SUMMARY

THE HALF-LIFE OF FACTS

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Summary of “The Half-Life of Facts” by Samuel Arbesman

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Learn Why Everything We Know Has an Expiration Date

Introduction

As the world changes, our knowledge changes with it. You see, when author Samuel Arbesman's grandfather was in dental school in the late 1930s, he was taught some of the most state-of-the-art medical knowledge, including the number of chromosomes in a human cell. Biologists first visualized the nuclei of human cells in 1912 and counted 48 chromosomes. Therefore, his grandfather learned that there were 48 chromosomes. Then, in 1953, a well-known cytologist, someone who studies the interior of cells, even stated that the chromosome number of 48 in man can now be an established fact. But in 1956, Joe Hin Tijo and Albert Levan, two researchers working in New York and Sweden, attempted a new technique for looking at cells. After counting several times, the two researchers nearly always got 46 chromosomes. Eventually, they made the bold suggestion that scientists had been wrong all along. Today, we know that there are 46 chromosomes in a human cell. Facts are constantly changing. Take a look at smoking, what used to be doctor-recommended is now deadly. Look at meat, which used to be good for you, then bad, then good again! The Earth, for example, used to be the center of the universe. Now, we have no idea whether red wine is good or bad for us and if we should eat meat.

Other facts about our world have changed too. Internet connection is much faster than it was ten years ago. In the past one hundred years, the Earth's population has exploded from less than two billion to more than seven billion. We have gone from earthbound humans to having humans walk on the moon. Our knowledge is changing all the time and according to Arbesman, "Knowledge is like radioactivity. If you look at a single atom of uranium, whether it's going to decay - breaking down and unleashing its energy - is highly unpredictable. It might decay in the next second, or you might have to sit and stare at it for thousands, or perhaps even millions, of years before it breaks apart. But when you take a chunk of uranium, itself made up of trillions of atoms, suddenly the unpredictable becomes predictable." It turns out, facts, much like uranium, have a half-life. Even better, facts are just as predictable. In fact, through mathematical and

scientific techniques, we can take a closer look at how our knowledge changes over time.

Scientometrics Allows Us to Understand the Underlying Patterns in Knowledge

When you think about a fact, you think about something true. Facts bring order to our surroundings, they provide us with a sense of control and comfort. For instance, when you see something out of the corner of your eye around dusk, you don't need to immediately assume that there is a creepy bird of the night looming nearby. No, you call it a *bat*, a winged nocturnal animal that "sees" by using echolocation and is likely more afraid of humans than you are afraid of the bat. You no longer become scared, or you only become half as scared, right? It's when our facts change that we begin to feel a loss of control. Suddenly, we don't trust what we once understood as truth. If doctors didn't know smoking was bad for us, what else could doctors be wrong about today? "But if we can understand the underlying order and patterns of how facts change, then we can better handle all of the uncertainty around us."

Before we even understand all the math science behind how knowledge changes, we can organize facts into three categories based on how often they change. First, we have fast-changing facts, these are the ones that are constantly in flux, like the weather or the stock market. Next, we have the slow-changing facts, the fairly constant ones. These are facts like the number of continents on the planet or the number of fingers on the human hand. Finally, we have the facts that change, but not too quickly. These are the facts that might change over years, decades, or a single lifetime, like the population of the world, the number of planets in the solar system, or the average speed of a computer. These are what Arbesman calls *mesofacts,* facts that change at the meso-, or middle, timescale.

Mesofacts are all around us and it is, perhaps, most important to simply acknowledge their existence. If someone graduating from dental school understands that some of the knowledge he or she learned will eventually become obsolete, it would prevent them from being surprised by basic biological facts, or from working with outdated knowledge. Of course,

simply knowing that knowledge changes isn't enough. We must also understand the underlying patterns to become better prepared for when they do change. As British professor William Macneile Dixon once wrote, "The facts of the present won't sit still for a portrait. They are constantly vibrating, full of clutter and confusion." But how can we better understand this confusion?

