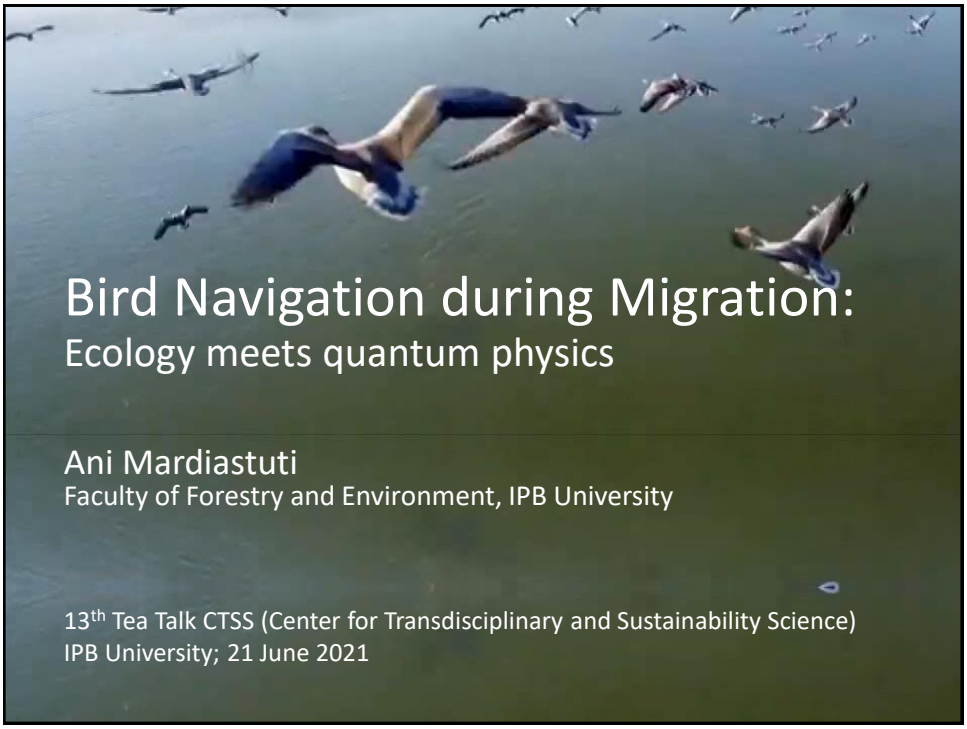


Bird Navigation during Migration:
Ecology meets quantum physics

Ani Mardiastuti
Faculty of Forestry and Environment, IPB University

13th Tea Talk CTSS (Center for Transdisciplinary and Sustainability Science)
IPB University; 21 June 2021

