Where do great ideas come from?

A British engineer named Tim Berners-Lee is widely credited with having first conceived of the World Wide Web during the late 1980s. A few years ago, an intrepid technology reporter asked Berners-Lee how he came up with such a visionary idea. Berners-Lee just sat there stunned.

It's not that Berners-Lee had simply forgotten the circumstances surrounding his "eureka moment," and thus was unable to recount them to the journalist. It's that he never actually had a "eureka moment." Instead, the basic idea for the World Wide Web had percolated in his mind for nearly a decade, largely unconsciously. It was only when Berners-Lee began stumbling across related ideas from others working in the high-tech field that his revolutionary ideas finally crystallized in his own mind. For Berners-Lee, like so many other great inventors throughout history, there was no magical epiphany. No light bulb switching on. No eureka moment.

In his sixth book, Where Good Ideas Come From: the Natural History of Innovation, renowned science writer Steven Johnson sets out to dispel the popular mythology of the "eureka moment."

Unlike Johnson's previous scientific history books (e.g. The Invention of Air), this time around Johnson doesn't do a deep-dive into the origins of a single, game-changing innovation. Rather, in Where Good Ideas Come From, Johnston instead surveys dozens of important man-made inventions, some dating back to antiquity, and then compares them to the grand biological innovations that occur on a natural scale, such as the evolution of new species and ecosystems. He then argues that the striking similarities to be found between innovation in nature and innovation in the laboratory (or the workplace) hold important lessons for would-be inventors.

"Some environments tend to squelch new ideas," writes Johnson in his opening chapter, "while others seem to breed them effortlessly." He points out that Big Cities (as opposed to rural and suburban areas) have historically been such engines of innovation because they are powerfully suited for the "creation, diffusion and adoption of good ideas." In much the same way in nature, dense coral reefs on the ocean floor create a dynamic environment where biological
innovation can flourish. Through the rest of his book, Johnson distills the seven essential characteristics, or patterns, that typify unusually fertile environments, both of the natural and man-made kind. Each pattern occupies a separate chapter in his book. "The more we embrace these patterns," writes Johnson, "the better we will be at tapping our extraordinary capacity for innovation."

**Pattern #1) The Adjacent Possible**

The first of Johnson's seven patterns of innovation is something he calls "the adjacent possible". This is the notion that important innovations — including the Internet — typically emerge from old concepts, through incremental trial and error. They don't suddenly spring up out of thin air.

In the natural realm, Johnson explains how we can see the concept of the adjacent possible at play during every critical step of evolution. He uses the example of the emergence of early life on Earth from a primordial soup of molecules like methane, oxygen and formaldehyde. These molecules did not combine together in the very first instance (perhaps prodded along the way by a propitious lightning strike) to create, say, a fully formed sunflower. No, they combined together to create other simple molecules, such as water, which then led over time to the emergence of more complex molecules and life forms, as so on. "It's true that the basic atomic elements that make up a sunflower are the very same ones available on earth before the emergence of life," explains Johnson. "But you can't spontaneously create a sunflower from ground zero, because it relies on a whole series of subsequent biological innovations that wouldn't evolve on earth for billions of years (e.g. chloroplasts to capture the sun's energy)."

The scientist Stuart Kauffman first coined the term the "adjacent possible" to describe these sorts of first-order combinations. In Johnson's view, Kauffman's novel phrase perfectly encapsulates both the limits and the creative potential of change and innovation. When speaking about the emergence of early life on Earth, the adjacent possible defines all those molecular reactions that were incrementally achievable coming out of the primordial soup. Complex life forms, such as sunflowers, mosquitoes or human beings — obviously exist outside that circle of possibility. The adjacent possible is a kind of shadow future, hovering just next to the present state of things. It's a map of all the ways in which the present can reinvent itself.

Also, the adjacent possible is a constantly moving target. "Think of it as a house that magically expands with each door you open," writes Johnson. "When you first walk into this house, you begin in a room with four doors, each leading to a new room that you haven't visited yet. Those four rooms are the adjacent possible. But once you open one of those doors and go into that room, more doors appear, each leading to a brand-new room that you couldn't have reached from your starting point. Keep opening new doors and eventually you'll have built a palace."

