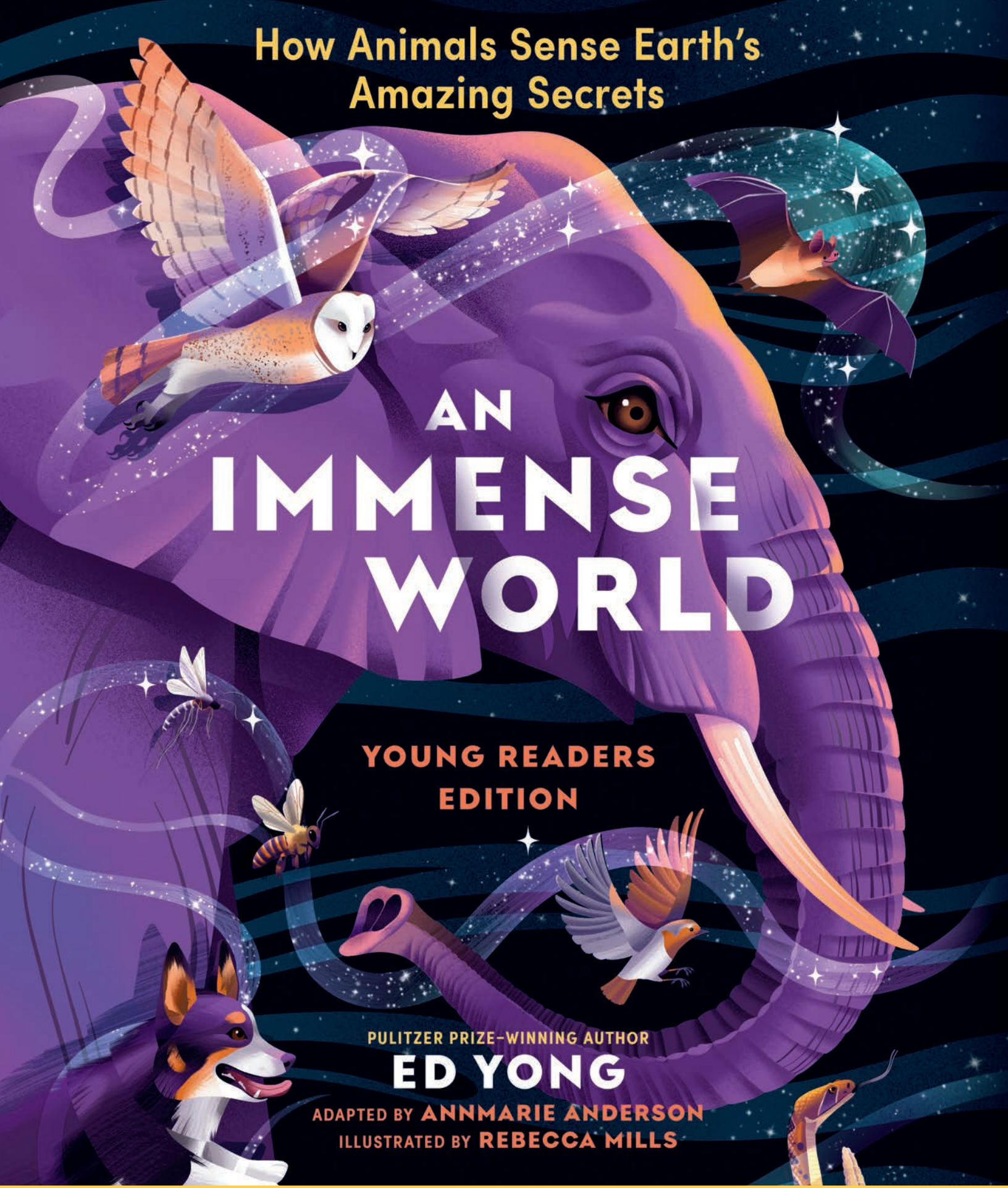


EDUCATORS' GUIDE

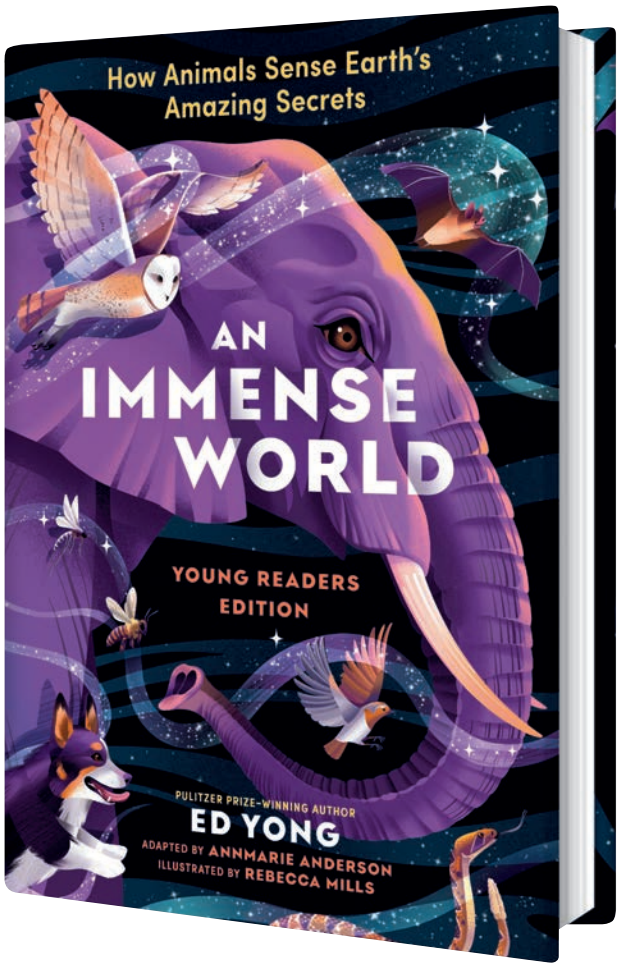
RHTeachersLibrarians.com

ABOUT THE BOOK

Did you know that there are turtles who can track the Earth's magnetic fields? That some fish use electricity to talk to each other? Or that giant squids evolved their enormous eyeballs to look out for whales?

The world is so much BIGGER and more "immense" than we humans experience it. We can only see so many colors and we can only feel so many sensations, and there are some senses we can't access at all.

Exploring the amazing ways animals perceive the world is an excellent way to help understand the world itself. And this young readers adaptation of the mega-bestseller *An Immense World* is perfect for curious readers. It is filled with amazing animal facts and stunning full-color illustrations.



