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Chapter 1

Punctuated Equilibrium

I am not sure history repeats itself, but it does seem to rhyme.[1] In management, I find one of the most important skills is pattern recognition: the ability to sort through complexity to find basic truths you recognize from other situations. As I approach my pursuits in information technology, my decisions and choices are made in historical context.

I recently addressed an investment conference in New York. There, I was intrigued by a discussion at lunch with Jim Coulter, a founder of Texas Pacific Group. Jim was thoughtfully wrestling with the similarities he saw between the dynamics of evolutionary biology and societal change. His talk highlighted the idea of evolution by "punctuated equilibrium"—a relatively new take on how and why evolution occurs. It piqued my curiosity, and I began to research the topic.

In his pioneering book *On the Origin of Species*,[2] Charles Darwin proposed that natural selection was the driving force of speciation and evolution. Darwinian evolution is a force of continuous change—a slow and unceasing accumulation of the fittest traits over vast periods of time. By contrast, punctuated equilibrium suggests that evolution occurs as a series of bursts of evolutionary change. These bursts often occur in response to an environmental trigger and are separated by periods of evolutionary equilibrium.

The reason this idea is so compelling is its parallel in the business world: Today we are seeing a burst of evolutionary change—a mass extinction among corporations and a mass speciation of new kinds of companies. The scope and impact of this change, and the evolution required for organizations to survive, are the focus of this book.

According to Darwinian natural selection, organisms morph gradually from one species into another. Species go through intermediate forms between ancestor and descendant. Thus all forms should persist

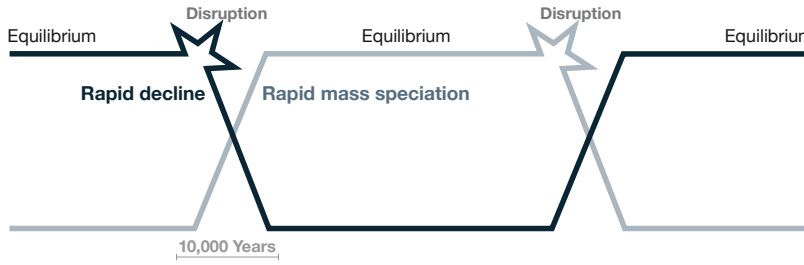

FIGURE 1.1

in the fossil record. Evolutionary biologists like Darwin relied heavily on fossils to understand the history of life. Our planet's fossil record, however, does not show the same continuity of form assumed by natural selection. Darwin attributed this discontinuity to an incomplete fossil record: dead organisms must be buried quickly to fossilize, and even then, fossils can be destroyed by geological processes or weathering.[3] This core assumption of *Origin* has been hotly debated and widely criticized since its publication in 1859. But no critic provided a viable alternative that could explain the scattered fossil record.

In geologic time, the fossil record shows discontinuity as the rule, not the exception. Evidence for the first forms of life dates back to about 3.5 billion years ago, as microscopic, single-celled organisms. These bacteria-like cells ruled the planet in evolutionary stability for almost 1.5 billion years—about a third of our planet's history. Fossils then show an explosion of diversity resulting in the three cell types that founded the three domains of life. One of those cell types was the first ancestor of everything that is commonly considered life today: animals, plants, fungi, and algae.

According to the fossil record, another 1.5 billion years passed in relative equilibrium before life on Earth experienced another evolutionary burst approximately 541 million years ago. This rapid diversification of multicellular life, known as the Cambrian Explosion, was vital to transforming simple organisms into the rich spectrum of life as we know it today. Over a time span of 20–25 million years—less than 1 percent of Earth's history—life evolved from prehistoric sea sponges to

land-dwelling plants and animals. The basic body shape of every plant and animal species alive on the planet today can be traced back to organisms born of the Cambrian Explosion.[4]

The known fossil record indicates that species suddenly appear, persist, and more often than not, disappear millions or billions of years later.

In 1972, Darwin's foundational work in evolutionary theory was successfully reinterpreted in the context of such a punctuated fossil record. Evolutionary biologist and paleontologist Stephen Jay Gould published his new theory of evolution in *Punctuated Equilibrium*,[5] "hoping to validate our profession's primary data as signal rather than void."[6] *Punctuated Equilibrium* suggests that the absence of fossils is itself data, signaling abrupt bursts of evolutionary change rather than continuous, gradual transformations. According to Gould, change is the exception. Species stay in equilibrium for thousands of generations, changing very little in the grand scheme of things. This equilibrium is punctuated by rapid explosions of diversity, creating countless new species that then settle into the new standard.

