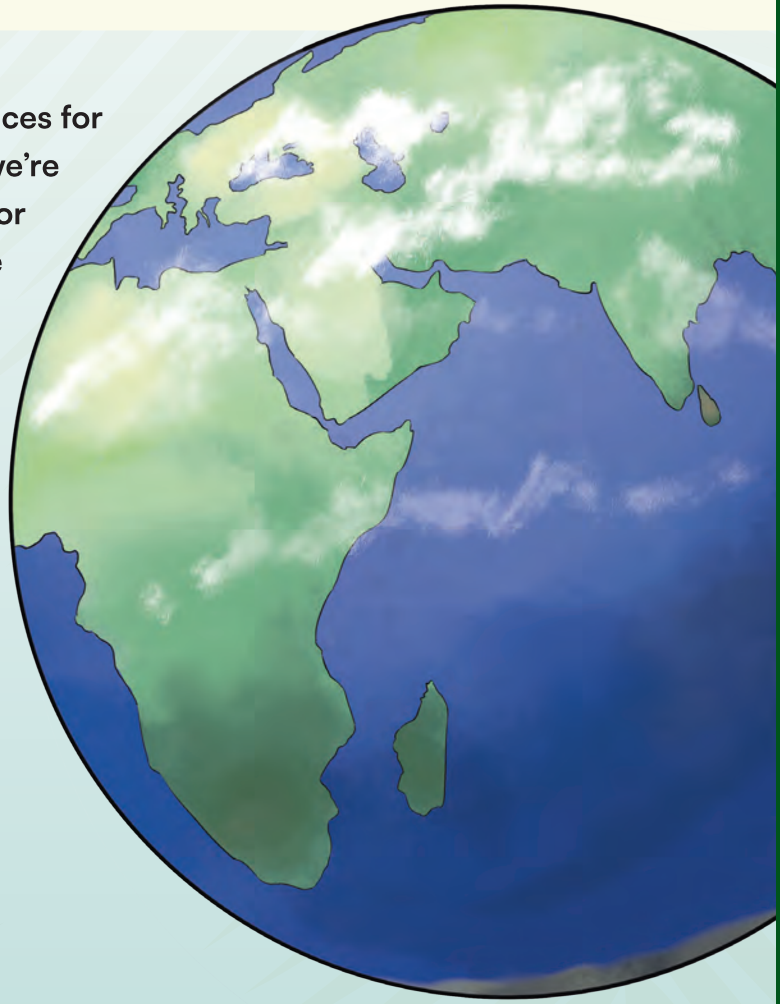
THERE'S NO DENYING THAT SOME SPECIES HAVE AN OUTSIZED IMPACT ON EVERYTHING AROUND THEM—AND AS HUMANS, WE'RE AT THE TOP OF THE LIST.

We're one of the only species to make choices for reasons other than survival, and whether we're hunting, farming, creating new industries, or building cities, we don't always make these choices with other living things in mind.

The result? Rhinos born without horns, pigs born without tails, moths forced to change color entirely, and lizards who can climb glass and concrete walls but struggle to climb trees. This is evolution under pressure.

Luckily, there's hope: the better we understand how we're all connected, the better we can weigh the consequences of our choices and help shape a world that works for everyone and every thing.



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EVOLUTION UNDER PRESSURE: HOW WE CHANGE NATURE AND HOW NATURE CHANGES US

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WRITTEN BY
YOLANDA RIDGE

ILLUSTRATED BY
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update chap open for colour; all green?

For Oliver.
Thank you for helping me see the world in different ways and spreading optimism with every step you take. —Y.R.

To my mom and dad, who read to me when I was little and inspired me to never stop learning. —D.T.

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INTRODUCTION

Have you ever looked in the mirror and wondered how you could possibly be related to a fish? Or a spider? Or even one of those blobby-looking amoebas you've seen swimming in pond water under the microscope?

