16 The Law of Evolution: Darwin, Wallace, and the Survival of the Fittest

Who made the second successful ascent of Mt. Everest? Who ran the second under-four-minute mile? Who was the second African American to play major league baseball? Who was the second man to set foot on the moon, and what did he say when he arrived there? If the public takes little note of those who come in second, scientists pay even less homage to the also-ran: priority of discovery is one of their few rewards. Which is why the unusual career of the second person generally credited with articulating the theory of evolution is captivating.

Saying that someone is perhaps the greatest naturalist of the Victorian age is saying a lot, because that was a time when natural history, the study of the earth and the living things that inhabit it, was all the rage. The Victorians loved to dabble in science, which in those days consisted mostly of collecting and classifying plants and bugs and shells and fossils. Many in the burgeoning middle class made these activities their hobby. The best of their collections were displayed in the glass cases of the British Museum, where visitors thronged to view them. If this trend had continued to today, many of us might retreat to the basement to do some stem cell research or genetic engineering after a hard day at our jobs, and spend our weekends sitting in lecture halls being regaled by the latest advances in science instead of walking around manicured meadows hitting a little white ball. Amateur naturalists were as prevalent then as weekend duffers are now.

Alfred Russel Wallace was one of those amateur naturalists, perhaps the greatest of the Victorian age. Born into a solidly middle-class family in 1823, he had to drop out of school at the age of thirteen when his family fell on hard times and couldn't support him. Wallace was apprenticed to his older brother, a land surveyor living in London, where he learned that trade and often worked for the rapidly expanding railways. Working outdoors among the birds and bees stimulated his budding interest in biology. A lull in the railroad-building frenzy put him out of work, but as would happen throughout his life when things went south for him, he landed on his feet, securing a position in Leicester as a teacher of surveying and cartography.

His new position provided him the freedom to indulge his curiosity about the natural world. “There was in Leicester a very good town library . . . and as I had time for several hours’ reading daily, I took full advantage of it,” he wrote in his memoir *My Life*. Among the books he read were *Personal Narrative of Travels in South America*, by the German explorer and naturalist Alexander von Humboldt, and *The Voyage of the Beagle*, by a naturalist named Charles Darwin, both of which whetted his appetite for travel to the tropics.

The book that had the most influence on him was *An Essay on the Principle of Population*, Thomas Malthus’s doomsday dissertation that predicted massive global starvation due to a relentlessly increasing rate of growth of the population in the face of a more modest and constant rate of growth of the food supply. Malthus foresaw in the near future a fierce struggle for survival among people, a struggle he was sure only the strongest would survive.

It was in that public library in Leicester that Wallace met someone who changed his life, and the course of history. Henry Bates was almost a carbon copy of Wallace, and they immediately hit it off. Two years younger than the twenty-year-old Wallace, Bates was an aspiring naturalist and self-taught scientist who had also dropped out of school at a young age. He had already published a paper in a scientific journal describing his study of beetles, “and also had a good set of British butterflies,” Wallace later remembered.

Bates’s vast collection of beetles, with their enormous variety of forms and colors and markings, ignited Wallace’s smoldering interest in collecting and classifying creatures. Bates estimated there were perhaps a thousand different kinds of beetles within walking distance of his home. This diversity of life astounded Wallace, and he was exhilarated by the realization that most of it was unknown. “I at once determined to begin collecting [and] obtained a collecting bottle, pins, and a store box; and in order to learn their names and classifications I obtained at wholesale price . . .

Stephens's *Manual of British Coleoptera*. . . . This new pursuit gave a fresh interest to my Wednesday and Saturday afternoon walks into the country."

Wallace's enthusiasm soon outstripped the diversity of life, vast as it was, in England. After a day spent in the insect room of the British Museum viewing "the overwhelming numbers of the beetles and butterflies," he began "to feel rather dissatisfied with a mere local collection" because "little is to be learnt by it." He surmised that if he studied one group of insects thoroughly, "principally with a view to the origin of species . . . some definite results might be arrived at." Wallace had been pondering the big questions all of us ask: Where do we come from? Why are we here? If he was to find answers to those questions, he had to venture beyond his current hunting grounds.