An essential piece of this evolutionary theory is *scale*. In punctuated equilibrium, Gould focuses on species-wide patterns of evolution, whereas Darwinian evolution draws insight from the traits, survival, and reproduction of individual organisms through generations. A finch and its direct descendants, for example, will certainly show small changes in form as they are passed down through the generations. Much like agricultural corn has become plump and juicy from generations of breeding and interbreeding only the plumpest and juiciest kernels, finches with beaks that enable them to access and eat their main food source most easily will pass their beak structure on to future generations. Some finches have a longer beak to reach insects in small cracks; others have a thicker, stouter beak to crack open seeds. But the crucial point Gould makes is that a beak is still a beak—this is not a revolutionary innovation. It is the difference between graphite and ink, not pen and printing press.

Mass Extinction, Mass Diversification

When science and technology meet social and economic systems, you tend to see something like punctuated equilibrium. Something that has

been stable for a long period suddenly disrupts radically—and then finds a new stability. Examples include the discovery of fire, the domestication of dogs, agriculture, gunpowder, the chronograph, transoceanic transportation, the Gutenberg Press, the steam engine, the Jacquard loom, the locomotive, urban electrification, the automobile, the airplane, the transistor, television, the microprocessor, and the internet. Each of these innovations collided with stable society, and then a little hell broke loose.

Sometimes hell literally does break loose on Earth. Natural disasters like volcanic eruptions, asteroid impacts, and climate change send life into an evolutionary tizzy. This does not just mean a burst of new species. Historically, evolutionary punctuations have been intimately linked with the widespread death of species. Especially the dominant ones. Over and over again.

Since the Cambrian Explosion, the cycle of evolutionary stasis and rapid diversification has become more frequent and more destructive with each repetition. Roughly 440 million years ago, 86 percent of species on Earth were eliminated in the Ordovician-Silurian extinction from mass glaciation and falling sea levels. Life on our planet nearly came to an end roughly 250 million years ago in what is often called "the Great Dying."[7] In this Permian-Triassic extinction, a whopping 96 percent of species became extinct due to enormous volcanic eruptions and subsequent global warming and ocean acidification. Perhaps most well known, 65 million years ago the combination of an asteroid impact in the Yucatán, volcanic activity, and the resultant climate change eliminated 76 percent of species on Earth—including the dinosaurs, a group of animals that had sustained itself successfully for over 150 million years of relative stasis.[8]

Evolutionary punctuations are responsible for the cyclic nature of species: inception, diversification, extinction, repeat.

In the past 500 million years, there have been five global mass extinction events. A minority of species survived. The voids in the ecosystem were then rapidly filled by massive speciation of the survivors. After the Cretaceous-Tertiary event, for example, the dinosaurs were replaced largely by mammals. And thank goodness. But for that, I would not be here to write, nor you to read.

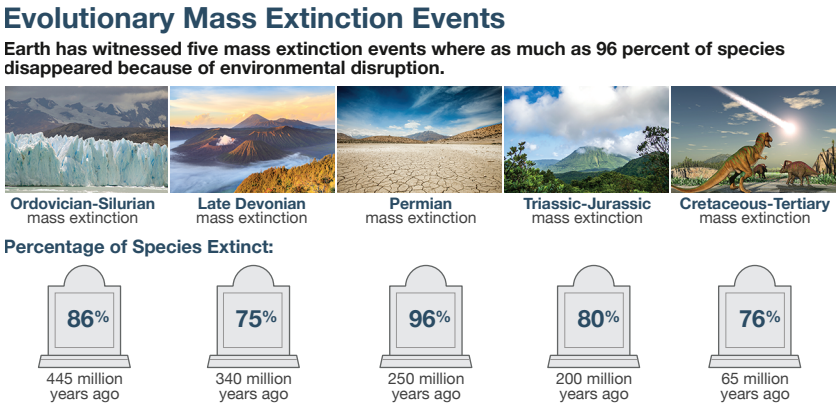

FIGURE 1.2

Evolutionary punctuations are not a matter of competitive advantage like beak size is; they are *existential*. This is the case in technology and society as much as in biology. Think horse-drawn carriages disappearing at the advent of automobiles. But it's not all doom and gloom. From mass extinction springs astonishing mass diversification.