Maybe you've watched your brother eat a banana and thought he looked a lot like a monkey? Or tried to follow your sister up a tree and wished you were more of a monkey yourself.

If every creature on Earth came from the same ancestor, why are we all so different? If we're all related to one another, why do just some of us thrive in the water? And how come only some of us can fly?

Each of us has our strengths—and weaknesses—which allow us to coexist within the same ecosystem. We can't all live in the trees, for example, or they would get crowded.

But only humans have figured out how to exist in almost every part of the world (even in space) by doing things like cutting down trees, growing crops, building cities, and inventing new ways to travel. We're the only ones who have altered our natural environment—on purpose—so it's better suited to *us*, rather than adapting to make us better suited to *it*. How does this affect plant and animal interaction? What impact does it have on our shared environment?

Understanding what evolution is—and isn't—is helpful in trying to answer these questions. The theory of evolution based on natural selection is a good place to start. But to really understand our role on Earth—and the effect humans have had on the evolution of all other species, including ourselves—we can also look at the idea of "not-so-natural selection."

What do animals like hornless rhinos, porky pigs, peppered moths, and anole lizards have in common? They're all good examples of not-so-natural selection, showing us how hunting, farming, inventing, and even moving to the city can have a huge impact on other animals.

None of these human activities are bad. We've always had an impact on other creatures, just like other creatures have an impact on us. The problem is, through not-so-natural selection, human activity has had a bigger impact on the environment and the creatures within it. We've changed the way the world works, interrupting the natural evolution of almost everything—and pretty quickly.

So what now? It's not like we can go back in time and "un-invent" things. And no one wants to go back to a time when we didn't live such a comfortable life.

How do we decrease the impact of human activity in a way that works for all creatures? How do we exist as part of the large tree of life without breaking too many branches?

To start, we'll take a quick trip back to the beginning and look at our own evolution. How did we start hunting, farming, and building factories and cities? How have these activities changed as humans have evolved?

Then we'll look at some specific characteristics—from horns and feet to appearance and attitude—to understand how not-so-natural selection has interrupted the evolution of certain animals.

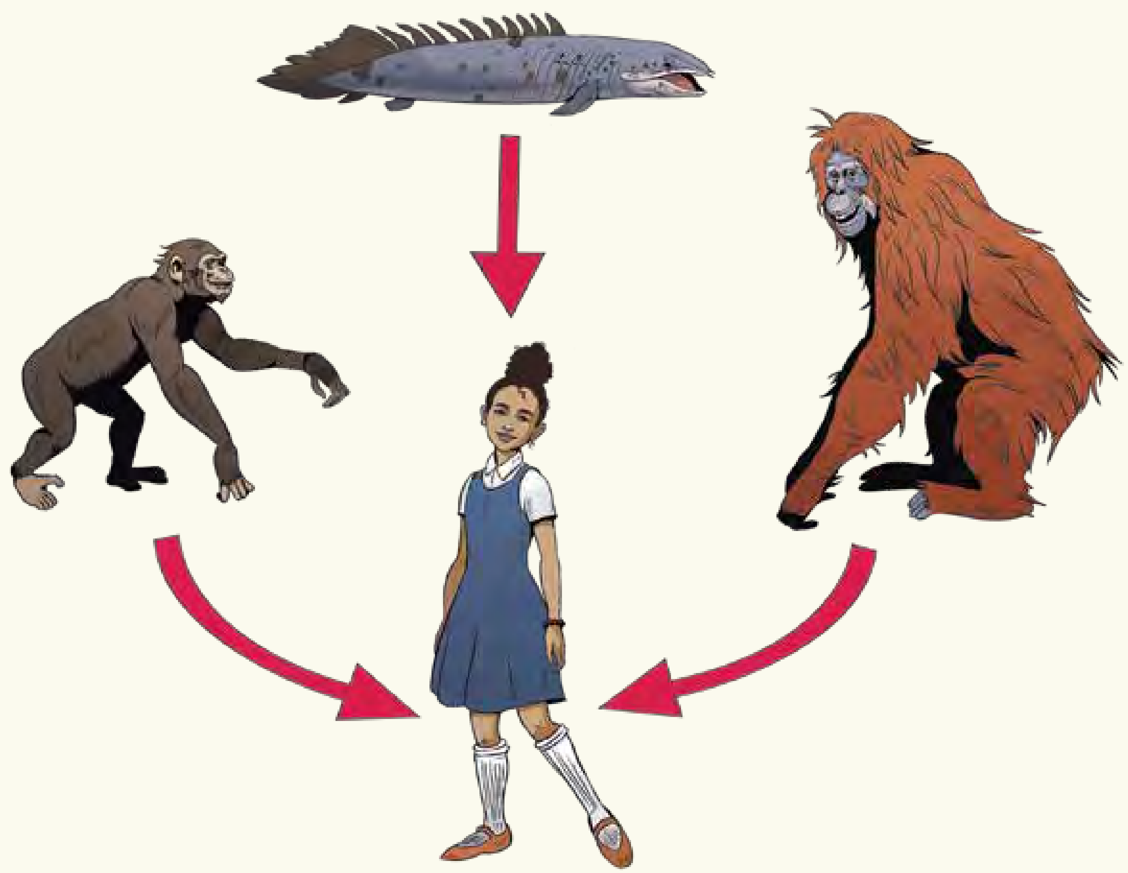
Looking forward, we need to be more aware of where we've been and where we're going. It's not too late for humans to make choices that go beyond what's best for us and consider what's best for all of us, from amoebas, spiders, and moths to rhinos, lizards, pigs, and humans.

