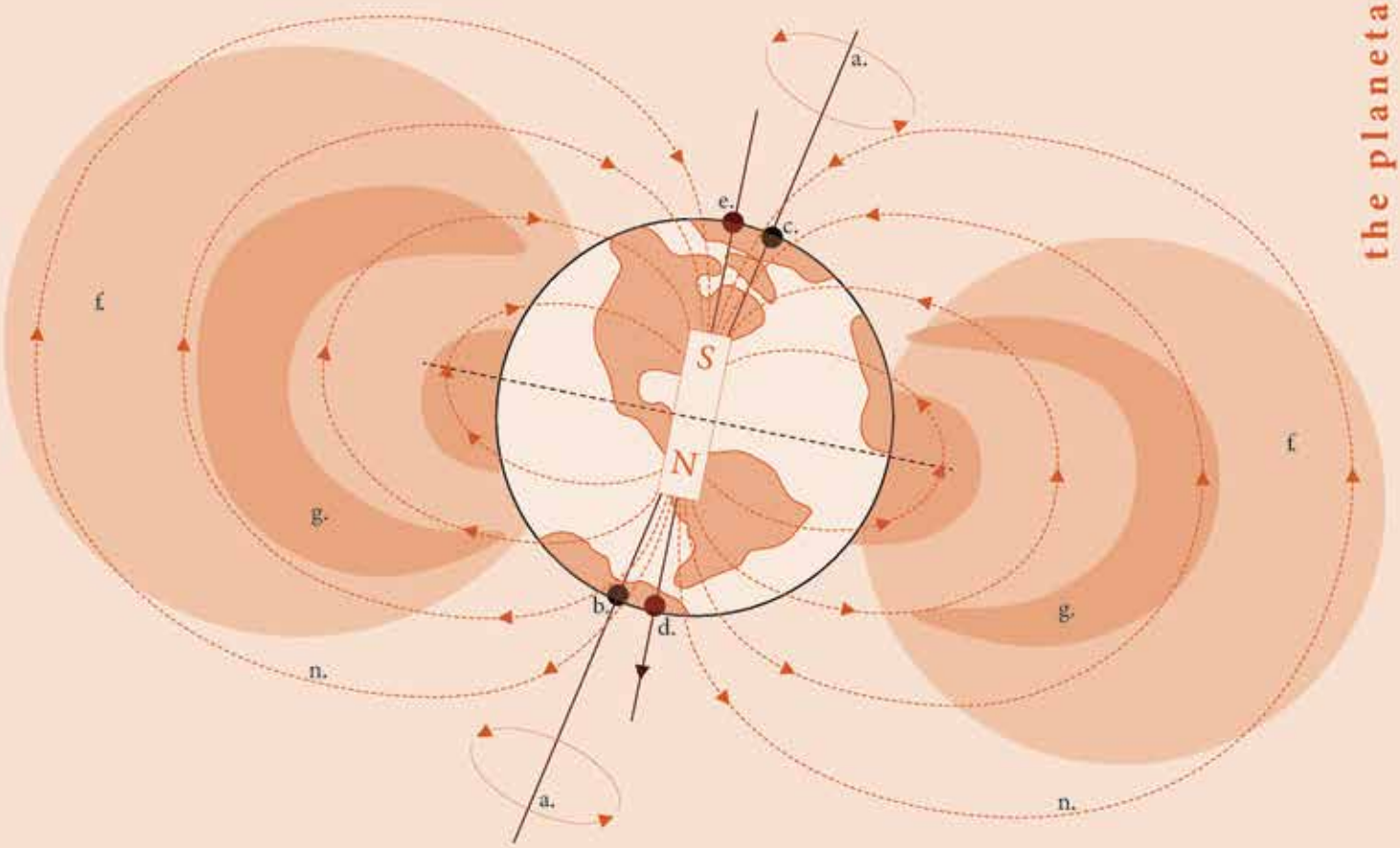
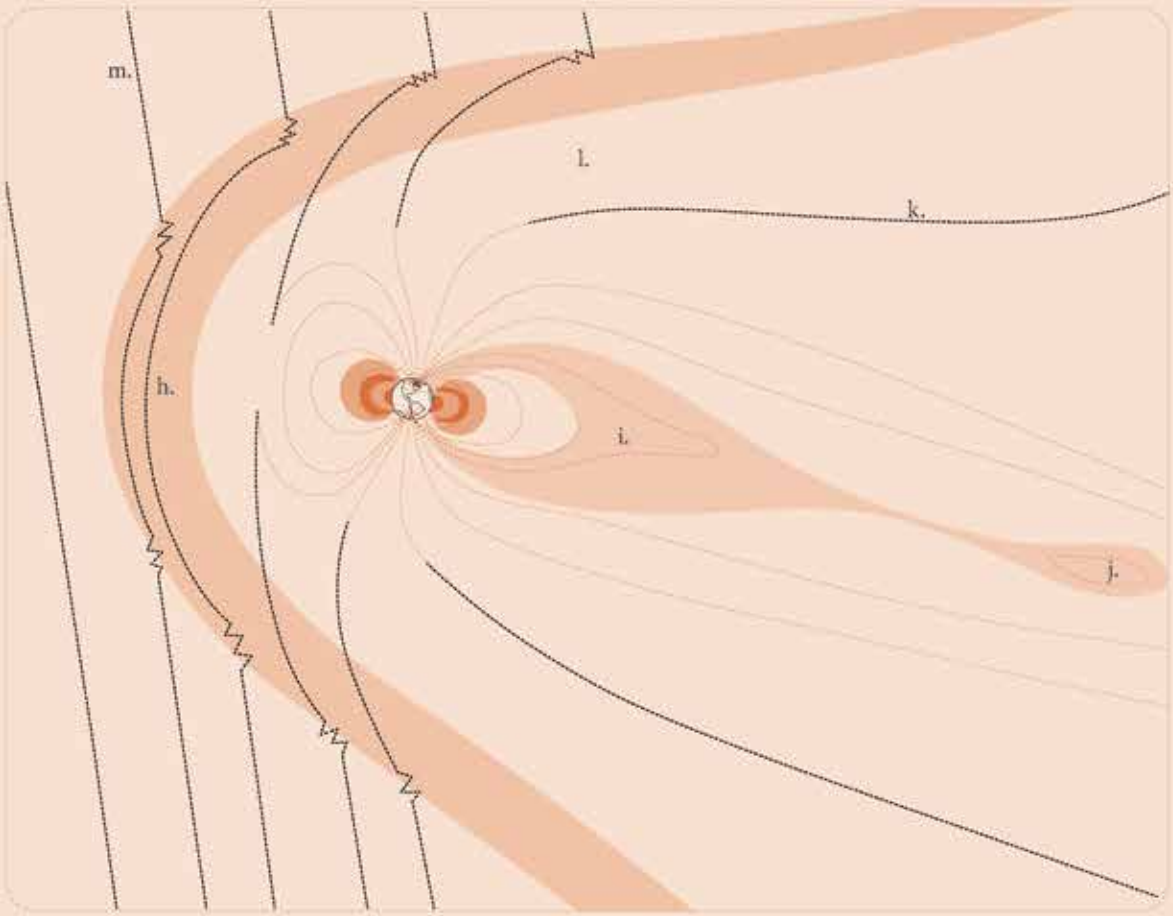