So he and his buddy Bates took off for the Amazon in 1848 to pursue their hobby of collecting wildlife. You may wonder how they financed such an exotic trip. In Victorian England, collecting things was so popular that there was a good market for beetles and butterflies pinned in boxes. Since Wallace and Bates knew that the tropics were teeming with life, almost all of it unknown to science, they saw a goldmine. They retained an agent in London who would broker their bug collections and caught the next boat to Brazil.

Wallace wandered throughout the Amazon basin for four years, first with Bates, then on his own, collecting beetles and birds and flowers and fauna, exploring regions never before seen by a Westerner. He seemed to love every minute of it, recalling fifty years later "the wonderful variety and exquisite beauty of the butterflies and birds . . . as ever new and beautiful and strange and even mysterious forms, are continually met with. Even now I can hardly recall them without a thrill of admiration and wonder. . . . There are . . . few places in England where during one summer more than thirty different kinds of butterflies can be collected; but here, in about two months, we obtained more than four hundred distinct species, many of extraordinary size, or of the most brilliant colors." He felt like a kid in a candy shop.

Truth be told, he didn't love *every* minute of it. In fact, the trials and tribulations he endured were extraordinary. The bugs that provided his livelihood also brought misery, especially the aggressive black flies: "My feet were so thickly covered with little blood-spots produced by their bites as to be of a dark purplish-red colour, and much swelled and inflamed." The weather was miserable: "Day after day the rain poured down; every afternoon or night was wet." He frequently suffered from what he called "the ague"—yellow fever or malaria, possibly both together, which sometimes weakened him so severely that he could not speak nor write nor walk, and laid him up for weeks on end.

In addition to the constant threat of disease were wild animals: "Jaguars I knew abounded here, deadly serpents were plentiful, and at every step I almost expected to feel a cold gliding body under my feet, or deadly fangs in my leg." Then there were the vampire bats, many of them rabid, whose painless bite usually came while their victim was sleeping: "I myself have been twice bitten, once on the toe, and the other time on the tip of my nose."

Most days in the rainforest Wallace followed a routine of waking at six in the morning and setting off into the jungle to collect by eight. He carried a gun for harvesting birds and small beasts, and a net for snaring butterflies and other bugs. He worked hard until mid-afternoon and then headed to the nearest stream for a bath. Upon returning to camp, he "changed . . . clothes, dined, set out our insects," and, like any self-respecting Victorian "in the cool of the evening took tea." Dinner often consisted of alligator meat, sometimes of grilled red ants. And he continued to contemplate the origin of species, confident he could make progress on the problem.

Meanwhile, at Down House, his estate in Kent, not far from London, the naturalist Charles Darwin was similarly pondering the origin of species. His son Francis remembered that his father led a life of rigid routine: he breakfasted at seven forty-five, did research until nine-thirty, then retreated to the study to peruse the morning mail, which was delivered to him by his butler and read to him by his wife, Emma. If the correspondence was light, Emma would read to him from a novel while he lounged on the sofa. Back at his research at ten-thirty, he worked clear until noon, breaking for an hour-long walk with his dogs before having lunch. He read the newspaper in the drawing room, and then wrote letters by the fireplace until three. Exhausted from all that activity, he rested on the sofa for an hour while Emma read him more of the novel. After a brief stroll for fresh air, he went back to his research for an hour, then he relaxed in his study or listened to Emma read another chapter or two. After a light dinner at seven-thirty with Emma and their five children, he played two games of backgammon with Emma. Reinvigorated, he repaired to the study to read some scientific articles until nine, whereupon Emma played for him on their Broadwood grand pianoforte. The novels must have been page-turners, because Emma read yet another chapter to him before he retired at ten.

Back in the jungle, Wallace, worn down by his daily struggles there, sick of being sick, decided to go home early. He made his way back to the mouth of the Amazon and caught the next boat back to England. Relieved that he had survived the tropics, he looked forward to a relaxing trip home, with time to organize and study his collections. But that's not what he got: about three weeks into the journey his ship caught fire and sank, taking with it the precious specimens he had risked his life to acquire, along with almost all the notebooks containing the "facts" he had painstakingly procured. Wallace almost lost his life in the disaster, floating in a lifeboat on the open sea for ten days before being rescued. After briefly mourning his loss, he characteristically dusted himself off and moved on: "But such regrets I knew were vain, and I tried to think as little as possible about what might have been, and to occupy myself with the state of things which actually existed." 'Stuff happens,' he seemed to be saying.