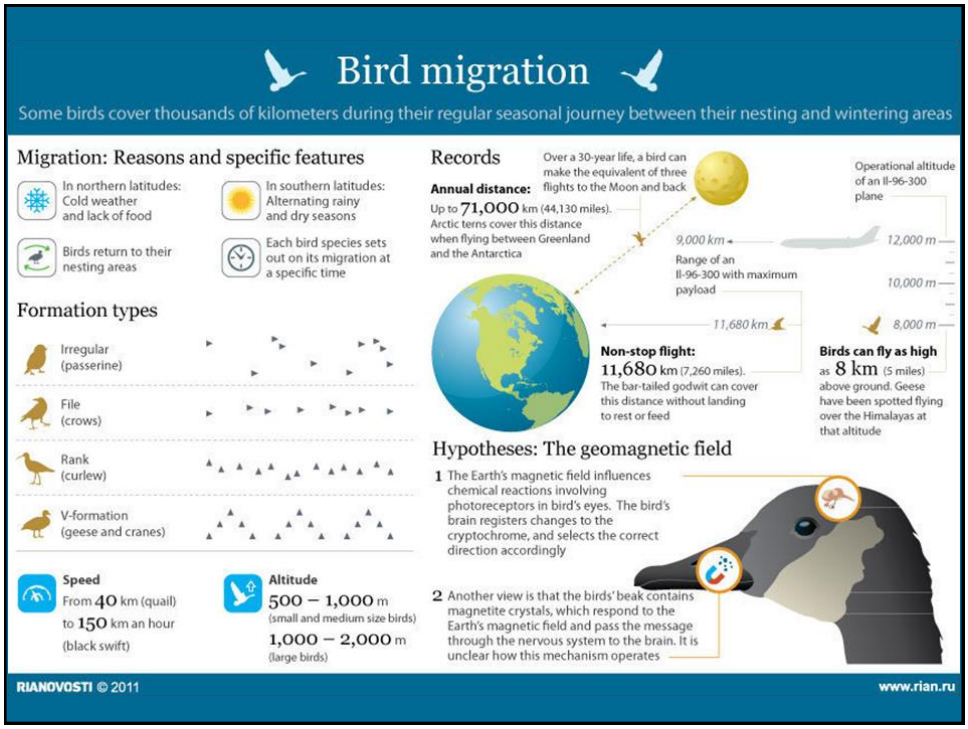
1st century; Egypt

"war pigeon"
"pigeon post"
merpati pos

Some animal species have abilities to navigate


Long-distance migration
needs precise navigation
Migratory birds in Berbak National Park


Bird migration:
What?
Why?
When?
Who?
Where? – from where to where?
How?


