

READING PASSAGE 2

The Compass Within

How migratory birds detect a field that human beings cannot feel

A Each autumn, migratory birds set out on journeys of thousands of kilometres, returning year after year to the same patch of ground with a precision that has long defied explanation. Among the cues they draw upon — the sun, the stars, landmarks and smells — one is especially mysterious: the Earth’s magnetic field. A range of animals, from sea turtles and salmon to robins and pigeons, can detect this field and use it to find their way. What makes the ability so baffling is that it has no obvious organ. We have eyes for light and ears for sound, and can point to the structures responsible; but the magnetic sense betrays no visible apparatus, and for decades no one could say where in the body it resided or how it worked.

B That birds genuinely sense the field, however, is not in doubt. The decisive demonstrations came from experiments with the European robin, a night-migrant, placed in cages ringed by coils that allowed the surrounding field to be altered at will. The birds proved to possess a compass quite unlike the magnetic compass that human beings build. A manufactured compass reads polarity, swinging its needle towards the magnetic north pole. The robin’s compass ignores polarity altogether. What it reads instead is inclination — the angle at which the field lines dip into the ground, steep near the poles and flat near the equator. The bird distinguishes not north from south but “poleward” from “equatorward”. Reverse the vertical component of the field and the birds turn around; reverse only the horizontal, and they do not.

C How might such a sense be built? The first and most intuitive answer points to magnetite, a naturally magnetic iron oxide. Minute crystals of it, it was proposed, could behave like the needle of a compass, twisting in response to the field and tugging on the nerve endings around them. Iron-rich cells were duly found in the skin of the upper beak of several species, apparently linked to the brain by the trigeminal nerve, and for some years these were widely taken to be the long-sought magnetoreceptor — a tiny biological compass that would register the strength and direction of the field much as a physical instrument does.

D A second proposal was altogether stranger. It placed the sense not in the beak but in the eye, and made it depend on light. When light of the right colour strikes a certain light-sensitive molecule in the retina — a protein called cryptochrome — it can knock the molecule into a state in which two electrons, one on each of a pair of linked molecules, are left unpaired. The spins of these two electrons may be aligned or opposed, and, crucially, the rate at which they switch between these arrangements is sensitive to the orientation of the surrounding magnetic field. Because the chemical fate of the pair depends on which arrangement it is in, the field could in principle leave a chemical trace — and, some suggest, the bird may even perceive the field as a faint pattern laid over what it sees. This “radical-pair” mechanism would explain a curious fact: that the birds’ compass works only when there is light to drive it.

E Several findings have tilted opinion towards this light-driven account. The compass is wavelength-dependent: robins orient normally under blue and green light but become disoriented under red. More striking still, exposing the birds to weak oscillating electromagnetic fields, in the radio-frequency range, throws their orientation into disarray — precisely the effect one would expect if the mechanism turned on the delicately balanced spins of electrons, and

very hard to account for otherwise. Attention has since fixed on a particular form of the protein, cryptochrome 4. When the version found in the retina of migratory robins was isolated and tested, it proved more sensitive to magnetism than the equivalent protein drawn from birds that do not migrate — though whether it behaves the same way inside the living eye remains to be shown.

F Meanwhile the magnetite story ran into trouble. When the iron-rich cells of the beak were examined more closely, many turned out not to be nerve cells at all but a type of immune cell, the macrophage, which happens to accumulate iron in the course of its ordinary work. The supposed receptor, in other words, may have been misidentified. Yet the case for some magnetite-based sense has not collapsed entirely, and a tidy possibility has emerged from the confusion: that birds carry not one magnetic sense but two. A light-based compass in the eye could supply direction — which way is poleward — while a magnetite-based system, responsive to the field's local strength, could serve as a kind of map, telling the bird roughly where on the Earth's surface it is.

G What can be said with confidence is modest but real: the magnetic sense exists, it has been demonstrated again and again in careful experiments, and the compass component, at least, appears to depend on light and, very probably, on the behaviour of electron spins. What cannot yet be said is exactly which cells do the sensing, how their signal reaches the brain, or how the whole system fits together. Should the radical-pair idea be confirmed, it would carry an implication reaching well beyond ornithology — that a subtle quantum effect, of a kind usually confined to the cold and the carefully shielded, can do useful work in the warm and untidy interior of a living bird. For now, the destination is certain and the route still partly in shadow.