He had no sooner set foot in England than he started planning his next adventure: to the Malay Archipelago, today's Indonesia. He did not yet understand the origin of species, and he was more determined than ever to crack the problem. In April 1854 Wallace arrived in Singapore, where he spent four months collecting beetles and becoming accustomed to that side of the globe before setting off for points more primitive. In the wilds of marshy Borneo, humid and blazing hot, with torturous terrain and disease-bearing insects, he couldn't have been happier: it teemed with life, almost all of it unknown. For a while he was collecting an average of about two dozen new species of beetles every day. A kid in a candy shop indeed!

He struck out into the jungle every day to collect, continually pondering the question: Where did all these species come from? For most of his contemporaries back in England, the answer was clear and simple: God put them there. Even if they were beginning to doubt that He did it around six thousand years before—the time the Bible said He did it—they were convinced that He had done it. The immutability of species—what we see is what He put here—was the dogma of the day. How could it be otherwise? Surely such astounding diversity couldn't have arisen spontaneously! Surely such complexity of form and function calls for a Creator!

By then Wallace was convinced it didn't. He had long been skeptical of the conventional wisdom on this matter, and the commonalities that he saw everyday among the creatures he collected convinced him that it had happened in some other way. He could see the species were related, and he came to realize they were changing. They were not "immutable." It became increasingly clear to him that he was viewing these creatures not as they were millions of years ago; he was seeing what they had become as the result of millions of years of evolution.

Evolution. It was not a new concept. The German philosopher Emmanuel Kant suggested in the 1700s that the similarity of species is so obvious that it "strengthens the suspicion that they have an actual kinship due to descent from a common parent." The French philosopher Jean-Baptiste Lamarck, one of the most famous scientists in Europe, proposed in 1809 that "the simplest of living things have given rise to all the others." More muddled versions of this opinion had been offered throughout history, back to the ancient Greeks. But those proposals had little impact, in part because the world wasn't ready for them, in part because the authors didn't express them very well, in part because no one could think of a plausible mechanism to explain how evolution could have occurred.

In 1855 Wallace joined the crowd by concluding that "every species has come into existence coincident . . . with a pre-existing closely allied species." But unlike the others, he brought the scientific method to bear on the question: he marshaled the "facts" he had been gathering in the tropics during the previous seven years to support his conclusion. His well-written, unusually clear paper entitled "On the Law which has Regulated the Introduction of New Species" was published in 1855 in *Annals and Magazine of Natural History*, a journal that was regularly read by the scientific luminaries of the day, including Charles Darwin.

Wallace's paper was a shot across Darwin's bow. The master of Down House had been striving to solve the mystery of the origin of species since his return from a trip around the world twenty years earlier. He had been the official naturalist for that expedition, a position arranged for him by one of his professors at Christ's College, Cambridge. While on the trip he frequently left the relative comfort of HMS *Beagle* to venture ashore, most famously on the Galápagos Islands, to collect "facts" about species. He returned to Down House to mull over what those facts meant for finding a solution to the mystery of species.

And he did consider it *his* mystery. After all, his grandfather Erasmus, a polymath who was an esteemed fellow of the Royal Society, the world's oldest scientific society, was well known for his theory of evolution. In fact, the term "Darwinism" had been coined to describe Erasmus Darwin's observations and speculations on that issue. Charles Darwin was keen on keeping the evolution problem in the family.

He had been pondering the "facts" for twenty years. They increasingly led him to the same conclusion Wallace later came to: species are not "immutable"; they evolve from other species. Darwin wrote voluminous notes and some essays laying out his theories of evolution, but he told only his closest confidants about his ideas. He wanted to accumulate more support for his theories before going public with them.