Humans might be significantly different than every other creature on the planet. But that doesn't mean we aren't dependent on our fellow creatures for survival.

Every living creature needs a healthy ecosystem to thrive. And as the animal with the largest impact, it's time for humans to ensure there's enough room—and trees—for everyone. Because it's about all of us—we're all interconnected.

CHAPTER ONE:

NATURAL AND NOT-SO-NATURAL: HOW SELECTION DRIVES EVOLUTION



Evolution is the gradual development of something simple into something more complex, like your science project changing from a page of notes into a multimedia presentation with slides, a light show, and an exploding volcano. Depending on who you ask—you, your teacher, or the classmate who got covered in a slimy mix of vinegar and baking soda—one is not necessarily better than the other, but one is definitely more complex. You could say the presentation evolved from the notes, just like the notes evolved from a blank piece of paper.

It's important to remember that the page of notes you worked so hard to create still exists. It could survive for a long time as is, in a box of school treasures, or it could evolve into something else—an essay, an exam study sheet, or the lining of your hamster's cage.

When we apply this idea of evolution to the development of life on Earth, it's often seen as a line with a beginning and an end: we started as apes/monkeys/fish (choose your ancestor) and ended up as perfectly evolved humans.

The problem? It's not that simple.

Things actually started way before apes, monkeys, and fish, with a stew of chemicals and molecules most of us would not consider "life." From there, single-celled organisms with the ability to reproduce emerged. As these single-celled organisms multiplied, changes occurred by random chance. This led to variation, eventually resulting in every organism we share the planet with today.