ABOUT THE AUTHOR

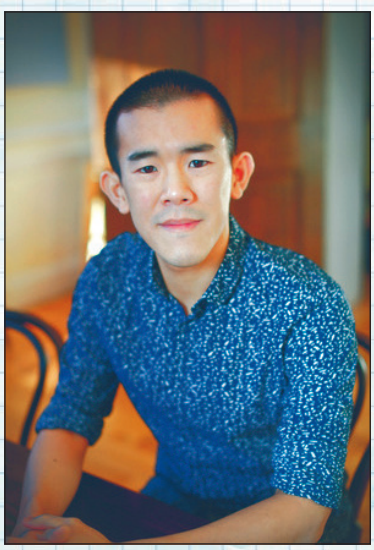
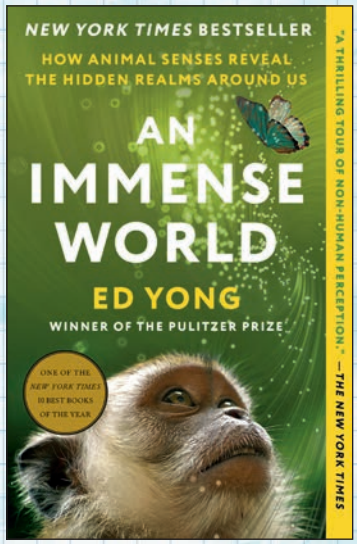


PHOTO BY URSZULA SOLTYS

ED YONG is an award-winning science writer who until recently was a staff writer at *The Atlantic*. His writing has also appeared in *National Geographic*, *The New Yorker*, *Wired*, *The New York Times*, *Nature*, *New Scientist*, *Scientific American*, and more. He talked about mind-controlling parasites at the TED2014 conference, and his talk has been viewed more than 1.4 million times. He is the winner of the Byron H. Waksman Award for Excellence in the Public Communication of Life Sciences, the Michael E. DeBakey Journalism Award, a National Academies Keck Science Communication Award, and awards from the Association of British Science Writers for Best Science Blog and Best Communication of Science in a Non-Science Context.