Of course, not everyone is sold on the idea of the adjacent possible, or the limitations and constraints it implies from an innovation perspective. Or more to the point, some critics would argue that, unlike biological evolutionary processes, our human brains are not necessarily bound
by the finite laws of molecule formation. And so, every now and then an idea may occur to someone that "teleports her forward a few rooms," skipping key steps in the adjacent possible. Johnson acknowledges the possibility of such occasional teleportations. But in his view, those ideas almost always end up being failures, precisely because they have skipped too far ahead. We have a phrase for those ideas, he says. We call them "ahead of their time."

The theory of the adjacent possible has important implications for would-be innovators. The most obvious one is that it may be a huge waste of time to sit around in glorious isolation trying to come up with grand new ideas. The trick instead, perhaps, is simply to tinker. Because it is only through small-scale efforts of trial and error that we'll unlock doors to the adjacent possible.

Pattern #2) Liquid Networks

In this chapter, Johnson argues that a really good idea is, in fact, not a singular entity. Rather, a good idea is actually a coming together — or a network — of a series of smaller ideas. Consequently, would-be innovators should try to locate and inhabit environments (e.g. places of work) that encourage and foster networking in as seamless (or "liquid") a way as possible.

To describe the concept of "liquid networks," Johnson invites his readers to consider the unique behavior of molecules in each of three conditions: gas, solid and liquid. When molecules are in a gaseous form, chaos rules. New configurations of molecules are occurring all the time, but they are constantly being disrupted and torn apart by the volatile nature of the environment. By contrast, when molecules are in a solid form, existing patterns have ample stability, but they are incapable of change. And so Johnson argues that a liquid network actually creates the most promising environment for molecules (and human innovators) to explore the adjacent possible. New configurations can emerge through random connections formed between related ideas, but the underlying system isn't so wildly unstable that it instantly destroys its new creations.

What does this idea mean for how our places of work are organized? Quite simply, it means that would-be innovators should not work in isolation, and those organizations that hope to foster highly innovative workplaces should do everything they can to foster frequent interactions between their employees. The likelihood of a solitary scientist, alone in his lab, stumbling across a major new finding is extremely remote. This is equally true of office workers sitting alone in cubicles. Instead, most important ideas will emerge during fluid meetings, where employees can gather and informally present and discuss their latest work. Or to borrow Johnson's words, "the locus of innovation is not the microscope. It's the conference table."

Johnson believes that simple changes to our work environments can have a transformative effect on the quality of our ideas. The quickest way to freeze a liquid network is to stuff people into private offices behind closed doors, he says. This is one reason so many Web-era companies have designed their work environments around common spaces where casual mingling and interdepartmental talk happens naturally and easily, without any formal planning. For Johnson, open spaces are crucial to workplace innovation. "Exploring the adjacent possible can be as simple as opening a door," he says. "But sometimes you need to move a wall."
Pattern #3) The Slow Hunch

In this chapter, Johnson documents how most great ideas first take shape in a partial, incomplete form, starting with a hunch. Those hunches, he explains, often have seeds of something profound, but they initially lack a key element that can turn the hunch into something truly powerful. And more often than not, he says, that missing element is somewhere else, living as another hunch in another person's head. To be sure, liquid networks create an environment where those partial ideas can connect. But liquidity typically isn't the only missing ingredient to bringing a hunch to fruition. Often, the other missing ingredient is time. Hence Johnson's theory of the "slow hunch."

"Snap judgments of intuition - as powerful as they can be - are rarities in the history of world-changing ideas," writes Johnson. "Most hunches that turn into important innovations unfold over much longer time frames. They start with a vague, hard-to-describe sense that there's an interesting solution to a problem that hasn't yet been proposed, and they linger in the shadows of the mind, sometimes for decades, assembling new connections and gaining strength. And then one day they are transformed into something more substantial: sometimes jolted out by some newly discovered trove of information, or by another hunch lingering in another mind."

According to Johnson, sustaining and growing a slow hunch is less a matter of perspiration than of cultivation. You have to give the hunch enough nourishment to keep it growing, and plant it in fertile soil, where its roots can make new connections. And then you give it time to bloom.