Darwin was working on his masterpiece, a book describing the basis of the origin of species, but it was going slowly. At a snail's pace, really. When the journal containing Wallace's paper arrived in his mailbox, Darwin had published nothing on the subject. Not a single word on evolutionary theory in the more than twenty years he had been cogitating on the problem. And then one morning a magazine carrying an article with the clearest description yet of the evolution of species appears on his doorstep, out of nowhere, written half a world away by an upstart who was not part of the "in crowd" of Victorian science. Darwin must have been concerned. Was he going to get scooped? Was his twenty years of work to be for naught? "I rather hate the idea of writing for priority, yet I certainly should be vexed if anyone were to publish *my* doctrine before me."

"Vexed." The Victorians were masters of understatement.

Darwin's friend and colleague, Charles Lyell, the founder of modern geology, a member of the Royal Society, and the acknowledged head of Victorian England's scientific aristocracy, also read Wallace's paper and immediately saw its significance, both to science and to Darwin's legacy. He headed to Down House to prod Darwin to publish something on the topic, lest Darwinism yield to Wallaceism. There was still time: both Wallace and Darwin by now understood that there was a succession of species—new ones arising through a series of subtle changes to members of existing species—yet Wallace's paper fell short of answering the big question: *How* does it happen? Successfully scaling that intellectual summit would seal one's place in history. Darwin was pretty sure he knew the answer, but he was cautious, not yet confident enough in his theory to go public with it.

Back in Borneo, Wallace was disappointed when he received no response to his paper. He knew it was good; he suspected it was groundbreaking. “What do I have to do to get those guys’ attention?” he probably asked himself. Little did he know that he *had* their attention. He didn’t realize that the starting gun had sounded in the race for a place in history, even though he was the one who had pulled the trigger.

It was a race between a tortoise and a hare. Lyell had convinced Darwin he should rush to print a shorter version of his book. Darwin redoubled his effort to do that, but a tortoise can only go so fast. Meanwhile, the hare was continuing to hop around the islands of the Malay Archipelago, pinning what would become one of the largest collections of insect species ever amassed by an individual, all the while contemplating the mechanism of evolution. Fortunately for Wallace, he came down with “the ague”—malaria.

This turn of events was fortunate, because it freed him from distractions: laid up with fits of fever, unable to venture outside his hut, all he could do was

> think over any subjects then particularly interesting to me. . . . During one of these fits, while again considering the problem of the origin of species, something led me to think of Malthus’s *Essay on Population*, and the “positive checks”—war, disease, famine, accident, etc.—. . . keeping all . . . populations nearly stationary. It then occurred to me that these checks must also act upon animals, and keep down their numbers. . . . While vaguely thinking how this would affect any species, there suddenly flashed upon me the idea of *the survival of the fittest*—that the individuals removed by these checks must be, on the whole, inferior to those that survived. Then, considering the variations continually occurring in every fresh generation of animals or plants, and the changes of climate, of food, of enemies always in progress, the whole method of specific modification became clear to me, and in the two hours of my fit I had thought the main points of the theory.

In a flash he had found the answer to the question he had been asking since he left Leicester ten years earlier, one of the biggest questions of all: Where did species come from?

“Survival of the fittest.” Now that was a new concept! Also known as “natural selection,” it is a simple statement of the fact that in dangerous circumstances, only those individuals most adapted to their environment survive—and the world, with its limited food supply, fearsome predators, and devastating diseases is always a dangerous place. An individual born with a physical or cognitive difference that renders it stronger or smarter or faster or sharper-eyed—in short, better adapted than its peers to the conditions it is confronting—will be more likely to live and mate and pass on its advantage to the next generation (through, as we now know, its genes). It's such a simple concept that it's surprising it took so long to conceive of. When Darwin's buddies back in England heard it for the first time, they must have slapped themselves on the forehead, chagrined that they had missed so obvious an idea.

As soon as he could get out of bed, Wallace put his theory to paper, producing a manuscript of 4,188 words that clearly laid out the manner by which new species arise: evolution through natural selection of the fittest individuals. By then Darwin's developing book on the same subject was over 250,000 words, and he was nowhere near the end. Darwin was still not prepared to publish, but as he would soon find out, Wallace was ready to reveal their theory to the world.