Bird migration
Some birds cover thousands of kilometers during their regular seasonal journey between their nesting and wintering areas
Migration: Reasons and specific features
In northern latitudes: Cold weather and lack of food
In southern latitudes: Alternating rainy and dry seasons
Birds return to their nesting areas
Each bird species sets out on its migration at a specific time
Formation types
Irregular (passerine)
File (crows)
Rank (curlew)
V-formation (geese and cranes)
Speed
From 40 km (quail) to 150 km an hour (black swift)
Altitude
500 – 1,000 m (small and medium size birds)
1,000 – 2,000 m (large birds)
Records
Over a 30-year life, a bird can make the equivalent of three flights to the Moon and back
Annual distance:
Up to 71,000 km (44,130 miles). Arctic terns cover this distance when flying between Greenland and the Antarctica
9,000 km
Range of an Il-96-300 with maximum payload
11,680 km
Non-stop flight:
11,680 km (7,260 miles). The bar-tailed godwit can cover this distance without landing to rest or feed
Operational altitude of an Il-96-300 plane
12,000 m
10,000 m
8,000 m
Birds can fly as high as 8 km (5 miles) above ground. Geese have been spotted flying over the Himalayas at that altitude
Hypotheses: The geomagnetic field
1 The Earth's magnetic field influences chemical reactions involving photoreceptors in bird's eyes. The bird's brain registers changes to the cryptochrome, and selects the correct direction accordingly
2 Another view is that the birds' beak contains magnetite crystals, which respond to the Earth's magnetic field and pass the message through the nervous system to the brain. It is unclear how this mechanism operates
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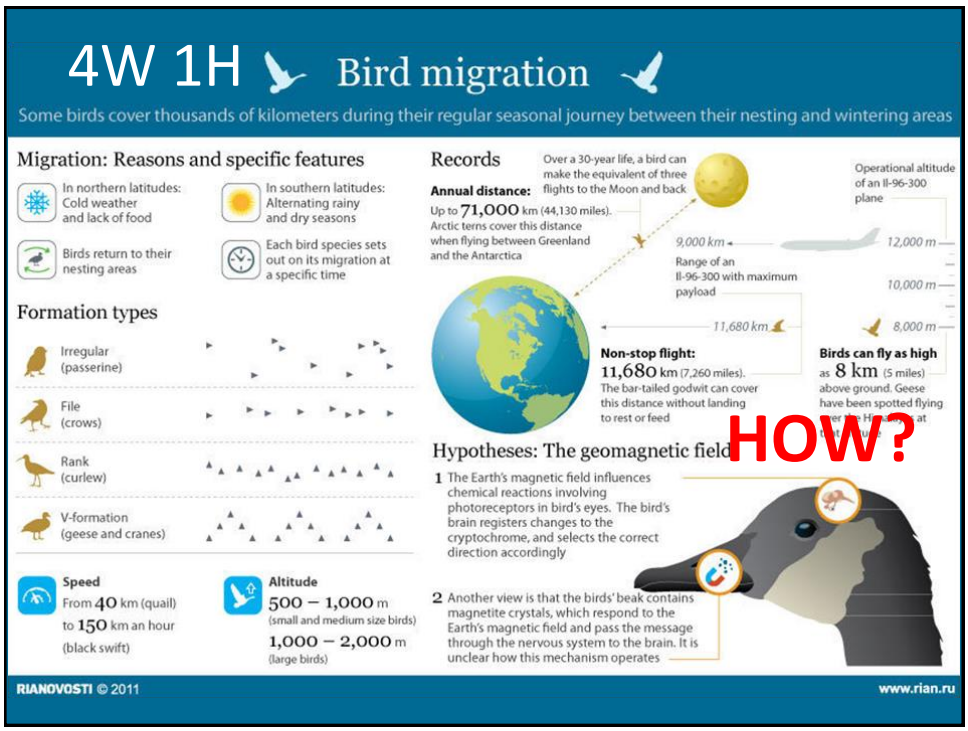
4W 1H
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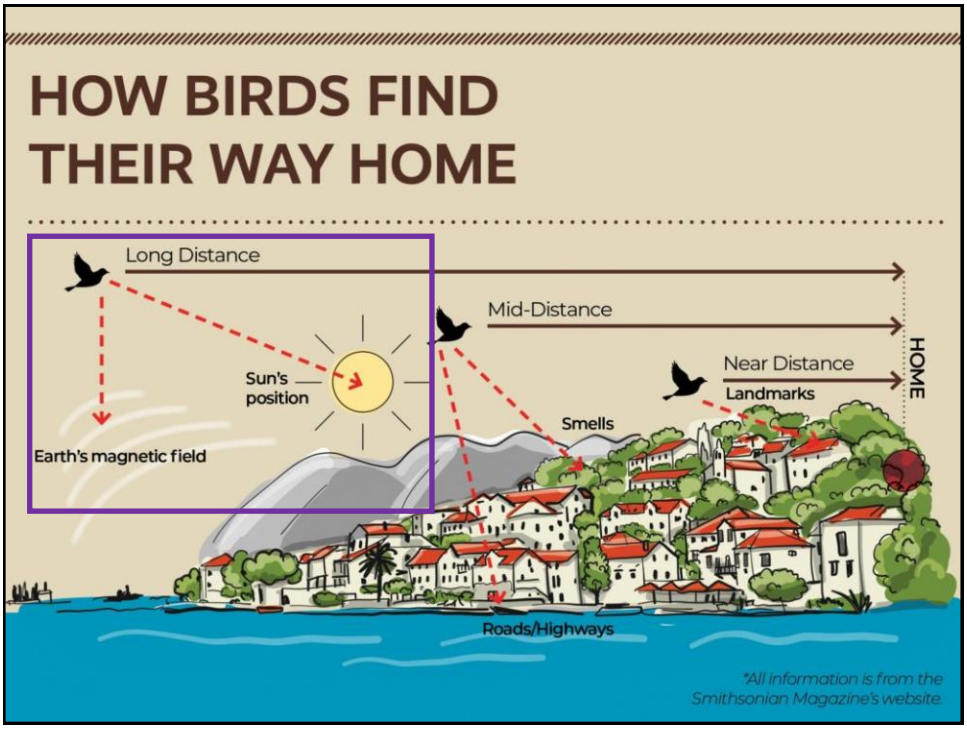
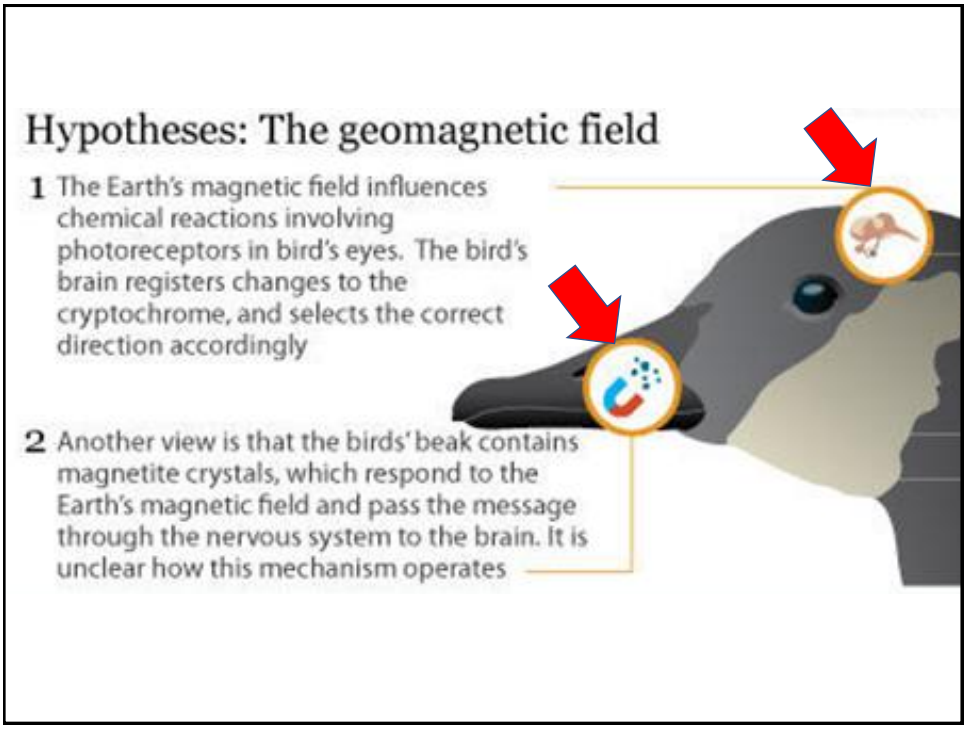

