

Erin Welsh

Hi, I'm Erin Welsh and this is This Podcast Will Kill You. Welcome everyone to the final episode in the TPWKY Book Club miniseries. Over the past months we have read some wonderfully fascinating and impactful books and covered a whole lot of ground when it comes to public health and medicine and biology and history. So much ground in fact that I'm going to skip the usual spiel I give where I attempt to list or describe all the books we've read. Whether this is your first time tuning in to one of these episodes or whether you've been here from the beginning, thank you so very much for joining me. And to all the authors who have been so amazing to come on to the podcast and answer my many questions, a tremendous thank you.

I'd love to bring this miniseries back next season so please reach out with your book recommendations for future episodes and your thoughts on past episodes. While I'm sad that this marks the end of the book club for now, I am so incredibly excited for this episode because I got to chat with another of my heroes of science communication, Ed Yong, about his latest book 'An Immense World: How animal senses reveal the hidden realms around us'. Yong, who was awarded a Pulitzer Prize in 2021 for his reporting on the COVID pandemic and whose previous book on microbiomes, 'I Contain Multitudes', was a New York Times Bestseller, transforms and expands readers perception of the world around us with his latest work.

To describe 'An Immense World' as simply a tour of the senses, though accurate, would I think fail to capture the wonder and magic found on every page through Yong's immersive and poetic writing. Each chapter focuses on a different sense and the many ways that animals experience that sense. Though as Yong points out early on, the borders among senses are often fluid. Starting out with the senses that most humans are familiar with, things like taste and touch and smell and sound, Yong reveals that while we may be able to imagine what it's like for us humans to taste a bar of chocolate or smell freshly brewed coffee or feel a soft piece of velvet, we can only begin to try to conceive the vast array of smells our dog can detect when he sniffs the telephone pole that all the neighborhood dogs like to pee on or what a catfish experiences through the taste buds all over its skin or how the world feels through the tentacle nose of a star-nosed mole.

And those are the senses for which we at least have somewhat of a reference point. Our imagination skills get put to the true test in later chapters, detailing senses such as electroreception and magnetoreception. Throughout, Yong is an incredible guide, writing with such skill and delight, accomplishing the tremendous feat of bringing to life the world around us, not as it is experienced by human senses but by a myriad of animal species. He encourages readers to resist the temptation to rank species or make lists of the top 10 best smellers or those with the best color vision and instead appreciate the unique sensory world of each species, how these senses evolved, and why they are important to each animal.

Just as fascinating as these sensory worlds that Yong beautifully describes is the research done to try to understand them. How do you measure the range of colors a peacock mantis shrimp sees? Or the pain, or lack thereof, experienced by the thirteen-lined ground squirrel as it hibernates through winters with temperatures that we'd find unbearable? Or the way a European robin or loggerhead turtle uses the earth's magnetic field to navigate incredibly long distances. Yong's interviews with a frankly mind boggling number of researchers demonstrate the constantly evolving and innovative field of sensory ecology and reveal some of the most pressing challenges, including the current and future impact of sensory pollution, a topic which she explores in the book's riveting final chapter.

It's not often that a book like 'An Immense World' comes along, one that truly changes the way you perceive the world and leaves you with a profound sense of wonder and appreciation. If you can't already tell, I absolutely loved this book and not just because I devoured the 'Animorphs' book series as a kid which has a ton of fun animal sense thought experiments, but because of the endless revelations hidden within and the deep sense of curiosity that shines through each page. I am so delighted to get to chat with Ed Yong about 'An Immense World'. So let's just take a quick break here and get right to it.

TPWKY

(transition theme)

Erin Welsh

Ed, thank you so very much for being here today. I am such a huge fan of your work and I especially loved your most recent book 'An Immense World'. It really has stuck with me and changed the way that I think about how we perceive the world. I'm constantly thinking like okay, what am I seeing or smelling or hearing that is, you know... What am I missing especially? And I will also say that my dog is a huge fan of your book also because now on our walks I'm much more patient. I'm like you know what? You smell that dog poop as long as you want, there must be more there that I can't tear you away.

Ed Yong

I love this for them.

Erin Welsh

Yeah, he's very appreciative. So tell me, how did this book come to be? Where did you get the idea to tackle such an enormous topic?