Of course, keeping a slow hunch alive in one's brain over several months — or even years — poses challenges on multiple scales. For starters, you have to preserve the hunch in your own memory, in the dense network of your neurons. This isn't easy. According to the author, most slow hunches never last long enough to turn into something useful, because they pass in and out of our memory too quickly. You may get a gut feeling that there's an interesting avenue to explore, a problem that might someday lead you to a solution, but then you get distracted by more pressing matters and the hunch disappears. Obliterated from your memory forever.

This brings us to the tried and true secret of hunch cultivation: write everything down. Johnson reveals how so many great innovators, from Benjamin Franklin to Joseph Priestly (the eighteenth-century researcher who first discovered that, unlike animals, plants actually breathe oxygen and emit carbon dioxide) were absolutely anal about keeping journals and documenting their hunches and ideas. In this day and age, with all so many of us carrying smart phones, laptops and iPads, it should be easier than ever before to get into the habit of writing things down, and organizing our ideas in such a way that we can revisit and add to them over time.

Pattern #4) Serendipity

"Like any other thought," writes Johnson, "a hunch is simply a network of cells firing inside your brain in an organized pattern. But for that hunch to blossom into something more
substantial, it has to connect with other ideas. And sometimes, those connections occur purely by chance."

The English language has a wonderful word that captures the power of accidental connections: "serendipity." Using an example from the natural world, Johnson explains how the act of sexual reproduction offers a vital testament to the power of serendipitous random connections. Johnson points out that many small organisms are able to reproduce asexually. For these organisms, reproduction without sex is a simple matter of cloning. They take their own cells, make an identical copy, and pass that along to their descendants. While asexual reproduction may not sound like much fun to our mammalian ears, Johnson notes that it's a strategy that has worked very well for billions of years for bacteria. From the perspective of one of these simple life forms, asexual reproduction is faster and more energy efficient than the sexual variety. It doesn't need to go to the trouble of finding a partner in order to create the next generation.

But for larger, and more complex, life forms, asexual reproduction simply doesn't cut it. While asexual reproduction may be faster, it does nothing to foster adaptation. From a human being's perspective, looking for a mate with whom you can scramble together two distinct sets of DNA does make for a far more complicated reproductive strategy, but pays immense dividends in the rate of innovation. What we humans give up in speed and simplicity, we make up for in reproductive creativity. And thus we continue to survive and thrive over multiple generations.

Returning to the modern workplace, the would-be innovator's challenge is how to create environments that foster these serendipitous connections. For Johnson, one way to invite serendipity into your life is go for a walk around your office building. The history of innovation is replete with stories of good ideas that occurred to people while they were out on a stroll.

Reading broadly also remains a critical vehicle for the transmission of interesting new ideas and perspectives. The author points out how Bill Gates (and his successor at Microsoft, Ray Ozzie) are famous for taking annual reading vacations. During the year they deliberately cultivate a stack of reading material - much of it unrelated to their day-to-day focus at Microsoft.

Johnson argues that more organizations should come to recognize the value of a reading sabbatical, the way many organizations already encourage their employees to take time off for offsite courses and seminars. "If Google can give its engineers one day a week to work on anything they want," writes Johnson, "then surely other organizations can figure out a way to give their employees dedicated time to immerse themselves in a network of new ideas."

Pattern #5) Error

Here, Johnson argues that innovative environments thrive on useful mistakes, and suffer when the demands of quality control overwhelm them. Without error, innovation cannot occur.

Marvelling again at the abundance of innovation in the natural world, Johnson invites would-be innovators to visit their local zoo or natural history museum to ponder the
extraordinary diversity of the organisms on display. The purpose of such a visit would be to remind ourselves that all this biological variation — from the elephant tusks and peacock tails — was made possible, in part, by error. Without frequent screw-ups, he explains, evolution would stagnate, an endless series of perfect copies, incapable of change. But because DNA transfer is susceptible to error, natural selection has a constant source of new possibilities to test. Most of the time, these errors lead to disastrous outcomes, or have no effect whatsoever. But every now and then, a mutation opens up a new wing of the adjacent possible. From an evolutionary perspective, it's not enough to say "to err is human." Error is what made humans possible in the first place.