HOW BIRDS FIND THEIR WAY HOME
Long Distance
Mid-Distance
Near Distance
Landmarks
HOME
Sun's position
Earth's magnetic field
Smells
Roads/Highways
*All information is from the Smithsonian Magazine's website.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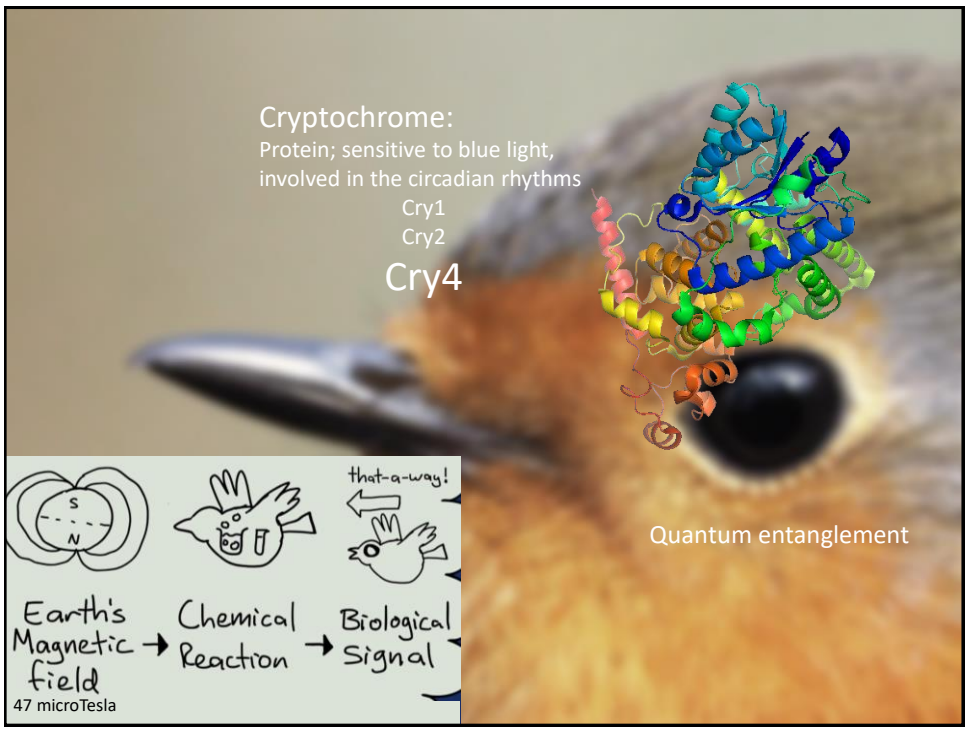
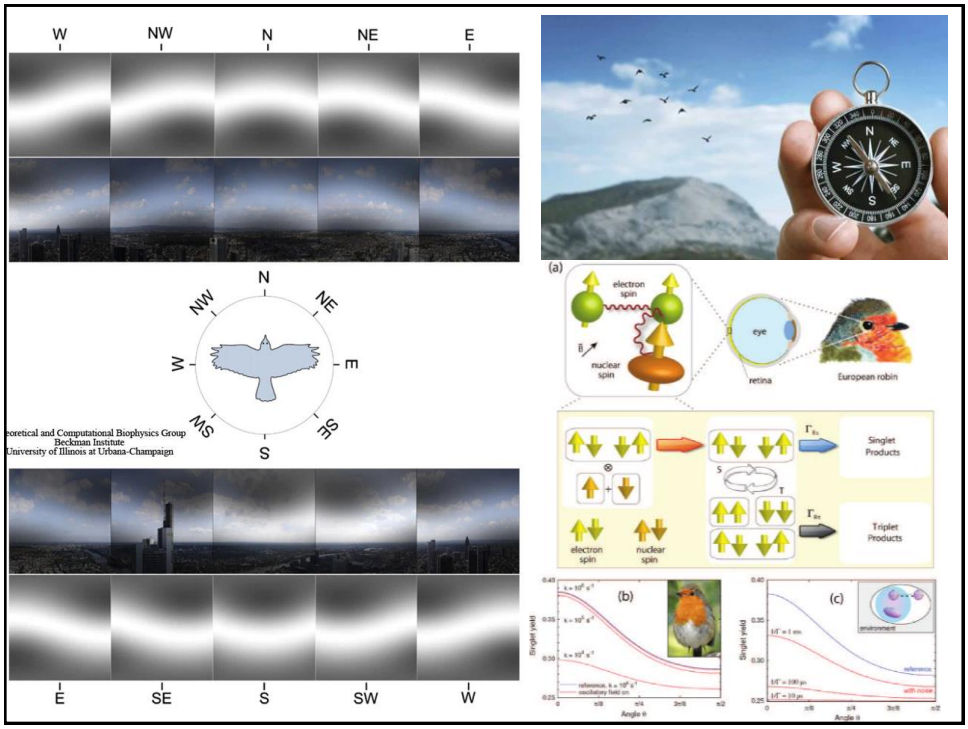
Cryptochrome genes
Zebra finch
Taeniopygia guttata
Lund University, Sweden
American robin
Turdus migratorius
University of Oldenburg, Germany