Ed Yong

The short answer is from my wife. The longer answer is that I've been writing about interesting animal behavior for as long as I've been writing about science. And this topic about how animals sense the world around them has always been one of the things, one of the threads that I've picked at over those years. It's also a thread that my wife picked at in her graduate work, she started her PhD studies on the vision of coral reef fish, like how they see color. And she has this very strong aesthetic sense so she's always been interested in the senses, in color, in vision in the marine world.

And we were talking in late 2018 about what I would do as a second book. And I say talking, I really mean that I was sort of complaining and self flagellating. And she very patiently listened to me and then suggested that this was a topic that was worthy of book length exploration and she was completely right. Because you know, I hope this comes across in the book, I think it's not just rich in terms of science, it's not just a series of fascinating discoveries, although it certainly offers that. I think it's also very, very philosophically rich. It just provides so much food for thought. And I really wanted to bring that to the page and to literally every page, I really wanted to give readers a pause on almost every page for them to really sit back and think about the experiences of other creatures around them.

Erin Welsh

One of the kind of both philosophical I suppose and biologically useful terms that you revisit throughout the book and introduce early on is umwelt, which I hope I'm saying right.

Ed Yong

Your guess is as good as mine.

Erin Welsh

Okay, excellent.

Ed Yong

Apologies to German listeners.

Erin Welsh

Yeah, oh boy, yeah.

Ed Yong

We'll probably butcher it.

Erin Welsh

Can you explain what umwelt means and where this term originated?

Ed Yong

Yeah. So the term is quite simple in that it is just German for environment but in this context, in the context of which we're speaking, it was popularized by a German zoologist named Jakob von Uexküll in the early 20th century and he used it in a very particular way, not to refer to the physical environment around us but to the sensory environment. And that's the kinds of information, the sights, the sounds, the textures, the smells that each creature or even each individual can perceive.

Von Uexküll's key idea was that the umwelt is unique to every animal and that every animal has a different way of experiencing the world. So one example he gave was a tick, a bloodsucking arachnid whose umwelt is very limited. It might consist of the feel of body hair of the mammal hosts that it sucks blood from, it includes the body heat of those hosts, it includes the smell of their skin. But it doesn't include like most of the things that we can see, it doesn't include color, it doesn't include a lot of things we can hear. It's a very thin sliver of our umwelt. But von Uexküll's key realization was that our umwelt, what humans can perceive, is also limited.

There's so much about the world around us that we are not privy to and that many other animals, sometimes most other animals can sense. And that includes things like the magnetic field of the earth itself which sea turtles and songbirds can detect, the electric fields of other living things which sharks and platypuses can sense, the ultraviolet light that's all around us that actually most other living things that can see can detect. So there's so much around us even in the senses that we have and are familiar with that is inaccessible to us except through tools or through technology and even then not really. So I'm really glad that this concept exists because it really does anchor the entire book. It tells us that even though our experience of the world feels complete, that is an illusion and it is one that all animals share. We are each only perceiving just a thin slice of the fullness of reality.

Erin Welsh

The term is so useful and I really want to kind of get into like okay, how are these senses being integrated together? But maybe I should take a step back and start at the beginning by saying what is the sense? Like what constitutes a sense and how flexible is that definition? How rigid are the barriers around what we perceive to be a sense?

Ed Yong

Yeah. So the senses really are just about taking information that exists in the world around us and drawing meaning from them and that's how I see it, right. And that information can take different forms. It could be electromagnetic radiation like light, that's how we see. It could be waves of pressure moving through the air, that's sound, it's what we hear. It could be the textures that we feel; it could be electric and magnetic fields like I've talked about; it could be molecules drifting through the air, that's what we smell. So the senses are ways of taking these actually quite abstract things and from them deriving knowledge about the world around us.

So light is not worth detecting just for its own sake. We detect light, we see because light gives us information about shelter, about the seasons, about where we are in the world, how deep we are in water or the presence of predators and prey and mates and rivals. If you really think hard about it, it's kind of miraculous that we can detect the stuff at all. Light really is just, well it's either particles or waves depending on which physicist you ask, but it's kind of abstract stuff out in the world. Like the ability to actually turn that into an electrical signal that our brains can make sense of is sort of wondrous just at the base of it. I say that in the book that in a way the senses are ways of biology taming physics. And that is very much how I see them.