True / False / Not Given

Questions 1-5. Do the following statements agree with the information given in Reading Passage 2? Tick (✓) one box for each statement.

1 Human beings have no conscious awareness of the Earth's magnetic field.

TRUE FALSE NOT GIVEN

2 The robin's compass works by detecting whether the field points towards magnetic north or south.

TRUE FALSE NOT GIVEN

3 Iron-rich cells in the upper beak were once thought to be connected to the brain by the trigeminal nerve.

TRUE FALSE NOT GIVEN

4 Weak radio-frequency electromagnetic fields were found to disrupt the birds' orientation.

TRUE FALSE NOT GIVEN

5 The magnetite-based sense enables more accurate navigation than the light-based compass.

TRUE FALSE NOT GIVEN

Multiple Choice

Questions 6-9. Choose the correct letter, A, B, C or D.

- 6 According to paragraph B, what does the robin's "inclination compass" respond to?
- A The strength of the magnetic field at a given location.
 - B The angle at which the field lines dip into the ground.
 - C The position of the sun during migration.
 - D The polarity that separates magnetic north from south.
- 7 Why does the radical-pair mechanism require light?
- A Because the birds are able to migrate only during the day.
 - B Because light is needed to set the magnetite crystals turning.
 - C Because light produces the unpaired electrons whose spins the field affects.
 - D Because the field becomes visible only when reflected within the retina.
- 8 What did closer examination of the iron-rich cells in the beak reveal?
- A That they were nerve cells wired directly to the brain.
 - B That many of them were immune cells rather than magnetoreceptors.
 - C That the beak in fact contained no iron at all.
 - D That magnetite occurred only within the retina.
- 9 How does the passage suggest the two mechanisms might be reconciled?
- A By assigning a light-based compass to direction and a magnetite-based system to position.
 - B By showing that both systems detect the field's polarity in the same way.
 - C By concluding that the magnetite system does not, after all, exist.
 - D By proposing that each species relies on only one of the two systems.

Sentence Completion

Questions 10–11. Complete the sentences below. Choose **NO MORE THAN TWO WORDS** from the passage for each answer.

- 10 The light-dependent mechanism is thought to rely on a light-sensitive protein called _____, located in the retina.
- 11 Robins orient normally under blue and green light but become disoriented under _____ light.

Matching Information

Questions 12–14. The reading passage has seven paragraphs, A–G. Which paragraph contains the following information? Write the correct letter, A–G.

- 12 A description of how mineral crystals could act like the needle of a compass. A B C D E F G
- 13 The use of oscillating electromagnetic fields to interfere with the birds' orientation. A B C D E F G
- 14 A proposal that birds may possess two separate magnetic senses with different functions. A B C D E F G

Answer Key

For teacher / self-study use. Fold or detach before distributing to students.

Q	Answer	Para	Explanation
1	TRUE	A	We have eyes for light and ears for sound, but the magnetic sense “betrays no visible apparatus” in us; the field is one humans cannot feel.
2	FALSE	B	The robin’s compass “ignores polarity altogether”; it reads inclination, distinguishing poleward from equatorward, not north from south.
3	TRUE	C	Iron-rich beak cells were “apparently linked to the brain by the trigeminal nerve”.
4	TRUE	E	Weak radio-frequency fields throw the birds’ orientation into disarray.
5	NOT GIVEN	F	The two senses are given different roles (compass vs map), but their relative accuracy is never compared. (A comparison trap.)
6	B	B	Inclination is the angle at which the field lines dip into the ground. A is the “map” cue; D is what the compass ignores.
7	C	D	Light knocks the molecule into a state with two unpaired electrons whose spins the field influences.
8	B	F	Many proved to be macrophages (immune cells) rich in iron, not magnetoreceptors.
9	A	F	A light-based compass for direction; a magnetite-based system as a map for position. D (one system per species) is not stated.
10	cryptochrome	D	“a protein called cryptochrome”. Accept ‘cryptochrome’ or ‘cryptochrome 4’.
11	red	E	“become disoriented under red”.
12	C	C	Magnetite crystals twisting like a compass needle.
13	E	E	Weak oscillating radio-frequency fields disrupting orientation.
14	F	F	The proposal of two senses — a light-based compass and a magnetite-based map.

Approximate IELTS Band Equivalence (14 questions)

Score	14	13	12	11	10–9	8–7	6–5	≤4
Band	9.0	8.5	8.0	7.5	7.0–6.5	6.0–5.5	5.0	<5.0