The first known mass extinction in Earth's history was the Great Oxidation Event, about 2.45 billion years ago. Also known as the Oxygen Holocaust,[9] this was a global apocalypse. For the first half of our planet's history, there was no oxygen in the atmosphere. In fact, oxygen was poisonous to all life, and nearly all life that did exist resided in the oceans. The dominant species at the time were cyanobacteria, also known as blue-green algae. They were photosynthetic: using sunlight to produce fuel and releasing oxygen as a waste product. As the cyanobacteria flourished, the oceans, rocks, and ultimately the atmosphere were filled with oxygen. The cyanobacteria were literally poisoning themselves and became threatened as a species. Their populations plummeted, along with almost all other life on Earth.[10]

The anaerobic species—those that could not metabolize oxygen—died off or were relegated to the depths of the ocean where oxygen was minimal. Organisms that survived the Great Oxidation Event used oxygen to produce energy remarkably efficiently—16 times more so than anaerobic metabolism. Life had reinvented itself. Anaerobic life remained microscopic, concealed, and slow, while aerobic life bred faster,

grew faster, and lived faster. Unsurprisingly, these survivors exploded into a dizzying array of pioneering new species that thrived on oxygen and finally ventured out of the ocean.[11] It was the first—and possibly greatest—mass extinction our planet has ever seen. But without it, the dinosaurs never would have existed in the first place for our mammal ancestors to replace them.

Every mass extinction is a new beginning.

Punctuated Equilibrium and Economic Disruption

I find the construct of punctuated equilibrium useful as a framework for thinking about disruption in today's economy. In the technology world, we often think about Moore's Law[12] providing the foundation for constantly increasing change, much like Darwinian evolution's constant accumulation of change. But that's not the way revolutionary evolution works.

The exponential trend described by Moore's Law—that the number of transistors on an integrated circuit doubles every two years at half the cost—is appropriate. But its application underestimates evolution. Just as profound biological evolution is not a measure of how quickly a finch's beak elongates, profound technological evolution is not a measure of how quickly the number of transistors on a circuit increases. Measures of evolutionary growth should not revolve around rates of change of innovations. Instead, they should focus on what brings about those revolutionary changes. History shows that punctuations themselves are occurring more and more frequently, causing more and more rapid upheavals of species and industries alike.

In the past million years alone, the world has experienced disruptive evolutionary punctuations on the average of every 100,000 years.[13] That's 10 punctuations in 1 million years. Compare that to five mass extinctions in 400 million years, and the singular Great Oxidation Event in the previous 3.3 billion years. Disruptive punctuations are clearly on the rise, and the periods of stasis in between punctuations are dwindling. This same pattern is evident in the industrial, technological, and social realms.

We see this in telecommunications. The telegraph revolutionized long-distance communication in the 1830s thanks to Samuel Morse.

Forty-five years later, Alexander Graham Bell disrupted telegraph communication with the first telephone. It took 40 years to place the first transcontinental call from New York City to San Francisco. Add another 40 years for the first wireless telecommunication with pagers. Only 25 years later, pagers and landline operators were massively disrupted by the first cell phones. The arrival of high-speed wireless, increased processing power, and touch screens led to the first "web phones" and then billions of smartphones starting in 2000.[14] We saw economic "speciation" from Motorola, Nokia, and RIM (maker of BlackBerry), each at one time dominating the market. The mobile phone industry was in turn upended with Apple's introduction of the iPhone in 2007. In the following decade, that has settled into a new stasis with Samsung, Huawei, and Oppo offering a set of products that look similar to the iPhone. Today the telecommunications industry is dominated by over 2.5 billion smartphone users.[15] And it hasn't even been 20 years!

The digital entertainment industry has seen similar accelerating punctuations driven by technology and social trends. The world's first movie theater, the Nickelodeon, opened its doors in 1905, exclusively showing motion pictures for the price of a nickel (hence its name). Fifty years later, in-home television decimated the theater industry. VHS tapes ruled the market for about 20 years until DVDs made them a relic. Now, DVDs and their evolutionary replacement, Blu-ray discs, have all but vanished in the market. The convergence of mobile and personal computing and the internet—with over-the-top video streaming services like Netflix, Hulu, and Amazon—has led to an explosion of professional and amateur video content and binge watching that is reshaping the video entertainment world.[16] Sorting out this change in an established industry is every bit as interesting and complex as the invention of the new technology.