Cryptochrome:
Protein; sensitive to blue light, involved in the circadian rhythms
Cry1
Cry2
Cry4
that-a-way!
Earth's Magnetic field
47 microTesla
Chemical Reaction
Biological Signal
Quantum entanglement


W
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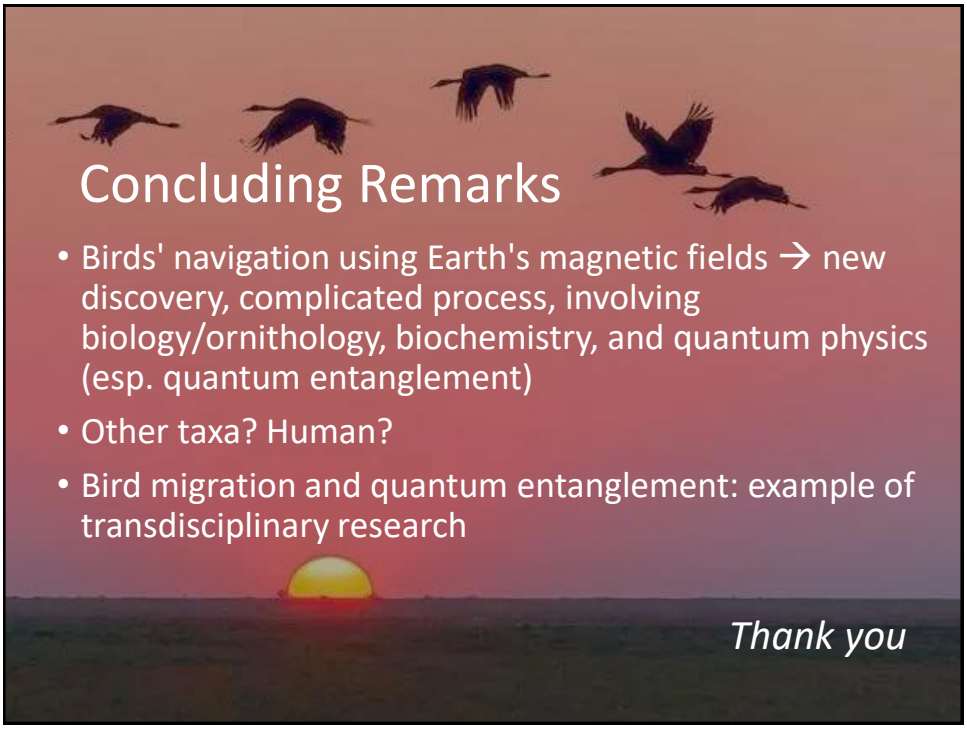
SE
S
oretical and Computational Biophysics Group
Beckman Institute
University of Illinois at Urbana-Champaign
E
SE
S
SW
W
(a)
electron spin
nuclear spin
eye
retina
European robin
Singlet Products
Triplet Products
electron spin
nuclear spin
(b)
(c)
Angle θ
Angle θ


Navigation/homing system of other species?


Concluding Remarks
• Birds' navigation using Earth's magnetic fields → new discovery, complicated process, involving biology/ornithology, biochemistry, and quantum physics (esp. quantum entanglement)
• Other taxa? Human?
• Bird migration and quantum entanglement: example of transdisciplinary research
Thank you