And to your question of how you define them and how porous the definition is, I would argue that they are very porous. There's this long standing thing in science about whether people are lumpers or splitters, like whether you're prone to put things together in categories or actually focus on the differences between them. And you could take two of those different approaches with the senses. Like how many senses are there? Most people would say five, we say five because that's what Aristotle said and everyone has sort of accepted that since. But even with humans there are more than that. There are things like proprioception which is the sense of what my body is doing. Like if I'm sitting here I know where my arm is even if I close my eyes, I know that because of proprioception. And then when you go into other animals, the number increases even more.

But then you could start to combine the senses together. In many ways, hearing and touch are actually kind of the same. They have a shared evolutionary history, they're really about detecting mechanical disturbances in the world, whether something pressing against your skin or a sound wave deflecting your own structures inside your ear. So in the book I noted that if you really wanted to be lumpy about this, you could argue that there are two senses, there's chemical and mechanical, and then if you wanted to be super splitter about it, you could do maybe dozens. And I think that sort of speaks to what the senses are doing, right. They are weaving something interesting out of things that are actually quite abstract and how they do that you could kind of categorize in lots of different ways.

Erin Welsh

If we talk about a sense in the traditional definition or in the traditional way that we think of it, there are tradeoffs in some of these senses.

Ed Yong

Yes.

Erin Welsh

Like in vision, you discuss some of these tradeoffs. And so this is kind of a two parter. Number one, what are these trade offs within some of these senses? And the second question is are there also tradeoffs between different types of senses?

Ed Yong

Yeah, that's a great question. So yes. And this is crucial, I think this question is crucial because it actually gets at a really fundamental question which is why do umwelts exist in the first place? Why is it that each animal only perceives a small sliver of reality? Like why don't we just perceive it all? And partly the answer is that we don't need to. So the senses have been tuned by evolution to give us what we need about the world around us. And no animal needs to sense everything, right? A starfish has no need for eyes as sharp as an eagle because a starfish isn't trying to spot prey from miles away. But there's also the fact that all of this stuff, all of the messy biology that allows us to detect things in the world, cost energy. Vision costs energy, smell costs energy.

And they don't cost energy just in the act of sensing. Like even if I close my eyes and my eyes don't seem to be doing anything, they are soaking up a large amount of my daily calorie budget just in the mere act of existing. And that's because the neurons in my eyes that allow me to see need to constantly maintain electrical gradients across themselves in order to be ready to fire when I actually use them. So the analogy I give in the book is that it's a bit like having to draw a bow and keep the string really taught so that when the moment comes to fire, you can lose the arrow. But if you do that all the time, your arm is gonna get really tired and it's gonna take a lot of effort to keep that string taught. That is what it's like to own any kind of sense organ. And it means that animals often hit a ceiling of what kinds of senses they can invest in, not all of them. How can they invest in those senses? They don't have infinite energy supplies to put to the task.

And that means that the senses have limits but the senses also do have tradeoffs that go beyond the the energy thing. So with vision for example, you can either have an eye that has extremely high resolution, so imagine lots of pixels in the image, really sharp eyesight, or you can have an eye that is incredibly sensitive and that works really well in the dark. And you absolutely cannot have both because the kinds of eye that are really good for resolution suck at sensitivity and vice versa. So there's just an inevitable trade off there that always happens. And it means that for example, an animal like us, humans have some of the most acute eyes in the animal kingdom. But the minute the lights go off we're helpless, like we can't see very well at all. Whereas something like a lion can see really well in the dark but its eyesight isn't actually very sharp and that's why to a hunting lion in the dark, that lion will be able to see a zebra but will not be able to make out the zebra's stripes.

Erin Welsh

As you talk about also in the book, most of these senses aren't being used independently or in isolation ever, it's all part of this massive information gathering process. So how do different senses interact? Which is a very big open ended question but I guess maybe more specifically, are there certain pairs of senses that are more likely to be found in combination than others?

Ed Yong

Oh that's a really interesting question. So to begin with, yes, you're right that the senses always interact. And I think there's no animal that only uses one sense. I'm pretty confident in saying that, like every animal is multi sensory, they're trying to get as much information from the world as possible. And when you see how they do that, you get a sense for the strengths and weaknesses of the different senses. Distance is a really important thing. So think about a shark that's hunting. As it's trying to track its prey, the first clues that it gets come from smell which travel over very, very long distances. Once the shark gets closer to its prey, vision becomes more important. And when it gets even closer still, then it's electric sense kicks in, that's the sense that allows it to detect the electric fields that all living things can't help but produce especially in water.