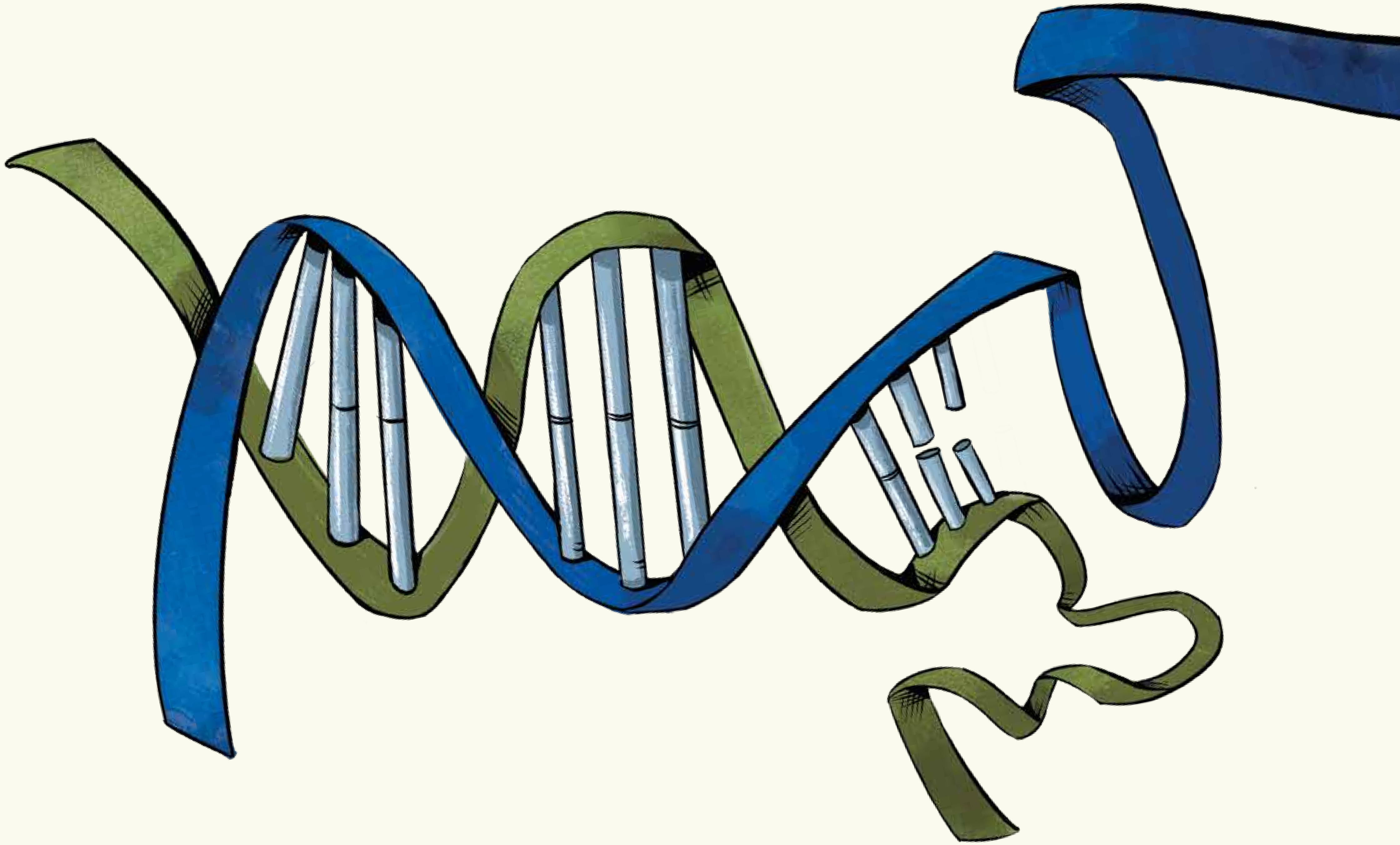
GENE MUTATIONS

Where do these random changes happen? In the genes—bits of instruction inside each cell that determine how a living creature will develop, function, and reproduce.

These instructions are made of DNA (deoxyribonucleic acid). Just like English is written using a code of twenty-six letters, genes are written with four letters—or bases—of DNA.

When a living creature reproduces, it passes on the genes in its instruction manual to the next generation by copying and packaging all those DNA bases into the nucleus of a new cell. This is how the next generation begins: with a single cell and a genetic instruction manual on how it can grow up to be just like its parent by making more and more cells.

But even the offspring of single-celled organisms can turn out different than their parent. Why? Mistakes are sometimes made in the copying of DNA. Like a spelling mistake, changing one of the letters in a gene's code—often called a mutation—can change how the instructions are read.