It is a simple theory, with only two fundamental components: variation and selection. Variation among individuals is the grist for evolution that gets refined in the mill of selection. Such variation is always present in a population and is manifested as differences in the fitness of individuals—their ability to survive in the environment they share. Wallace and Darwin both remembered Malthus's essay, which pointed out that resources always become limiting because populations tend to expand to exploit what's available, creating a constant struggle among individuals for those resources that are soon limited. The less fit are eliminated; the fittest survive. Variation ensures that there will always be a few individuals more fit than most, ensuring that evolution is a continual process. Hence the title of Wallace's seminal paper: "On the Tendency of Varieties to Depart Indefinitely from the Original Type."

Rather than send his paper to a journal for publication, Wallace made the fateful decision to send it to Darwin. Why? Because Darwin was famous, a fellow of the Royal Society, like his father and grandfather, whereas Wallace was a nobody. His previous paper had seemed to go unnoticed. Maybe Darwin could help him get some recognition among the scientific establishment. In the letter that accompanied the manuscript, Wallace asked whether Darwin would be so kind as to show his paper to Lyell. Wallace hoped Darwin might persuade Lyell to give his paper some visibility.

After likely retrieving his heart from the pit of his stomach and recovering from the shock of seeing, right there in his own study at Down House, *his* treasured theory issuing from the pen of another person, Darwin dispatched Wallace's manuscript to Lyell and said, in effect, "What am I to do?" Undoubtedly, Darwin was "vexed." We imagine that an exchange ensued along the following lines:

Lyell: "I told you, you should have published something on your theory sooner rather than later. But, not to worry: we'll simply present your paper on this subject along with Wallace's at the next meeting of the Linnean Society of London"—an organization whose meetings were attended by everybody who was anybody in Victorian science—"and we'll present your paper first. After all, you *did* have the idea twenty years ago. That way you'll retain your precious priority as well as your integrity."

Darwin: "But I don't *have* a paper!"

Lyell: "No problem. I'm sure you can whip something up from your notes by the time of the meeting. The next one isn't for three weeks."

Darwin: "Three weeks! Are you kidding? You expect me to write up *my* theory, the one I've been formulating for over twenty years, for its first presentation to the world, in *three weeks*?!"

Lyell (calmly): "I'm sure you'll come through. Besides, you don't have much choice."

Darwin did come through, organizing and clarifying some of his previous writings, and retrieving from friends some of the letters he had written to them explaining bits of the theory. A passable version of *his* theory of evolution by natural selection was presented at the meeting of the Linnean Society in London on July 1, 1858, after which somebody read Wallace's crisply argued paper to the group—without his consent, or knowledge, and without giving him the opportunity to edit the rough draft he had sent to Darwin. A scientist who did that today—who presented another's paper without consulting him—would be shunned by the scientific community, but back then Darwin's action was seen as honorable because it gave Wallace the credit he deserved—even though reading the paper second prevented Wallace from procuring the priority he might have had. "Darwinism" would continue to be the word that described evolutionary dogma; the less catchy "Wallaceism" would not enter the lexicon. (Wallace didn't help his cause when he later published a book describing his version of the origin of species by natural selection. Its title? *Darwinism*.)

Darwin "rushed" a book on the subject into print that appeared a year and a half later—at 477 pages a mere "abstract" of the masterpiece he was still working on. It was an immediate bestseller. Would Darwin have produced this book if Wallace had succumbed to yellow fever, or to the sinking of his ship on his way home from Brazil, or to the malaria that brought him his epiphany in Borneo? Probably not, Darwin's closest confidants acknowledged. Indeed, Darwin's long masterpiece never materialized, but the condensed version, *Origin of Species*, is still in print, as is *Darwinism*, Wallace's version of the story. So the contribution that Wallace, the first person to compose a presentable theory of evolution, is best known for is lighting a fire under Darwin, stimulating him to do what was necessary to garner credit for *his* theory of evolution by natural selection. Wallace's fire resulted in the composition of one of the most influential books ever published. Not bad for a guy with a seventh-grade education and no connections.