Now the electric sense is amazing, it allows a shark to detect even buried prey, prey that it can't see, let alone smell. But the electric sense is very, very short range. So it can't work over the kinds of distances over which some things like light and scent can travel. So different senses work at different ranges, they might vary depending on how they are obscured by barriers, whether they can travel around, whether they work around corners, whether they work in the dark. And because each sense has its own strengths and weaknesses, that's one of the reasons why animals rely on lots of them. You asked about senses in combination and some humans have this, right. Like a lot of people have synaesthesia where their perceptions from different senses are fused together. So certain concepts or textures might have a smell associated with them, a smell might have a color associated with it.

Those kinds of examples where the lines between the senses blur even more I think are actually quite common in the animal world. So an ant with its antennae is both smelling and touching at the same time. And I'm not sure that those things will feel very different to the ant. I think that it has a kind of chemical-mechanical sense that fuses together. The same is likely true for an octopus. The octopus' suckers has receptors that taste and receptors that touch and just because of the way those are wired together, I think it's likely that the octopus has a sense of taste-touch. Perhaps when the arm makes contact with the surface, the octopus is tasting a shape or getting a feel of a flavor. And again, those are just two examples but I think that sort of thing is actually probably quite common in the animal kingdom.

It's so interesting to talk about these, just in the example that you gave there about taste-touch. And I think it kind of reveals in a way our limited vocabulary as humans for talking about other types of senses. And we also I feel like in general as humans use so many visual words or metaphors, and you talk about this in your book, 'it's plain to see' or 'from my point of view'. And that reveals in part how reliant we are as a species on vision. After writing this book, have you found yourself thinking more or being more aware of the vocabulary that you use and how it relates to certain senses?

Yeah. This was one of the biggest struggles with writing this book, that so much of our vocabulary for perception at all is visual in nature. And to the extent that it's not, there are only a few words that really capture what we're trying to do, like 'feel' is obviously touch-based but we use it in a kind of a nebulous way, people talk also about feeling love or feeling hunger, which is actually quite different to the kind of sensing I'm describing in the book. So there are definitely senses with much more limited vocabularies including some of the more familiar ones to us like smell, smell greatly suffers from a lack of very specific words.

Now you might be sitting there thinking like oh, I've got plenty of words to describe things I smell. Actually think about those words. Most of those are loan words from other senses or they are like nouns, so like lemon, smell of lemon, right? Like that's very different to the rich vocabulary we have to describe visual things. And then it gets even harder when you talk about things like electric fields or magnetic fields where we really don't have any good vocabulary but the vocabulary we do have feels opaque and jargony.

In the chapter on the electric fields, I'm writing about concepts like voltage and capacitance, there's nothing that captures the very vivid sensations that words like bright or loud or rough can convey. So that was a challenge with the book. And since writing it, I have thought about this a lot and if anything it just makes the the lack of the relevant vocabulary just that much harder. I'm a writer, my job is to find words and it really kind of sucks, it gnaws on my soul when I can't do that. I will give you an example, right. Like we'll probably talk about dogs at some point, I have a dog, his name is Typo, he's wonderful. And as I'm trying to appreciate him sniffing the world around him, I also sniff him, like I know what my dog smells like. And he actually smells great.

We cuddle a lot, like I'll just snuffle along the top of his head and I'm really interested in the fact that different parts of his body smell differently. Like his back smells different to the top of his head, which smells different to like his feet, which smells different to like the backs of his ears. Like he has very distinct smells in different parts of his body. And I find that fascinating. Can I describe to you what those smells are like? I really cannot, I've really tried. I think this top of his head smells a little bit like cookies, like it smells really nice, like a kind of a sweet baking flavor smell. But again, right, like I'm borrowing words from other things because I don't have the vocabulary to describe the smell of the top of my dog's head. And that is kind of endlessly frustrating to me.

Erin Welsh

I love, I'm so glad that you think that your dog smells so great because I'm thinking my dog is just a stinky mess, like one day after a bath he's a scruffy little scruff ball and his feet always smell like Fritos which is a very-

Ed Yong

My dog also. Yeah, his feet also. Well but I think weirdly, I think specifically one of his feet smells really strongly of Doritos and the others kind of don't.