If you unraveled all the DNA in your cells, it would stretch to the moon and back six thousand times. That's a lot of letters to copy! And many mutations happen constantly, with different consequences. Some mutations are deadly, like changing "add vinegar to three teaspoons of baking soda" to "add poison to three teaspoons of baking soda," when building a model volcano. (A silly example, maybe, but remember: genes are written with only four bases of DNA, so little errors can create *big* changes.)

Most mutations have no effect on how the code is interpreted, like changing "three" to "3." But some gene mutations can actually change the instruction manual, creating something different, possibly even better, such as changing "add vinegar to three teaspoons of baking soda" to "add vinegar and red food coloring to three teaspoons of baking soda."

Like a spelling mistake, mutations are random. No one decides to add a spelling mistake to their essay, and creatures have no control over DNA copying mistakes in their genetic instruction manual.

What isn't random is what happens after a mistake is made. If the mistake makes something better, that set of instructions will likely be kept and followed over and over again until it becomes the new way of making a model volcano. But if a mistake makes something worse, that set of instructions will likely be tossed and forgotten.

Mutations that make a kid different from their parent in a way that helps them survive can become a permanent part of a new genetic instruction manual that's passed on to their kids. This creates the variation between generations, driving evolution.

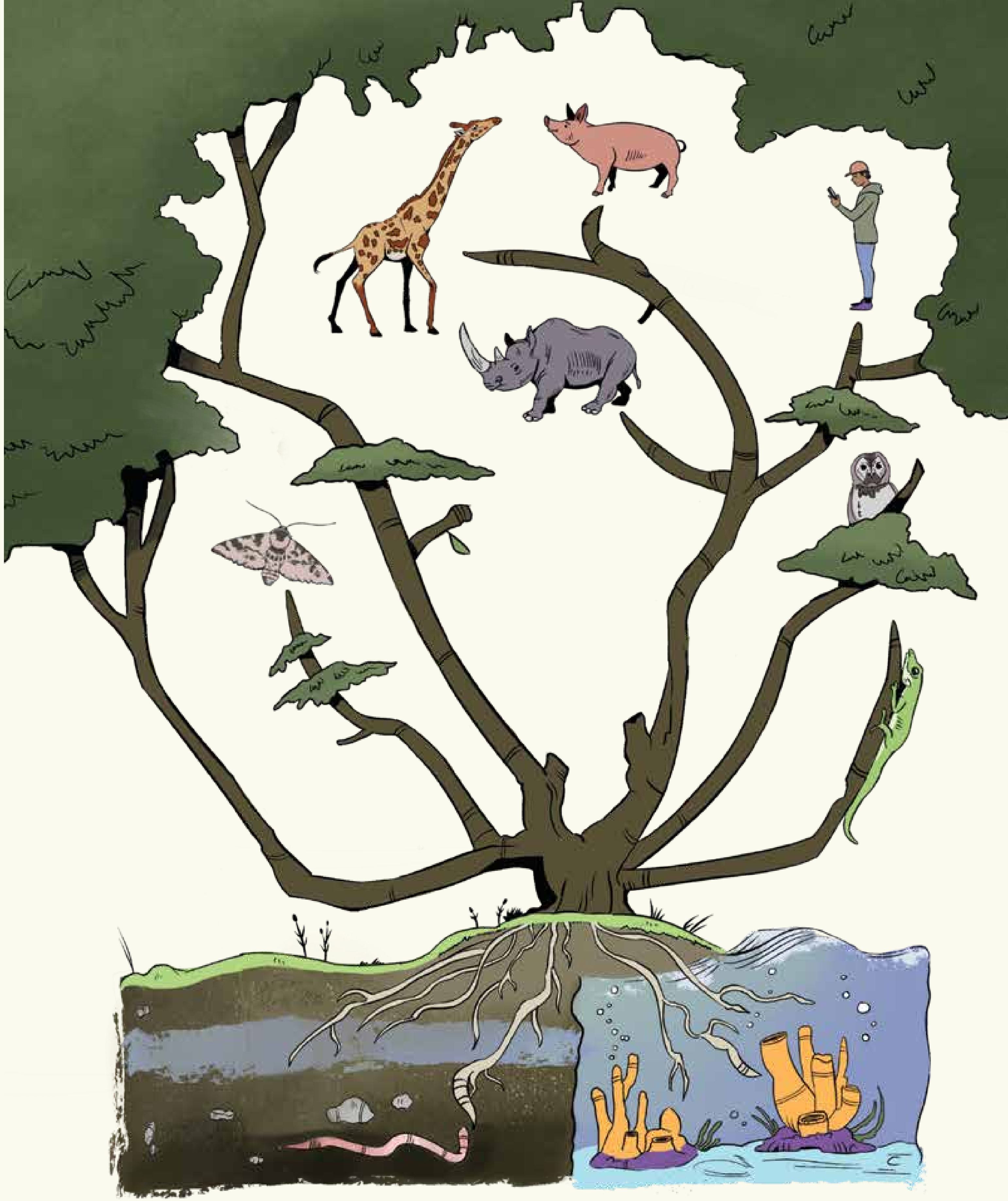
THE TREE OF LIFE

Over time, this variation doesn't just create kids different than their parents. It also produces species of plants and animals totally different from one another.

From one basic instruction manual, all life on Earth evolved from a single-celled organism. And this evolution of life is more like a tree with branches than a straight line. From these single-celled organisms, different forms of life split off and then followed their own path. Plants formed their own big branch near the trunk, growing so large it was almost a second tree. Later, groups of animals as different as sea sponges (the kind that live in the sea, not in your sink) and insects branched off. Around 700 million years ago, another branch eventually produced creatures like starfish. Other branches appeared from this branch, including ones that led to vertebrates, then mammals, then people.