legend

a. axis of the Earth
b. south geographic pole
c. north geographic pole
d. magnetic north pole
e. magnetic south pole
f. radiation belt
g. plasmasphere
h. bow shock
i. plasma sheet
j. magnetotail
k. magnetopause
l. magnetosheath
m. interplanetary magnetic field lines
n. magnetic field of Earth

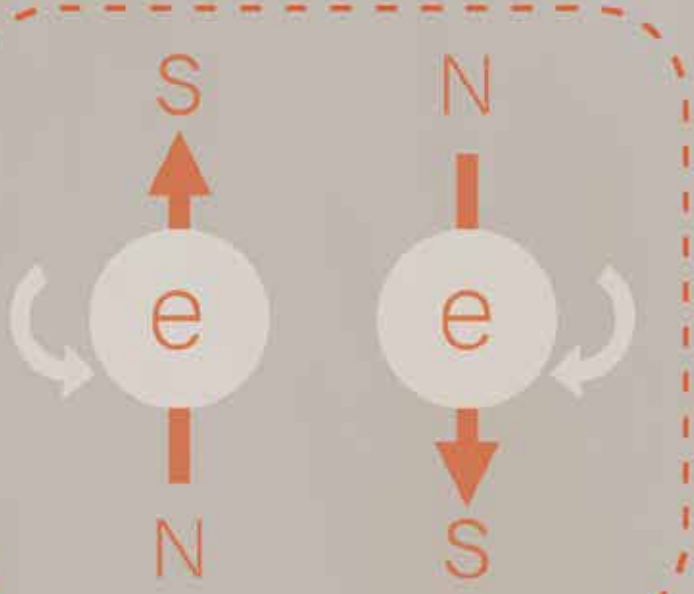


Definition:

An intrinsic, quantized angular momentum that is inherent to all elementary particles

Visual representation:

Some butterflies are upwards, some are downwards



SPIN


IMAGINE TO RECEPT

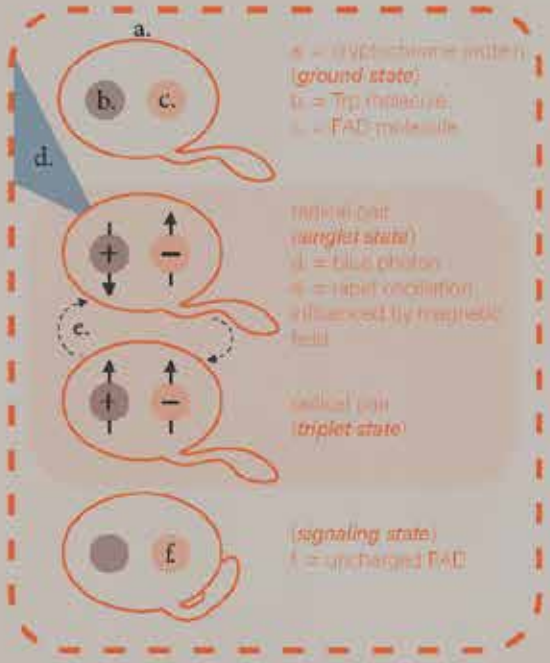
CRYPTOCHROMES

Definition:

Cryptochromes are proteins that are sensitive to blue light. They regulate circadian rhythms, and are hypothesised to be involved in sensing Earth's magnetic field

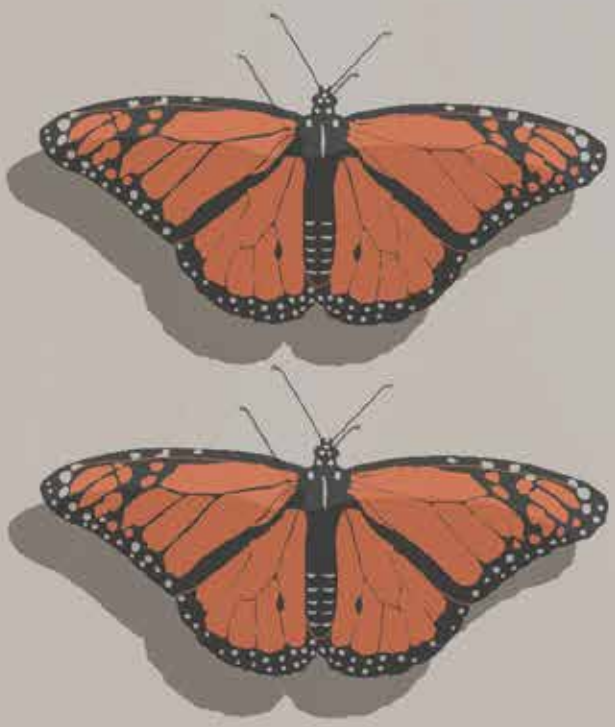
Visual representation:

Literal blue light shining upwards to illuminate butterflies



*It is still debated by researchers whether magnetoreception

RADICAL PAIRS

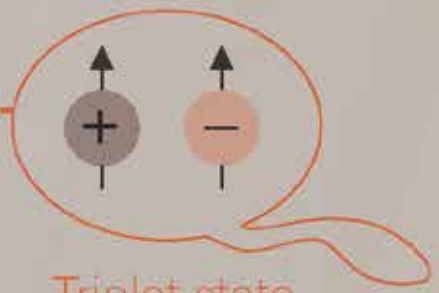


Definition:

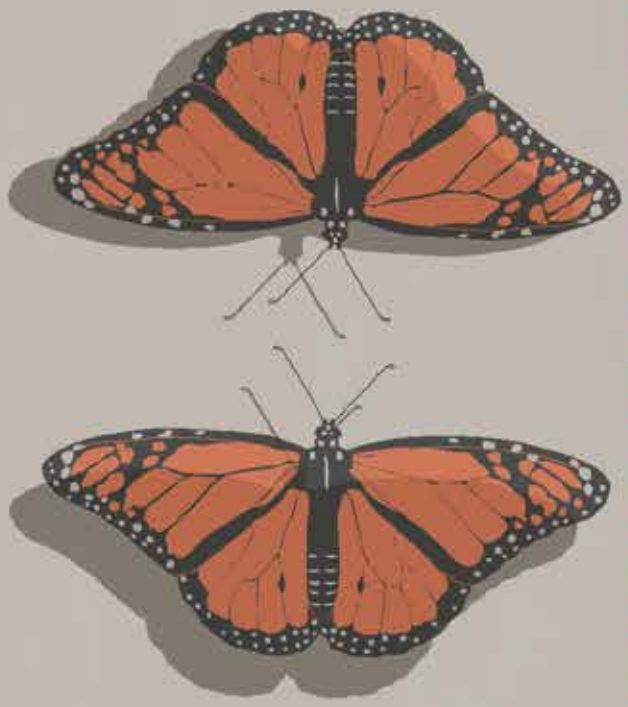
These are chemical intermediates (transient and short-lived outcomes within a multi-step reaction) that consist of two molecules, both having an unpaired electron, with the spin being either opposite (singlet state) or parallel (triplet state)

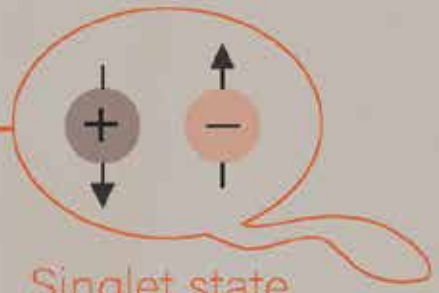
Visual representation:

Monarchs are paired up on the branch, some as singlet and some as triplet states



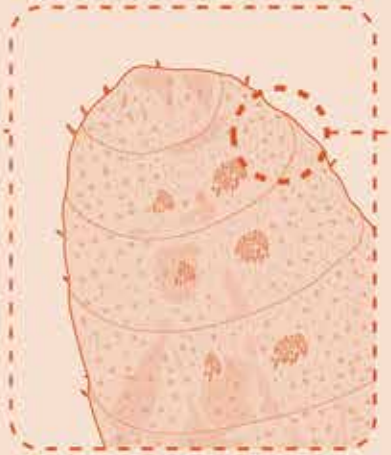
Triplet state





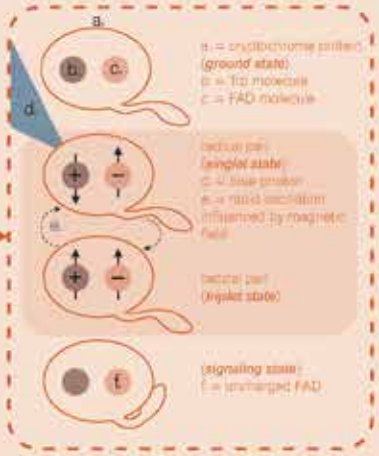
Singlet state

THE QUANTUM

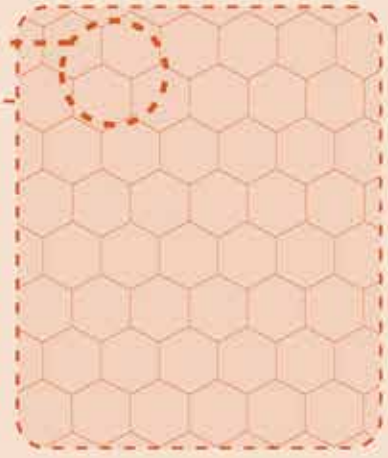


Antennae club with clusters of densely packed chemoreceptors which help adult monarchs to smell odours and pheromones

Cryptochrome protein (CRY-1): the blue light-sensing protein found inside the antennae and eyes of the monarch



Caveat: It is still debated whether magnetoreception definitely occurs through radical-pairs, and whether CRYs function as genuine photo-magnetoreceptors



Ommatidia: thousands of extremely small units that make up each compound eye of the monarch butterfly; the compound eyes encode the solar azimuth to help in navigation

MAGNETORECEPTION

Definition:

A biological sense enabling some organisms to detect the magnetic field of Earth for navigation and orientation

Visual representation:

Neodymium magnets (NdFeB), the strongest permanent magnets Earth has, (made from neodymium, iron, and boron), have been placed on the branch in two locations. Two pairs of monarchs, with magnets at their antennae clubs, hover in the air, suspended in the magnetic fields