Erin Welsh

That's amazing. Okay, now I'm gonna have to smell each one of his feet and see. That's hilarious. And yeah, that discussion in your book and also just sort of like right now when you were talking about sort of language and vocabulary was making me think or wonder if other animals could talk, what kind of metaphors or what kind of language they would use to relate to the world around them? And which sense would predominate? Would dogs talk in terms of smells? Would a bat talk about, I don't have the vocabulary but like the shape or feel of something in their minds? It's just is interesting to think about what would be the leading drive, the leading sense underneath these metaphors or vocabulary words.

Ed Yong

Yeah, I think so too. What would our descriptions of the world feel be like if they were rooted in the concepts of another sense? I think that's really fascinating to think about. And I'm glad you mentioned bats. The philosopher Thomas Nagel is very famous for writing this essay called 'What is it like to be a bat?' Where he argued that it is very, very hard, almost impossible, probably impossible, to really understand the subjective experience of another animal. You could understand how a bat echolocates, how it navigates through sound. But you'll never fully understand what it is like to experience the world in that way. And I think he's right. But this thought experiment I think really shows the odd nature of some of these senses.

So most bats echolocate, they produce these high pitched sounds and they're listening out for the echoes that come back and they're using the timing between the call and the echo to gauge distance between themselves and things in the world around them. That's how they can avoid obstacles in the dark, how they can hunt insects in the air. Technically that's hearing, right, it's just sound, they're listening for sound and they're extracting information from that. But it works in a way that is very different from the way we hear which is a very passive thing.

The bat is producing energy, it is actively adding things to its environment and using that to sense the world. And it is doing that in a kind of exploratory way. And in many ways, echolocation is actually more similar to something like touch than it is to hearing I think because of that exploratory aspect. That sort of thing becomes I think clearer when you think about something like a dolphin which also echolocates in the water. So dolphin echolocation I think is incredible for lots of reasons. So one of them is that if a dolphin echolocates on an object in the water that it cannot see, it can then recognize that object if presented an image of it even on a screen, right. So it is creating some kind of mental representation in its mind of the object that it is analyzing through the use of sound and using that to kind of feed one of its other senses, vision.

And I think it's really hard to think about that in terms of hearing, right? Like listen to the sound of my voice, can you reconstruct what my body looks like? Like no, right? You listen to a piano, a piece of piano music, you can't imagine if you had never seen a piano before, you would never work out what a piano looks like. But a dolphin is using sound to reconstruct the shape of an object in a way that allows its eyes to actually recognize it too. And that feels more like touch to me. That's like I'm closing my eyes now and I'm touching, what am I touching? An adapter on my desk. And I can feel the shape of it, I can feel the prongs, I can draw you what this thing looks like. And that's sort of how echolocation is operating. It is exploratory and it feels quite like touch to me.

Erin Welsh

We are going to take a quick break here but when we get back there is so much more of the animal world of senses to explore.

TPWKY

(transition theme)

Erin Welsh

Welcome back, everyone. Let's get back into it. It's so interesting, this discussion between active and passive sensing-

Ed Yong

Yes.

Erin Welsh

And how certain senses are active or passive or... And I think you also bring this up in the context of taste and smell. I was kind of thinking, you gave one example with the way that bats vs humans hear essentially or use sound, are there other senses like this that process information differently or passively vs actively? And what can those differences tell us about either how that information is used by that species or how important that sense is to that species? Or yeah.

Ed Yong

Yeah. This is a great distinction. So most of the senses can be active in some way, right. So I am sitting here and I am seeing things in front of me. But I can also look around and I do and that act of gazing around a scene is active. Similarly like you can sniff with your nose, you can press and explore with your hands. It's hard to do with your ears, you could like cup your hand around your ears to focus on something. But you can turn a lot of senses into active acts of exploration. The crucial difference between those kinds of sensors and things like echolocation is that the latter are always active, like echolocation has no passive mode to it, it doesn't work at all if there is no echo, if there isn't a call in the first place. So it's always active. And the other sense that is like this is what's called electroreception. And that is a speciality of about a few 100 or so species of fish that live in Africa and South America and that produce their own electric fields.