Hanging out at the end of all these branches are the organisms that have evolved most recently. They're not better or more powerful than creatures that evolved millions of years earlier, just the newest. Being new might make them more suited to our current world—like grandkids tend to be better at technology than grandparents—but it doesn't put them "on top."

The end of every branch in the evolution of life continues to grow. The random mutations that allowed humans to evolve from bacteria are still happening. So even though single-celled organisms are at the start of evolution (or close to it), there is no end point. At least not yet.



NATURAL SELECTION

Charles Darwin and Alfred Russel Wallace—naturalists who traveled the world researching and observing animals—were the first ones to come to the revolutionary conclusion that living things change over time in response to their environment. When they published their theory of natural selection, they weren't trying to explain where humans came from or how we climbed up the evolutionary tree. They were attempting to explain the similarities and differences between creatures living on different parts of Earth.

These scientists didn't know about genes and DNA (they were discovered later), but they observed that when animals reproduced, their offspring were sometimes different than the parents. These random changes were not always beneficial to the next generation. But when a random change helped an organism survive, it was more likely to stick around and be copied. This is why natural selection is sometimes called "survival of the fittest." A creature that changes in a way that makes it more suited to its environment is more likely to survive long enough to reproduce and pass on their updated genetic instruction manual to the next generation.

For example, let's talk about the giraffe and how it might have developed a neck that looks better suited to mythology than life on Earth. During evolution, the ancestor of what we now call a giraffe had a baby with a longer neck than her parents because of a random gene mutation—let's call her Jandy. Luckily, Jandy was born in an environment with lots of tall trees, as well as with other animals that competed with the giraffe-like creatures for food.