In 1951, Derek J. de Solla Price published a paper called "Quantitative Measures of the Development of Science" detailing how science grows and develops over time. His research then led to a new field, the quantitative study of science, or *scientometrics,* as it became known. Also known as the "science of science," Price set out to understand just how science changes. While Price had to complete calculations by hand and depend on teams of graduate students to discover patterns throughout science, we now have massive databases and computers that can complete calculations and locate patterns more quickly and easily. As a result, scientometrics has allowed us to understand nearly every aspect of how science is done.

Thanks to scientometrics, we can measure how quickly knowledge grows. For example, a psychologist named Harvey Lehman set out to count the number of major contributions made in various fields, ranging from genetics and math to the arts. He found in all of these there were exponential increases in output over time, in which new findings, methods, and ideas, were discovered. In the field of Medicine and Hygiene, for instance, major contributions are made every 87 years. In Mathematics, it only takes 63 years. And in Chemistry, only 35 years. This simply shows that fields like medicine and hygiene proceed at slower rates, this is likely because they rely on more basic fields for discoveries. In other words, more derivative fields move slowly when compared to the basic areas of knowledge on which they depend.

How Information Spreads and What it Can Mean for Our Future

In today's world, information spreads faster than ever before. We have access to technology and databases that connect millions of people across the world. However, this doesn't mean that facts are always spread rapidly. Let's take a look at Mary Tai, who in February of 1994 authored a paper in the journal of *Diabetes Care,* which at first glance appears to be a quantitative approach to understanding certain aspects of metabolism. Upon closer inspection, you realize that her "discovery" is simply determining the area under a curve. She even went so far as to boldly term her discovery "Tai's Model;" however, her discovery can also be found in a high school calculus textbook.

Tai was not the first person to discover calculus. In fact, calculus was developed in the latter half of the seventeenth century by Isaac Newton and Gottfried Leibniz more than three hundred years before Tai's calculations. Even though Tai's model represented a concept that had been previously discovered, her writing passed through editors and has received more than 100 citations in scientific literature. This simply shows that despite our technological advancement, knowledge can spread far slower than we might expect. Because the creation and decay of facts are governed by mathematical rules, we don't necessarily hear of new facts, or their debunking, instantly.

In fact, there is a substantial amount of public knowledge that remains undiscovered. According to library-science professor Don Swanson, society is quickly digitizing information but not making it easily available or relatable. As a result, public information remains unknown to many people, including scientists who would benefit most from this knowledge and research. Perhaps if they knew this information, they could combine it with what they already know and create new advancements. You see, in our modern world, we benefit most from an accumulation of knowledge. When we combine knowledge, we have the power to spark incredible,

groundbreaking developments, and each new development inches us closer to the truth.

For example, the belief that the world is a sphere isn't exactly true - it's actually an ellipsoid. This false belief, however, is still a far better approximation than the previously held belief of the Earth being flat. Developments like this can be made quicker than ever before when you consider the thousands of specialists across the world working in their fields of expertise. Furthermore, many of these fields are interconnected, meaning that discoveries in one field have the potential to help solve problems in many more. Imagine making a pile of sand using just one grain at a time. As your pile grows higher and higher, it only takes a single grain of sand to cause the whole thing to collapse.

The development of knowledge functions in the same way. As little advances from different areas add up, they create an avalanche of significant breakthroughs that have the power to transform our thinking. Therefore, being aware of current trends and new developments in knowledge is critical for understanding facts and controlling the ever-changing world we live in.

Technological Advancements Are Faster Than Ever

Buying the latest cell phone, computer, or tablet in today's world means having the newest, most advanced piece of technology for only a few months. It doesn't take long for the next latest and greatest model to come onto the market. Advancements in technology happen so quickly today, but why is this? As we learned in the previous chapter, each new development builds up upon one another to spark more groundbreaking innovations. Technological development follows this same pattern.