The famous electric eel is the most well known of these but there are a lot of others that are less dangerous. They produce their own electric fields and they can sense how those fields are distorted by the objects around them, whether it's something insulating like a rock or something that's conducting like another fish or a plant. So it produces the field, it senses how that field is distorted by those objects, and through that it senses the world around it. Again, it's quite like touch. It has been described as touch at a distance. It only works about a few inches or so away from the fish's skin but it gives the fish this kind of omnidirectional understanding of what's around it. Is there a morsel of food? Is there a rock? Is there a predator approaching imminently? It gets all of that in water that can be too hard to see, it can be too murky to see in. It gets all of that in all directions.

So electric fish are typically very, very good at doing things like swimming backwards or swimming upside down, it doesn't really matter. If you have this totally immersive 360 degree understanding of your world through this sense, you're not limited to just the forward direction, the whole world is full of possibility to you. So this is another sense I think that is always active. If the fish doesn't produce the electric field, it can't sense the world around it. Now it can passively sense electric fields as well and a lot of living things give off electric fields especially in the water. It's kind of different, that's more limited into applications, that's good for doing things like sensing other living things and at like short distances. And then all of these things work together as a way of communication.

So these electric fish can produce electric fields and use that as signals that other electric fish can detect and they can send messages, they court each other using electric communications, they fight and threaten each other using electric messages. There's a whole chorus of electric talk in a lot of the rivers of the world that we are not privy to. And I think the thing that really, really blows my mind about this is because this kind of sensing is always active, and so the fish needs to produce its electric field in order to understand the world around it, that's its primary sense, and because it uses those exact same fields to communicate with other fish, now the lines between perception and communication are really, really blurry.

So if I am trying to wave someone down, that doesn't affect my vision, right. Those two things are separate to me. But that's not so for an electric fish. Like when some electric fish fight, if one of them loses, it will often produce a submission signal which means that it stops producing its electric field, right. It shuts that down as a way of saying I give in. But when it does that, it now loses the ability to sense the world around it. So it's as if I wave a white flag and as part of that I have to close my eyes. The communication and perception cannot be separated in these animals and how that works I think is really, really interesting, both on an individual basis and then just if you think about the evolution of that, it starts getting really crazy.

Erin Welsh

How much of this is predictable? If we are provided a prompt that says here's your environment, like the Arctic Ocean or a North American temperate forest or the Sahara Desert, and if you were given the size of an animal, the type of an animal, like is it a rodent, is it a mustela, is it a water bird, and then like their feeding guild, how much can we guess about an organism's sense composition or maybe which sense it primarily relies on?

Ed Yong

Oh that's a really good question that I've not been asked before. I love that. I think you could make quite broad generic predictions that would probably hold up. But I think the details would always, always surprise you because there's just so much flexibility in a lot of the senses and I think there's just tons of room for surprise. So let me give you an example, right. Like caves are a good example of this because caves are environments that are notably dark. So one thing that is very common among cave animals is that they lose their eyes. There are blind cave fish and blind cave salamanders and blind cave insects. Vision ain't much good if there is no light around. And that's a pretty obvious thing to predict. But now what do you do in instead of that? So a lot of blind cave fish have heavily invested in a sense organ called the lateral line that all fish have and that allows them to sense the flow of water around their bodies.

You could just take the basic lateral line and just supe it up, which seems to be pretty common among cave fish. Or you could do what one catfish in South America has done, which is sort of dispense with the lateral line almost entirely and instead create these little joystick-like things all over its body that turn out to be teeth. And I don't mean they're like teeth, like tooth-like things, I mean they're like actual teeth. They have enamel, they're teeth. And this fish has created this like body-wide set of teeth that do the job of a lateral line in most other fish. I could not have predicted that, the scientists who discovered this, Daphne Soares, absolutely did not predict that. Nothing about that is obvious or predictable. So sure, the fish is blind, cave fish are blind, but what it has done instead is just... That's ludicrous and wonderful and I think very unpredictable.

Erin Welsh

In your book, you bring up some incredible evolutionary arms races between species in terms of senses like bats and moths, for instance. Did you come across one that you were like wow, this is my favorite sensory evolutionary arms race?