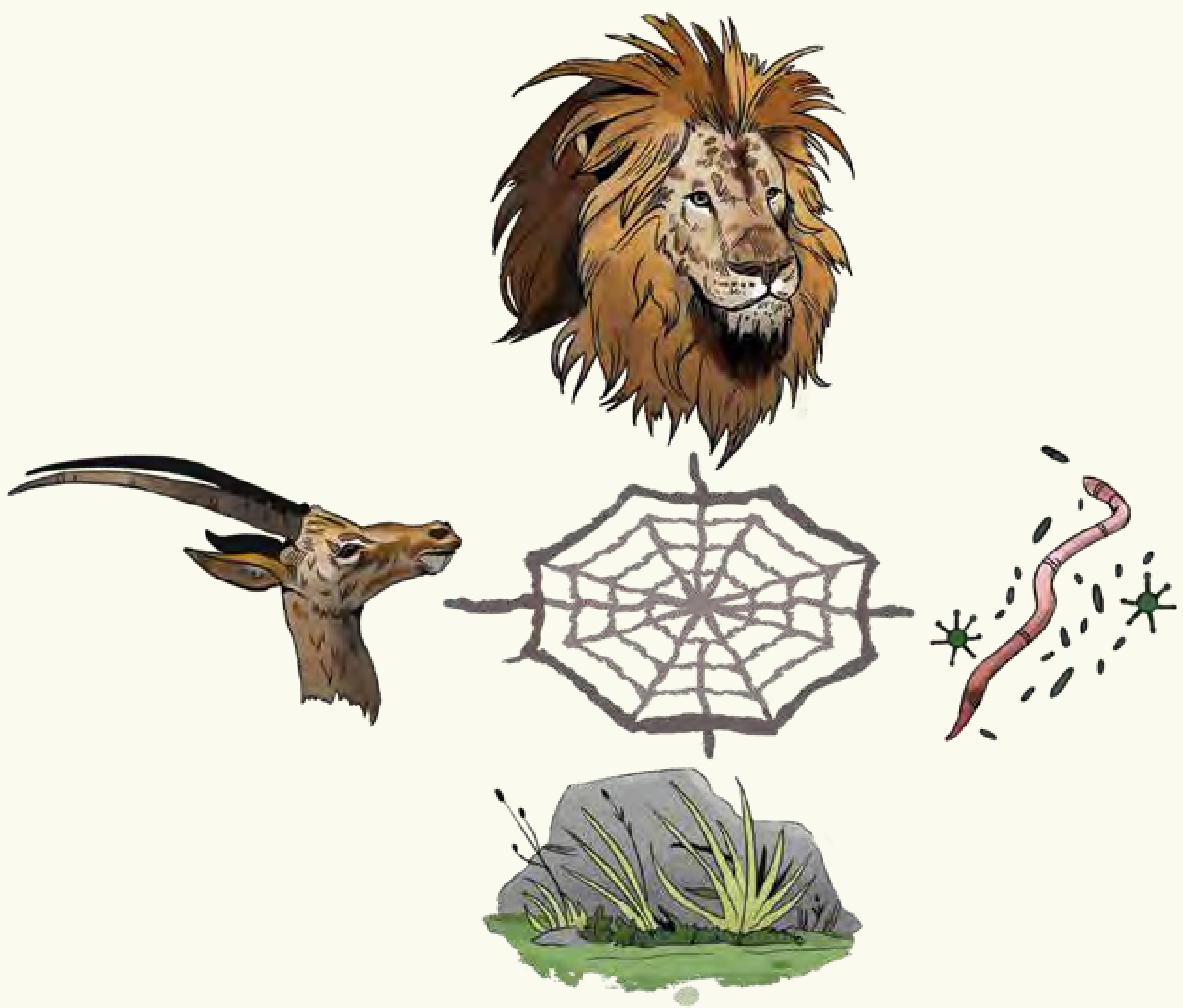
Since Jandy's long neck allowed her to eat the leaves at the tops of trees, she had lots of food compared to her competitors. This made her extra healthy and able to produce many offspring. And Jandy's long neck gave both her and her calves a better view not just of the beautiful African landscape but also of dangerous predators with a craving for giraffe meat.

Both these advantages helped more of Jandy's family survive and then have more children with long necks or perhaps even longer necks than their parent. Evolution is a process that takes a long time—that neck doesn't grow overnight—so Jandy may have been the great-great-great-great-great-grandmother of the modern giraffe, which sports an even longer neck than she did.