In the 150 years since the theory of evolution by natural selection was sprung upon the world at that meeting of minds in London, thousands of scientists have followed in Wallace's and Darwin's footsteps, reinforcing the theory, embellishing it, sometimes revising it, but never refuting it. Along the way they learned that the source of the variation was changes in DNA, the mutations that affect genes and, ultimately, the proteins they encode (something Wallace and Darwin could not have known). Most of those mutations have no effect on the fitness of the individual and therefore don't contribute to the evolution of species. Some of them reduce the fitness of an individual and get eliminated from the population. Every once in a while a mutation results in a change in the function of a critical protein in a way that makes the individual better able to compete with its peers for resources, leading to the spread of the mutation through the population with every generation. Eventually, most individuals carry that mutation, and the trait it confers on them then predominates. The population has evolved. It's a slow process, but there has been a lot of time for it to proceed—the earth formed over four billion years ago—and it does happen. The astounding diversity of life on this planet that so excited Wallace is testimony to that.

Scientists studying evolution have provided a bounty of examples of the process. Take the case of a gene in vertebrates called *BMP4*. It encodes a protein involved in building bones. Changes in that protein can have profound effects on components of the jaws of mammals and the beaks of birds. In fact, changes in this gene are responsible for the radical differences Darwin observed in the beaks of different species of birds on the Galápagos Islands, birds now known as Darwin's finches.

The differences in the beak were selected for because they render the individuals who have them better able to crack a particular variety of seed, giving them an advantage over their unfortunate rivals with less well adapted beaks. The variation in beak structure, a consequence of variation in the DNA sequence of the *BMP4* gene, was sifted and winnowed by means of natural selection. A change in the *BMP4* gene that makes the beak a little thicker or a little wider or a little stronger enables the bird fortunate enough to possess that particular form of *BMP4* better able to crack open seeds with hard shells, and therefore better able to compete with its rivals for those kinds of seeds. Another bird with a variant of *BMP4* that results in more curvature of the beak finds itself slightly better than its rivals at digging into fruit for seeds.

Small changes like these in the *BMP4* gene, and many, many others in many, many other genes, went through the sieve of natural selection time and again, over many millions of years, resulting in the several very closely related species of finches that Darwin observed on the Galápagos Islands, each with its own distinctive style of beak. If you visit there today you will see the descendants of the birds Darwin studied, but their beaks are slightly different now, because they have evolved in the 179 years since Darwin set eyes on them. And the beaks of those birds are still evolving according to the principles of natural selection, which culls the persistent variation in *BMP4* and other genes in our dangerous world.

Some of the most beautiful and convincing examples of evolution began to surface about thirty years ago, when scientists gained the ability to determine the sequence of amino acids in proteins and of base-pairs in DNA, using methods developed by Fred Sanger (discussed in chapter 3). The relatedness of organisms was immediately obvious when the first short DNA sequences began to emerge from a few labs. When the sequences of entire genomes of organisms began to flow from DNA-sequencing factories a dozen years ago it became crystal clear: all organisms on the planet are built from the same set of genes. That's because, way back when, we all had the same ancestor. Its name was LUCA—for "last universal common ancestor" of all living things—and it lived around three and a half billion years ago. This organism is no longer around, and no one knows what it looked like, but we can be confident that it was a one-celled creature. And it had genes made of the exact same kind of DNA we have, and it passed them on to us and to all the other living things we share our world with. As near as anyone can tell, life arose just once on earth, and we're all descended from that event. LUCA and the next cell it gave rise to when it split for the first time are the real Adam and Eve.

So we're just going to have to accept it: our genes, which encode our proteins, are not all that different from those of the fly that just landed on the kitchen counter. About half our genes are obviously similar to its genes, meaning we can line up the sequence of base-pairs in the human and fly versions of many genes and find lots of positions where the base-pairs are identical. In fact, they're so similar that many of our genes will work in the fly: we can generate a fly with one of its genes replaced by the human counterpart and observe nothing obviously different with that fly. The experiment has been done many times.

Flies get Parkinson's disease, and it's because of defects in some of the same genes that contribute to Grandpa's Parkinson's disease. Flies get heart disease—or a disease of an organ that passes for their heart—because of defects in genes similar to some of those that probably contributed to Isaac Asimov's heart attacks. Flies get brain tumors due to defects in genes similar to some human genes responsible for certain kinds of brain tumors. We're not all that different, genetically speaking, from flies. You don't want to know how similar your DNA is to that of rats!