Ed Yong

Honestly I think you've hit on the best one. Bats and moths are pretty classic and I think they are incredible in the kinds of adaptations that they have produced in each other and in the fact that that story just keeps on changing, right. So there's this idea that bat echolocation evolved to allow them to hunt moths at night. But actually the timing of that doesn't really work. And that story that has been sort of repeated in textbooks actually probably isn't true. And so what the actual truth is, I don't know. But it's a great tale I think of an evolutionary arms race that is so textbook that it's literally textbook, it's in all the textbooks. And most of those textbooks are kind of wrong about it.

But then regardless of how it originally started, like bats and moths are unquestionably locked in this tight arms race, bats want to eat moths, moths don't want to be eaten. And as a result of that, both have incredible adaptations. So some moths can produce jamming clicks that corrupt or interfere with the sonar of bats. Moths famously have all these scales on their bodies and their wings that acts as acoustic armor, it kind of deadens some of the sounds that come out from bats. Some moths have these very beautiful elaborate tails at the end of their wings. If you've ever seen a lunar moth in North America, it's just a beautiful insect with these long streamers coming out of the hind wings. it looks like those are acoustic defenses too, they sort of flap and rotate as the moth flies and they seem to mess with the bats' echolocation. maybe it's not entirely clear how, maybe it just distorts the bats perception of where the moth is.

But whatever the case is, bats that attack lunar moths with intact tails tend to miss and bats very rarely miss when they attack moths that don't have such defenses. And then bats have evolved not just echolocation in its basic form which is already incredible enough, but I think very, very specific, very tailored forms of echolocation to sort of counter some of what moths can do. I think it's fascinating because these are not animals that people tend to love, right. Like bats have often a bad reputation, moths, I think a lot of people think of moths as like boring butterflies. One of the scientists I talked to basically thinks of them the other way around, they basically think of butterflies as like lame day flying moths.

Erin Welsh

I love that. That's amazing. Yeah. So one of the ways that I think our human bias has perpetuated certain evolutionary narratives that we have told is the example that you just provided about bats and moths. But it struck me that there were so many other ones, I guess I shouldn't be surprised by this, humans are biased in so many ways. But there were so many that you brought up in your book. And one that I thought was really interesting was sort of this this long time story that we've told about how zebras got their stripes and what these stripes do. So can you tell me a little bit about how research has changed what that story used to be and what we know today?

Ed Yong

Yeah. That's a great question. So there have been a bunch of different hypotheses about why zebras are striped and one of the most common ones is that it's for camouflage, so it makes the zebras harder to hunt. And again, there's variants of that, right. Is it that the stripes cause confusion when the zebras run? Do they break up the zebras outline? Do they make it look a little bit like... Do they allow it to blend amid vertical tree trunks? Whatever those sub ideas you want to pick, they are wrong, they have to be wrong. And they have to be wrong because as Amanda Melin showed, zebra predators can't make out zebra stripes. They just don't have eyes with high enough resolution. So a lion or a hyena at a kind of stalking distance cannot make out, cannot distinguish between the black and the white stripes. A zebra to its predators just looks like a gray donkey. And that stops being true at close distances but at that distance the lion can smell the zebra, other senses kick in, it cannot be for camouflage.

And this was I think shown within the last decade or so, this is pretty recent stuff. And I think it shows that these very long standing ideas about the adaptive nature of specific animal traits can often be completely wrong if we're not actually considering how the audiences for those traits perceive the world. In case you're wondering, the current lead hypothesis for why zebras are striped is that they are anti-fly adaptations. So there's something about those stripes that really confuse biting flies like horse-flies. And this has been shown in some really wonderful experiments where scientists have taken normal horses and put zebra coats on them or painted horses with zebra stripes and just watched flies trying to bite them. And the flies just flub the landing all the time, they just can't seem, there's something about the stripes that really, really baffles them.

And then you might ask like well then why zebras and why isn't everything striped? Why am I not striped? I live in DC, I'd be very happy if nothing bit me. And I think the answer to that might be that there's something about zebras have remarkably thin skin compared to a lot of other horses and they live in parts of the world where biting flies aren't just a nuisance but actually carry some pretty nasty diseases that horses can get. So there's something about these horses in this part of the world with these insects carrying these diseases that mean that they have really, really gone all in in some weird adaptation to stop themselves getting bitten by flies.

Erin Welsh

It's an amazing story and I love it, I love that it comes down to diseases, that's my bias there.