To track technological developments, we can use Moore's Law, which is one of the best examples to show how predictable the development of knowledge can be. In 1965, the journal *Electronics* published a paper by chemist and physicist Gordon Moore, who later co-founded the tech giant Intel. In the paper, Moore stated, "the processing power of a single chip or circuit will double every year." This prediction has become known as Moore's Law, and time has only proved this law to be true. However, as we continue to create more technological advancements, the doubling rate is now closer to 18 months.

This ongoing doubling of technological capabilities has even been found in robots. One study showed that a robot's ability to move concerning the duration and speed of movement has nearly doubled every two years! This doubling in advancements means that technology develops even faster as it continues to evolve.

For example, through technology, we can use computer models to connect and combine information from various sources, allowing once hidden knowledge to come forward. One such computer program is that of Co-Pub Discovery, which has found new associations between genes and diseases by analyzing data from studies and synthesizing the findings. As a result, the program was able to identify genes associated with an autoimmune disease of the thyroid gland called Graves. If it weren't for these

advancements in technology, this discovery and new connections would have never been brought to light.

The Discovery of Errors

When someone asks you about the tallest mountain in the world, you know the answer is Mount Everest. But do you know exactly how tall it is? In 1856, Mount Everest was named the tallest mountain, yet it's exact measurements remain a mystery. In 1954, height estimates varied by as much as 17 feet! Today, we have improved measurement techniques, like global positioning satellites, which enable us to make more precise measurements. However, after a few measurements, scientists discovered that the height of the mountain constantly changes due to erosion, glacial melt, and the collision of continental plates.

Measuring is a continuous process because it is important to be as accurate as possible when conducting scientific research. However, no matter how precise scientists are when making measurements, error and uncertainty are inevitable. Measurement errors occur due to the reliance on outdated or incorrect information. For instance, the official length of a meter used to be measured against metal. Metal, however, is susceptible to corrosion and expands when exposed to heat. Therefore, metal is an unreliable tool for measurement.

Ultimately, scientists aren't immune to making errors. The Latin proverb *errare humanum est* means "to err is human." This simply means that it is only human nature to make errors and mistakes. We must take this into account when discussing knowledge as human error plays a large role in affecting our knowledge. These errors, unfortunately, can spread quickly. For instance, let's take a look at how human error infiltrated its way into mainstream society through the popular cartoon character, Popeye.

With his odd accent and improbable forearms, Popeye used spinach as his "anti-kryptonite." Spinach was the source of his strength. But why eat so much? Why did he become so obsessed with this strange vegetable? Well, the answer stems from human error. More than fifty years earlier, in 1870, Erich von Wolf, a German chemist, misplaced a decimal point when

recording the amount of iron in spinach, changing the iron content from 3.5 milligrams in a 100-gram serving to 35 milligrams. Once this incorrect number was printed, the damage began.

Spinach's nutritional value became legendary, so when Popeye was created, executives recommended he eat spinach for strength, due to its substantial health properties! As a result, the American consumption of spinach increased by a third. Eventually, the error was corrected in 1937 when someone rechecked the numbers, but the damage had been done and the information about spinach had spread at an alarming rate. Unfortunately, the story of Popeye shows just how easy it is for errors to spread. Ultimately, errors spread so easily because it is easier to spread the first thing you find rather than delving deeply into the literature to correct the fact. This is why only 20 percent of scientists actually read the articles they cite, which only contributes to the spread of misinformation.

So is there a way to prevent the spread of errors? Well, the only solution is going through the arduous task of making corrections. Scientists must seek out literature and examine further the article in which they are citing. When errors are spotted, they should identify them and ensure that they get corrected.

The Significance of Social Connections

Many people around the world have the misconception that a larger population of people results in the more rapid development of ideas. Perhaps this is why we see universities and research laboratories located in big cities! However, it's not necessarily the number of people that encourages the development of ideas but the social connections between people. With social media and the internet, people can communicate with others no matter where they are in the world.