We even carry some of the same genes as that yeast that produced the wine you had with dinner last night; one of them is the *WRN* gene, which encodes a protein that unwinds the DNA double helix so it can be copied. Humans have virtually the same gene. It's not exactly the same, because natural selection—acting on variation in the *WRN* gene over the billion or so years since humans and yeast evolved from their common ancestor—has changed it. But the two genes still encode obviously similar stretches of amino acids in their proteins; it is clear they evolved from a common source.

human	**MESYYQEIGRAGRDGLQSSC**
dog	**MESYYQEIGRAGRDGLQSSC**
mouse	**MESYYQEIGRAGRDGLQSSC**
chicken	**MESYYQEIGRAGRDGLPASC**
fish	**MESYYQEIGRAGRDGLPSAC**
worm	**IESYYQEIGRAGRDGSPSIC**
fly	**IEGYYQEAGRAGRDGDVADC**
rice	**LESYYQESGRCGRDGLPSVC**
yeast	**LEGYYQETGRAGRDGNYSYC**
bacteria	**IESYYQETGRAGRDGLPAEA**

The *WRN* gene is implicated in a disease called Werner's syndrome, which leads to premature aging. The figure shows the sequence of amino acids of a stretch of the WRN protein in humans, dogs, mice, all the way to bacteria. Each letter is an abbreviation of the name of one of the twenty amino acids. The sequence of this stretch of amino acids in the WRN protein is identical in humans, dogs, and mice; only six of the amino acids are different in this region of the bacterial protein.

The protein encoded by the *WRN* gene seems to be doing essentially the same thing for both humans and yeast. People with a defective *WRN* gene age unusually quickly, looking as though they're eighty years old by the time they're about forty. Most people who inherit Werner's syndrome die in their forties or fifties. Remarkably, mutations in the equivalent gene of yeast have the same effect: the yeast cells age about twice as fast as normal. Yeast aging is measured by the number of "daughter" cells they give birth to, and a yeast cell with a defective *WRN* gene dies young, giving birth to about twenty daughter cells rather than its usual litter of forty. Mutations in the *WRN* gene have the same consequence in two species that are vastly different because of the natural selection that operated on variation that arose over the last billion years. Remarkable? Not really. It's what Wallace and Darwin said we should expect.

Natural selection—"survival of the fittest"—is an easy concept to grasp. And one hundred fifty years of research by many thousands of scientists have generated evidence to support the validity of the hypothesis beyond any shadow of doubt. Why, then, is the issue still so controversial? We honestly don't know why. Perhaps it's because the notion of evolution conflicts with the view that many held in Darwin's time and that some still hold today: that God created living things just as they are today. Perhaps there is lingering doubt that humans and apes are related. Perhaps clever writings designed to sow suspicion of evolution to further some religion-driven agenda are persuasive to some. We lay some of the blame on the term “the *theory* of evolution.” It is a theory because no scientific principle can ever be proved: we can only disprove alternatives, at the same time postulating the most plausible version of reality consistent with our observations (we can’t be completely sure that the next time we release an apple it won’t fall *up*, but on the basis of the available evidence we hypothesize that it will fall *down*). In light of the overwhelming evidence that supports the theory, evolution by natural selection is right up there with the *law* of gravity, the *law* of conservation of energy, and the *law* of supply and demand. We think it’s time to ditch the word “theory” and call it the “*law* of evolution.”

The second successful ascent of Mt. Everest? Ernst Schmied and Juerg Marmet, of Switzerland. The second under-four-minute mile? John Landy, of Australia. The second African American to play major league baseball? Larry Doby, with the Cleveland Indians. The second man on the moon? Buzz Aldrin. His first words when he arrived there? “I’d like to take this opportunity to ask every person listening in, whoever and wherever they may be, to pause for a moment and contemplate the events of the past few hours, and to give thanks in his or her own way.” We expect you are now able to correctly answer the question: Who was the second person to pen a coherent theory of evolution? Charles Darwin.