Ed Yong

Right.

Erin Welsh

But another place where I feel like human bias really shines is this growing problem of sensory pollution. I wanted to ask you to describe a few of the different types of sensory pollution and who so far is the most impacted?

Ed Yong

Oh yeah. So the ones that we know the most about are light pollution and noise pollution. So that's when we talk about sensory pollution, we're talking about stimuli that are in places where they don't at times when they don't belong. So lighting at night is actually a huge problem. It means that we have broken these 24 hour cycles of light and dark that have been held inviolate for billions of years and to which a lot of animals have adapted. When we shine light in dark spaces, we often push out a lot of animals that don't like it, we make things harder for things like pollinating insects, we lure a lot of insects to things like lampposts often with fatal results, light at night near the ocean can attract hatchling sea turtles away from the ocean where they need to be, again often with fatal results. Light at night can waylay migrating birds that use celestial lights in the night sky to navigate. Again, this can be devastating for creatures that are already going on arduous treks and cannot afford to lose energy on being set off course.

And then noise pollution is kind of similar. A lot of the world is very quiet or used to be and because of planes and cars and the sounds of industry and the sounds of urban life, we have filled the world with noise in a way that's really harmful to a lot of animals. It might drown out alarm calls or courtship calls, it might make it harder for parents and offspring to interact. One great experiment by Jesse Barber and his colleagues really spoke to this. They created a phantom road in some area of wilderness by recording the sound of a busy highway and playing that sound from speakers attached to trees in an area where no cars were.

So now you're taking away a lot of the bad things that come with roads, there's no risk of being hit by a car because there aren't cars there, there's no exhaust so there's no chemical problem. It's just the noise. And the noise alone was enough to reduce the number of birds in that area that's used by migrating birds by I think a third. And a lot of the birds that remained were in worse condition because they spent a lot of time being alert, being watchful, and less time on doing things that they need to do like foraging. These are just a few examples but I think that the effects of light and noise pollution are pervasive and I think they have costs for us too as humans. I think they disconnect us from our appreciation of nature and they make nature seem remote and far away.

Most people in the US and really in North America and Europe have never seen true darkness. Most people have never seen the Milky Way, a thing that I think is breathtakingly beautiful but really is only visible in the darkest of places. And noise pollution also drowns out the sounds of animals around us. There are good reasons why at the start of the pandemic, a lot of people started suddenly talking about hearing birds around them for the first time. It wasn't that nature was healing and that birds were suddenly flocking to those areas, it was that the typical levels of noise that we produce in city life makes it impossible to hear birds around us and greatly shrinks the range over which we can hear natural noises. So I've described in the book sensory pollution as the pollution of disconnection. It severs the relationships between animals and each other and it severs our relationship from the animals around us. It makes nature feel like something not a part of our lives. And actually it's all around us.

Part of what I hope to convey in this book is that there is wonder and wilderness to be found even in the most familiar creatures in the most mundane settings. You know I can wax lyrical about what the sparrows in the tree outside my house see, what my dog experiences when he walks down the streets. These are magical and kind of miraculous things. And I think if we think about the experiences of other animals and if we do our best to try and create a world that is catered to their umwelt as well as to ours, then we can appreciate those incredible aspects of the world around us a bit better.

TPWKY

(transition theme)

Erin Welsh

What an amazing way to close out this season's book club. Ed, thank you so much for taking the time to chat with me today and for being just an incredible science communicator. If you all enjoyed this interview and would like to learn more about the sensory world of animals, check out our website thispodcastwillkillyou.com where I'll post a link to where you can find 'An Immense World: How animal senses reveal the hidden realms around us' as well as links to Ed's other works. And don't forget, you can check out our website for all sorts of they are cool things including but not limited to transcripts, quarantini and placeborita recipes, show notes and references for all of our episodes, links to merch, our bookshop.org affiliate account, our Goodreads list, a firsthand account form, and music by Bloodmobile.

Speaking of which, thank you to Bloodmobile for providing the music for this episode and all of our episodes. Thank you to Lianna Squillace for our audio mixing. And thanks to you, listeners, for reading with me. I have absolutely loved putting the TPWKY Book Club together and I could not have done it without you all. A special thank you as always to our fantastic, generous patrons. We appreciate your support so very much. Okay. Until next time, keep washing those hands.