It's important to remember that the environment and everything in it determine whether a new trait created by a random gene mutation will be carried into the next generation, or whether it will die out. If Jandy had been born in a land of shrubs or underwater, her long neck wouldn't have given her such a big advantage. It may have even been a disadvantage. The environment decides whether a new branch on the evolutionary tree will live or die.

NOT-SO-NATURAL SELECTION

Humans have influenced the evolution of other organisms for as long as we've been on the planet. Natural selection explains how plants and animals evolve through random gene mutations, helping them adapt to our interconnected environment. Not-so-natural selection, however, describes how plants and animals adapt to *us*.



If you've heard of the web of life (see below), you know all plants and animals have an influence over all other plants and animals within the same habitat. We know, for example, if the grass a deer typically dines on disappears—by a natural event such as disease or early frost or wildfire caused by lightning—the number of deer in that area will drastically decrease. With fewer deer, predators such as the mountain lion don't have much to dine on, so they're more likely to die. The only way to survive is by changing diets or moving.

Humans have this same type of influence over plants, animals, and even microorganisms like our single-celled ancestors. But there are several differences between natural selection caused by natural events and the not-so-natural human behaviors that influence evolution.

THE WEB OF LIFE

Imagine drawing lines between every plant, animal, and microorganism on Earth. This complex drawing represents the interconnectedness of all living things—each creature depends on every other creature for survival.

How does the "King of the Jungle" depend on a tiny microorganism?

A lion eats an antelope, which eats grass. Grass grows in soil containing nutrients from organic waste (including lion poop!), which relies on worms, bugs, and microorganisms to break it down.

Even though antelope may end up as a tasty lion treat, they rely on lions for the same reason—the grass antelope snack on grows with the help of lion poop containing different nutrients than the antelope's own poop. And in the end, they all rely on those poop-loving organisms to break it all down!

First, plants and nonhuman animals don't influence the evolution of other plants and animals *on purpose*. Humans are the only species that pick and choose which plants get to live through selective breeding and pest control. We are the only ones who've decided to grow specific plants in specific places and use animals for purposes other than survival.

Second, humans are the only species on Earth who make choices that have nothing to do with survival at all. When a mouse sneaks into your home to steal food, it's not doing it to win a bet or satisfy some curiosity about how humans live. The mouse just wants to survive and reproduce. It's not that simple for humans, though. As we have evolved, our motivations have also evolved far beyond survival.

Let's say you're chosen as a captain to build a team of classmates one by one, alternating your choices with the other captain. If all you cared about was winning, you'd pick the fastest or strongest person first. Or maybe the best leader. But because you're human, you won't necessarily do this—you might not pick the person most likely to help your team win.

Instead, you might pick someone because you like them—perhaps your best friend. Or because your teacher made you pick someone different. Why not choose the person who's going to help you win? Because people don't have to win to survive (although you may feel differently if you're super competitive). Survival's no longer the most important thing for people . . . not since survival became relatively easy for us.

But as the human population grows, survival is becoming harder. And we're starting to realize just how much we rely on that web of life and the health of the planet to sustain us.

In the rest of this book, we'll look at the evolution of humans and how we've changed over the past five million years or so. As we've become stronger, smarter, and obsessed with stuff, we've had a bigger and bigger influence on the environment and all the organisms—from microbes to plants to other animals—we share it with. Through examples of not-so-natural selection, we'll discover just how resilient nature can be; living things are constantly adapting to new environments and circumstances, and we've gotten pretty good at it too.

Still, there's a limit to how fast the natural world can change in response to human influence. The good news? While our power sometimes leads to damage we never intended or predicted, it can also be used to create positive change. Understanding how we've arrived at this place in history and exploring how we can move forward in ways that consider our place in the web of life are vital to making choices that support the surviving and thriving of all species—humans included.