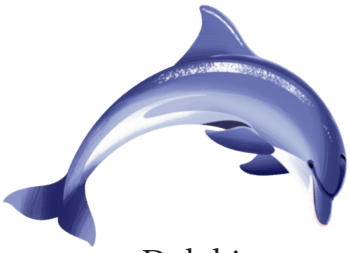


ABOUT THIS GUIDE

As you read, use the suggested discussion questions to promote critical thinking and engage students with the text. Before embarking on a new chapter, introduce important vocabulary, including definitions, before you encounter it within the chapter. Place vocab cards in a public area visible to students so they can revisit the words as necessary.

PRE-READING

Before you begin, given each student a notebook where they will record their field notes. In their notebooks, have them make predictions: How do you think animals sense the world? How do you think animals' senses might be different from ours? To get started, have them make predictions about how these animals might experience their environments:



Dolphin

Bird

Mouse

IN ADDITION TO RECORDING ANY ASSIGNED QUESTIONS, STUDENTS MIGHT ALSO USE THEIR FIELD NOTES TO IDENTIFY

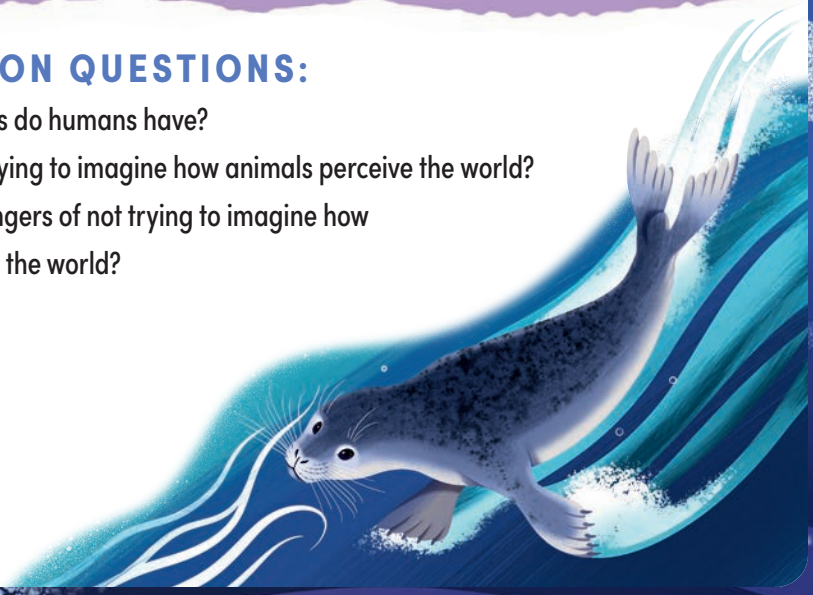
- When their predictions were correct
- Facts or information that surprised them
- Things they want to learn more about

Introduction

WORD WALL TERMS:
Umwelt
Stimuli
Receptors
Sense organs
Proprioception
Equilibrioception

DISCUSSION QUESTIONS:

1. How many senses do humans have?
2. Why is it worth trying to imagine how animals perceive the world? What are the dangers of not trying to imagine how animals perceive the world?



Chapter 1:

Leaking Sacks of Chemicals

WORD WALL TERMS:
Neurons
Odorants
Molecules
Olfactory bulb
Pheromones
Umami

DISCUSSION QUESTIONS:

1. How can knowing more about your dog's *umwelt* make you a better dog owner?
2. Think critically: Why are so many "smell words" borrowed from "flavor words"?
3. Why do you think scientists misidentified how a snake uses its tongue? Or believed that birds couldn't smell? Why would humans be getting this wrong?
4. Why is taste important? Why would a baby be born with the ability to taste bitterness?
5. What is the difference between taste and smell?