If you were to head to your Facebook, you'd find that not all of your friends live close to you. This doesn't prevent you from conversing and exchanging information, right? In fact, we can trace the power of social connections as far back as the fifteenth century. When the printing press, for example, was created in Germany, it didn't spread immediately to the rest of the country. Instead, it reached northern Italy before closer cities in Germany. But why? Well, social connections aren't just about proximity, they are about the connections between "thinkers" living in a particular area.

Social connections are far more important than we realize. To illustrate this importance, let's take a look at Tasmania. Somewhere between ten thousand and twelve thousand years ago, a land bridge between Australia and Tasmania was destroyed by the sea. Up until that point, individuals could easily walk between Australia and the small island. Without a bridge, however, Tasmania became completely isolated and cut off from the rest of the world. As a result, Tasmania fell behind in various developments in technology, like better fishing nets, boats, and even clothing. In other words, our social connections influence the availability of technology.

Similarly, technology influences the development of societies and cities. For instance, modern cities are bigger than ever before because of the development of knowledge and technology. Medical advancements have allowed our population to increase dramatically, increasing the need for bigger buildings. Therefore, modern construction techniques allow us to

live in buildings that are both larger and safer. Additionally, modern technology has made city maintenance, like the sewage system, easier and cleaner when accommodating such a large population.

Why We Refuse New Information and How to Begin Accepting It

As humans, it is only human nature to approach changes in facts with skepticism. When we think of something as fact, we sometimes refuse to accept anything else. This is partly due to the human ego and how we approach new information. Many of us tend to ignore information that doesn't align with our worldview; instead, we seek out information that we are comfortable with. For example, let's take a look at what happened when Galileo Galilei introduced findings that supported the fact that the Earth was not the center of the universe.

When asserting that the Earth was *not* the center of the universe, Galileo contradicted the Catholic Church's belief that God had centered the universe around humanity. As a result, the Church responded by attacking him and his ideas; the Church did everything in its power to suppress and silence Galileo. The Church is an example of how established ideas are hard to move away from, which we see today as well. In fact, even today we don't cope well with changes in knowledge. But there are ways to stay up-to-date in our fast-paced world.

Your best defense is to keep learning. Begin by instituting your own "information triage," in which you stay current in the areas of knowledge that matter to you. You can routinely re-examine what you know and avoid the risk of assuming outdated knowledge as fact. This may seem like a challenge, but the best way to stay abreast of ever-changing information is by reading continuously. Seek out trusted publications, websites, and blogs to guide you towards the pioneers of your field so you don't get lost in the times.

Of course, since knowledge is ever-changing, keeping up with everything sounds overwhelming. Luckily, we have the technology today to help us. With the internet, we can subscribe to blogs and other media channels that provide summarized knowledge of a particular field. That way, you don't

have to spend the time reading endless books and publications; take advantage of summaries and blogs! Lastly, you should abandon memorization. It would be too much to try and cram everything into your brain; instead, you should use the tools around you to stay up-to-date. The internet is a permanent storage system, so you don't have to remember the information. Instead, it's best to learn how to research and access the knowledge on the internet rather than accumulating all of it yourself.

In the end, you'll be more accepting of change and you'll be more aware of the inevitable changes. Ultimately, you'll stay open to new ideas and become less likely to stay attached to old, outdated ideas.

Final Summary

Our world is moving faster than ever before. Our population grows, and with it, technological advances only continue to multiply. As a result, our understanding of knowledge is changing. Today, we understand that facts change: the Earth is no longer flat, or even spherical, or the center of the universe. Additionally, it's not just the facts themselves that change, it's our understanding of those facts. We can now predict how quickly or slowly facts might die off, we can calculate their half-life. In the end, if we can stay up-to-date on recent discoveries and new information, we'll be able to better understand our world and better cope with the uncertainties it brings.