Punctuations in the personal transportation industry have resulted in largely internal evolution. After the first automobile replaced human- and animal-powered vehicles, the general form of automobiles has remained remarkably stable, although nearly everything under the hood has changed. Sound familiar? Just as the Cambrian Explosion laid the foundation for the underlying body structures of all life in existence today, so too did the first automobiles define the basic form of all those that followed. Whatever replacements occurred, under the flesh or

under the hood, they provided the same or enhanced functionality with improved performance. The steam engine, for example, was replaced by the gasoline engine in the early 20th century because it was lighter and more efficient, and gas was cheap, abundant, and readily available at the time.[17] Gas was risky—flammable and toxic—but the risk paid off. Sound familiar again? As the Great Oxidation Event did for life, this energy revolution allowed automobiles to go faster, longer, and stronger. After a period of relative equilibrium, the synchronous arrival of electric cars like Tesla; ride-sharing services like Uber and Lyft; and autonomous vehicle technologies like Waymo is now creating chaos in the industry. It will eventually settle into a new stasis.

The evidence suggests that we are in the midst of an evolutionary punctuation: We are witnessing a mass extinction in the corporate world in the early decades of the 21st century. Since 2000, 52 percent of the Fortune 500 companies have either been acquired, merged, or have declared bankruptcy. It is estimated that 40 percent of the companies in existence today will shutter their operations in the next 10 years. In the wake of these extinctions, we are seeing a mass speciation of innovative corporate entities with entirely new DNA like Lyft, Google, Zelle, Square, Airbnb, Amazon, Twilio, Shopify, Zappos, and Axios.

Merely following the trends of change is not enough. Just like organisms facing the Great Oxidation Event, organizations need to reinvent the way they interact with the changing world. They must recognize when an existing model has run its course, and evolve. They must create new, innovative processes that take advantage of the most abundant and available resources. They must prepare for future upheavals by developing systems with interchangeable parts: produce faster, scale faster, work faster. They must build something that will establish a clear existential advantage in order to survive into the new stasis and prosper.

Mass extinction and subsequent speciation don't just happen without reason. In the business world, I believe the causal factor is "digital transformation." Industries facing the wave of digital transformation are predicted to follow similar diversify-or-die trends as life during the Great Oxidation Event. While digitally transformed companies drive their industries to rise above the ocean, the rest are caught in the race to either learn to breathe again or go extinct.

This book attempts to describe the essence of digital transformation: what it is, where it comes from, and why it's essential to global industries. For now, suffice it to say that at the core of digital transformation is the confluence of four profoundly disruptive technologies—cloud computing, big data, the internet of things (IoT), and artificial intelligence (AI).

Enabled by cloud computing, a new generation of AI is being applied in an increasing number of use cases with stunning results. And we see IoT everywhere—connecting devices in value chains across industry and infrastructure and generating terabytes of data every day.

Yet few organizations today have the know-how to manage, let alone extract value from, so much data. Big data now pervade every aspect of business, leisure, and society. Businesses now face their own Oxygen Revolution: the Big Data Revolution. Like oxygen, big data are an important resource with the power to both suffocate and drive revolution. During the Great Oxidation Event, species began to create new channels of information flow, use resources more efficiently, and mediate connections previously unheard of, transforming oxygen from a lethal molecule into the source of life. Big data and AI, along with cloud computing and IoT, promise to transform the technoscape to a similar degree.

The history of life shows that established species whose survival depends on tried-and-true, perfectly functioning processes have no room for error, no room for innovation. Species that can only utilize a finite set of resources risk losing those resources as the world changes around them. Likewise, those who try to use new resources without the knowledge, instruments, or determination to process them will also fail. Companies that survive this punctuation will be truly digitally transformed. They will completely reinvent the way society, technology, and industry relate to one another. The resulting diversity of innovation is likely to be just as extraordinary as aerobic respiration, the Cambrian Explosion, and the human race.

It is nearly impossible to know what these innovations will look like at the end of an evolutionary punctuation like digital transformation. It is the dogged process of rapid innovation, constant learning through experience, and reiteration along the way that will make the difference between thriving existence and ultimate extinction. Companies that figure out how to breathe big data—how to harness the power of this new

resource and extract its value by leveraging the cloud, AI, and IoT—will be the next to climb out of the data lake and master the new digital land.