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INTRODUCTION

If you ask me why I love my job as a scientist, I can't help but think of the first scene in *The Princess Bride*. The movie opens with a grandfather (Peter Falk) about to read a book to his sick grandson (Fred Savage), and the skeptical kid asks, "Has it got any sports in it?" The grandfather replies, "Are you kidding? Fencing, fighting, torture, revenge, giants, monsters, chases, escapes, true love, miracles." I might say as much about the biology covered in this book. In fact, I'd have to add a few words, like electrocution, zombification, deception, and centuries-old legends. Although true love may be absent, I'd argue it's made up for by the beauty of the animals, which I have made a special effort to photograph so you can judge for yourself. I'd have to stop at miracles—I am a scientist, after all. That said, if there's one word that best captures my own recurrent feeling about the process of discovery and the things I'm going to describe, it would be: "inconceivable."

That may seem like an overly dramatic viewpoint for a scientist. But I've spent thousands of hours studying the brains and behaviors of unusual animals; I'm supposed to be an expert. Still, every time I investigate a new species, my best guess about what the animal can do and how it can do it is wrong. And I'm wrong in the best possible way; the animals are always able to do something unexpected and more interesting than I'd imagined.

This book is my personal account of those unexpected and interesting things discovered during a career spent investigating biological mysteries. These discoveries are presented much as they happened, as a chronological series of case studies, beginning with my first forays into research as an undergraduate working at the National Zoo in Washington, DC, where I was tasked with collecting and studying the famously enigmatic star-nosed

mole, a small mammal with pink, fleshy tentacles surrounding its nose. Like any good mystery, there were many false starts and blind alleys along the way, but that only made me more curious. What exactly is the star and what is it used for? How and why did such a bizarre structure evolve? After many failed attempts to solve this mystery, I tried to move on. But like an obsessed cold-case detective, I eventually returned to the star-nosed mole in graduate school. With help from my mentor and other scientists, we eventually cracked the case, so to speak—discovering many astonishing things about the mole's brain and behavior, not to mention how and why the star likely evolved. Along the way I discovered that you and I share some surprising habits with star-nosed moles.

The experience with star-nosed moles gave me a taste for unsolved biological mysteries and extreme adaptations. It inspired me to investigate other strange creatures, like tentacled snakes, water shrews, electric eels, zombie-making parasitoids, and even humans with some seemingly magical traditions. Electric eels, for example, turned out to be one of the most underestimated creatures on our planet. That's saying a lot, given their legendary status as electricians capable of generating hundreds of volts for both offense and defense. For centuries it was assumed that an animal with such impressive weaponry had no need for sophisticated behavior. As I soon discovered, electrical power is only half the equation. The other half is, as they say, "all in the delivery." The eel's behavior allows it to use electricity to rival weapons from science fiction (I should know; I tested the eel's electrical weapon on my own arm). The eels demonstrate that even animals we have studied for centuries still hold secrets to be uncovered. And there's another more specific lesson—where you find extreme anatomical traits, you can often expect to find equally extreme behaviors.

There's more of course. If you want to learn about a predator that sets the ultimate trap—as if it can predict the future—or if you need to know the best strategies to avoid becoming a zombie, you'll have to read on. Each of these cases reveals a masterpiece from evolution's work. But there is more to learn from these animals than simply the details of particular adaptations, as wonderful as they may be. Just as studying one masterpiece in a museum

can teach us much about the artist, each of these specific systems can teach us generalities about animal behavior, brain organization, development, and evolution. This is an important and often unappreciated theme in science.

To mention just a few examples, much of what we know about how brain cells (neurons) conduct signals was figured out in squid, because they have giant nerve fibers, which evolved for super-fast escape from predators. The result was a giant leap forward in our understanding of all animal brains (not to mention the Nobel Prize for the scientists). Similarly, the means by which neurons most quickly communicate with one another (the electrical synapse) was discovered by studying the humble crayfish, which uses its fast-conducting neurons to escape predators (but as you'll learn in chapter 5, it's not always fast enough). On the predator side, venoms of snakes and snails are a rich source of potential therapeutic agents. Some venoms are already being used to treat chronic pain, and many others are being investigated for potential stroke and cancer therapies. Even a predator as strange as an electric eel has advanced science immensely, first by inspiring Italian scientist Alessandro Volta to invent the battery in 1800, and much later by allowing the isolation of a key molecule (the acetylcholine receptor) that is required for virtually all skeletal muscle activity. I could go on. In short, you can't swing a stick without hitting a major scientific advance that resulted from studying diverse and specialized animals. That's true because all animals play by the same evolutionary rules. The result is what Richard Dawkins has so elegantly called "The Greatest Show on Earth." One of my goals is to showcase some great performances from that show.

But I have another goal as well. I hope the reader will learn something not only about these incredible animals, but also about the process of discovery. Like everyone else, I'm attracted to mysteries; that's part of human nature. Whether it's an unusual star in the heavens or an unusual star on a mole, outliers have always served as a beacon of sorts, compelling a much closer look. Over time I have found it's not the mystery or the outlier that's important, it's the closer look. I say this because, as often as not, the most interesting thing about an animal is not evident from the outset of an investigation. Moreover, in my own experience, even the seemingly simple

species do something truly remarkable (keep this in mind when you read about "primitive" shrews, "common" moles, or even the lowly cockroach). I often think of an experiment as akin to looking through a pair of binoculars. You see something at the edge of your vision and you put them to your eyes to get a closer look. But you never know what will come into focus, or what else might be in the picture.

Today's student in biology might be skeptical; after all, scientists have been taking "a closer look" at biological systems for centuries. Why should we expect new discoveries to abound? Part of the answer lies in what I like to call the "marvels of modern technology." Our metaphorical binoculars have vastly improved. Just as the Hubble Space Telescope has, literally and figuratively, changed our view of the universe, similar advances in the technologies for research into neuroscience, evolution, and behavior have opened new vistas for investigation and discovery. It's a great time to be a scientist.

And that brings up another reason for writing this book. I've had many adventures conducting research, but you would never know this from my formal publications describing the results. Scientists are trained to write a bit like Mr. Spock, delivering a series of facts in the third-person, using the passive voice and certainly not betraying emotions. There's good reason for this when it comes to technical literature, which needs brevity and a certain uniformity of style. But it gives the wrong impression. Not only does this leave out much of the backstory, there's also no mention of the sense of wonder when the clouds part and Nature reveals one of her secrets. One of my goals is to share those experiences and hopefully change some perceptions about how discoveries happen and what it's like to do research. But most importantly, I hope this small window into some remarkable animals will convince you that Nature is far more interesting than we imagine—and something to be treasured.

P.S.: I'm going to describe some things that seem (at least to me) extraordinary. If you'd like to judge for yourself, then when you see a QR code in the book, use the camera in your smart phone to scan it, and it will take you to a movie showing the animals in action.

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