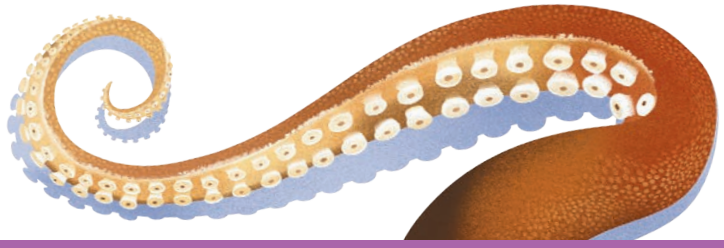
Chapter 2:

Endless Ways of Seeing

WORD WALL TERMS:
Lens
Retina
Photoreceptors
Opsins
Visual acuity
Cycles per degree (cpd)
Visual field
Photons
Monochromatic
Cones
Rods

DISCUSSION QUESTIONS:

1. Yong writes that both a starfish and humans "see what we need to see" (p. 38). What does he mean by this?
2. Why does Yong compare a scallop's brain to a security guard watching monitors?
3. What is the difference between resolution and vision?
4. Compare and contrast the vision of a scallop, a cow, a bird, and a human.



Chapter 3:

Rurple, Grurple, Yurple

WORD WALL TERMS:
Neurons
Dichromats
Trichromats
Ultraviolet
Tetrachromats
Nonspectral color
Panoramic vision
Circularly polarized light

DISCUSSION QUESTIONS:

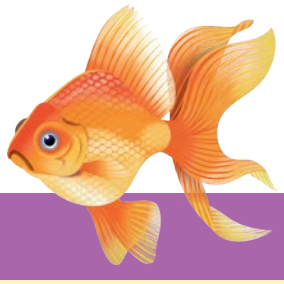
1. Yong writes, "Color, then, is something our minds create" (p.57). Can two people ever really see the same color? Reflect on this.
2. What is the difference between monochromats, dichromats, trichromats, and tetrachromats?
3. Why does Yong offer that color blindness shouldn't be a disability?
4. Why are tetrachromats so difficult to identify?
5. Yong writes, "Guided by evolution, eyes are living paintbrushes," and "Beauty is not only in the eye of the beholder. It arises because of that eye" (p. 74). What does he mean by this?

Chapter 4:

The Unwanted Sense

WORD WALL TERMS:

- Nociceptors
- Nociception
- Subjective
- Anesthetics



DISCUSSION QUESTIONS:

1. Why is the chapter on pain titled "The Unwanted Sense"? As you read, consider if pain is truly unwanted.
2. Why are rats used for experiments?
3. What is the difference between nociception and pain? How are they related?
4. Why do some people believe that fish can't feel pain?
5. Explain the research Robyn Crook is doing. Do you agree with her approach?
6. Why can't scientists treat all animals the same way?

Chapter 5:

So Cool

WORD WALL TERMS:

- Hypothermia
- TRP channels
- Thermosensor
- Capsaicin
- Thermotaxis
- Infrared
- Parasites
- Endothermy
- Membrane

DISCUSSION QUESTIONS:

1. How is hibernation different from sleep?
2. What are some examples of animals having "senses that match the places they live" (p. 99)?
3. Why do humans assume that animals are uncomfortable in certain environments?
4. Why are humans easy for parasites to track?

Chapter 6:

A Rough Sense

WORD WALL TERMS:

- Mechanoreceptors
- Vibrissae
- Oripulation
- Hydrodynamic
- Lateral line
- Trichobothria

DISCUSSION QUESTIONS:

1. Why do you think touch is one of the least studied senses?
2. What are the different kinds of organs animals use to touch the world around them? How does structure affect function?
3. For which animals does the sense of touch not necessarily rely on direct contact? Which animals do rely on direct contact?

Chapter 7:

The Rippling Ground

WORD WALL TERMS:

- Embryos
- Vibrometer

DISCUSSION QUESTIONS:

1. How do red-eyed tree frog embryos use their seismic senses to avoid their enemies?
2. What do treehoppers and elephants have in common, despite their huge difference in size?
3. How and when does a Japanese orb weaver change its web? Why is this useful?

Chapter 8:

All Ears

WORD WALL TERMS:

- Infrasounds

DISCUSSION QUESTIONS:

1. Yong offers, "For many animals, life and death is determined by the sounds they can hear" (p. 156). What does this mean? Provide a few examples of this.
2. How has hearing guided the evolution of some animals?
3. Why does bird hearing change across the seasons?
4. "Whales can communicate over such large distances that even though whales might look like they're swimming alone, they are together" (p. 170). How does human perception affect our experience?
5. Which animals can communicate at ultrasonic frequencies? Do any surprise you? Why?

Chapter 9:

A Silent World Shouts Back

WORD WALL TERMS:

- Echolocation
- Odontocetes
- Acoustic tags

DISCUSSION QUESTIONS:

1. How do tiger moths and luna moths avoid being eaten by bats?
2. Why is echolocation referred to as "touching with sound"?
3. Yong refers to echolocation as one of the most amazing animal senses of all. Do you agree with this characterization?

Chapter 10:

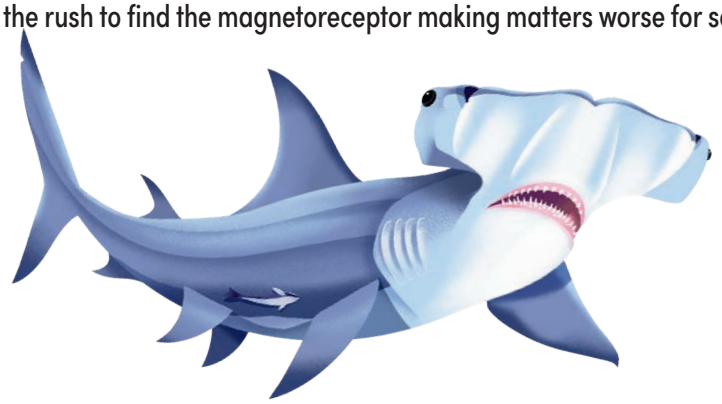
Living Batteries and Compasses

WORD WALL TERMS:

- Electrolytes
- Ions
- Active electrolocation
- Conductor
- Insulator
- Electroreceptors
- Passive electroreception
- Magnetoreception
- Zugunruhe
- Ornithologist
- Magnetoreceptors

DISCUSSION QUESTIONS:

1. Compare electrolocation and echolocation. How are they similar? How are they different?
2. Why is magnetoreception so hard to study?
3. Why is the rush to find the magnetoreceptor making matters worse for scientific study?



Chapter 11:

Every Sense at Once

WORD WALL TERMS:

- Synesthesia

DISCUSSION QUESTIONS:

1. Why must we think of the senses as a unified whole?
2. How does learning about an animal's experience of their world expand our understanding of our own?

Chapter 12:

Save the Quiet, Preserve the Dark

DISCUSSION QUESTIONS:

1. How does artificial light affect animals? Consider, too: How does artificial light affect humans?
2. What affects are humanmade noises having on animals? Why do they more dramatically affect sea creatures?
3. Yong explains that while some animals have been able to adapt to the changes brought by humans, it is not fair to expect animals to evolve. Why not?
4. What is the human sense—the "gift"—that we are blessed with, according to Yong? (p. 249)

AFTER READING

1. Revisit your field notes. Create one research question based on the things you'd like to learn more about. Work with a librarian to determine ideal sources for your research question. After you conduct your research, organize your findings and present your research!
2. Discuss: How do our human senses and biases obscure our understanding of animals and their perceptions?
3. Why is trying to imagine animals' experience of the world important, even if it's difficult—or impossible?
4. Have a debate: Consider ways dogs' *umwelten* are used for human benefit. Is this right?
5. Using knowledge about dichromacy, what are some changes you would recommend to make our world easier for dichromats to navigate? Do research about colorblindness as needed. As a challenge, try to design a colorblind-friendly newsletter, logo, or bulletin board, incorporating what you've learned.
6. Discuss: Given what you've learned about pain, nociception, and animals' experiences of the world around them, should we use animals for animal testing?
7. What are some changes you can make to help avoid sensory pollution? Get some practical tips from DarkSky educational materials. Consider rallying your community and educating others about what you've learned.
8. Write a personal reflection on this statement: "We tend to think of nature as something separate from us, rather than something we exist within" (p. 247).
9. Write a personal reflection on how reading this book has changed your perception and understanding of the natural world.
10. Discuss: Do you believe that it is humans' responsibility to protect this immense, natural world?

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