Unfortunately, says Johnson, too many modern workplaces are doing just about everything they can to avoid risk and clamp down on employee errors. Lots of big organizations like to follow perfectionist regimes like Six Sigma and Total Quality Management — i.e. entire systems devoted to eliminating error from the conference room or the assembly line. But Johnson believes these companies are walking dinosaurs. It's no accident, he argues, that one of the mantras of the Web startup world is *fail faster*. It's not that mistakes are the goal, he says. Mistakes are still mistakes, after all. But they're an inevitable step on the path to true innovation.

**Pattern #6) Exaptation**

In this chapter, Johnson tells the story of a young German entrepreneur named Johannes Gutenberg who, sometime around the year 1440, began fiddling around with the design of the wine press. Wine presses were commonly used in European wineries of that era as a means of increasing production yields. Yet while he was spending a lot of time hanging around wineries, the author tells us Gutenberg was not at all interested in wine. He was interested in words.

After years of tinkering around with various kinds of wine presses, and combining them with other simple machines, Gutenberg eventually developed the world's first printing press.

As many scholars have pointed out, Gutenberg's printing press is a classic example of combinatorial innovation. Each of the key elements that made Gutenberg's invention such a transformative machine — the movable type, the ink, the paper, and the press itself — had already been developed separately, years before Gutenberg printed his first Bible. But no one had the foresight to put them all together, as Gutenberg did. Amazingly, Gutenberg took a machine designed to get people drunk and turned it into an engine for mass communication.

In the natural world, evolutionary biologists have a world for this kind of borrowing. It's known as *exaptation*. Exaptation occurs when an organism develops a trait for a specific use, but then the trait gets hijacked for a completely different function. A classic example of this is bird feathers. Many scientists believe that feather initially evolved for temperature regulation, helping non-flying dinosaurs from the Cretaceous period to insulate themselves against cold weather. But when some of their descendants began experimenting with flight, feathers turned out to be useful for controlling airflow over wings, allowing those first birds to glide. In other words, a feather first *adapted* to provide warmth was eventually *exapted* to enable flight.
According to Johnson, the history of human creativity abounds with exaptation. To cite another example, in the early 1800s, a French weaver named Joseph-Marie Jacquard developed the first punch cards to weave complex silk patterns with mechanical looms. Several decades later, Charles Babbage borrowed Jacquard's invention to program the Analytical Engine. These primitive punch cards would remain crucial to programmable computers until the 1970s.

What lesson does this pattern hold for would-be innovators? Well, Johnson points out that many legendary innovators including Ben Franklin and Charles Darwin, all shared at least one defining personal attribute. They had many hobbies. Because of this, Johnson believes that these men were better able to capitalize on the power of exaptation. "It is not so much of a question of thinking outside the box, as it is allowing the mind to move through multiple boxes," says Johnson. "That movement from box to box forces the mind to approach intellectual roadblocks from new angles, or to borrow tools from one discipline to solve problems in another."

**Pattern #7) Platforms**

In his final chapter, Johnson canvasses the importance of open platforms to innovation.

In the natural world, platforms tend to manifest themselves in the form of "keystone species." These are organisms that have a disproportionate impact on their ecosystem - a carnivore, for instance, that is the only predator of another species that would otherwise overwhelm the habitat with unchecked population growth (e.g. wolves are a keystone species, in that they keep the deer population under control). Remove the keystone predator and the habitat falls apart.

Layered on top of that is a very specific and crucial kind of keystone species: the kind that actually creates the habitat itself. Scientists call these organisms "platform engineers."

Beavers are a classic example of platform engineers. By felling trees to build dams, beavers single-handedly transform dry forests into wetlands, which then attract a remarkable diversity of woodland creatures. According to Johnson, platform builders are key drivers of innovation in that "they don't just open a door to the adjacent possible; they build a whole new floor."

In the online world, open electronic platforms like YouTube, Facebook and Twitter also play a vital role in creating a fertile breeding ground for innovation. To Johnson, the most fascinating thing about these three platforms is how much has been built on top of them in just a few short years. And none of this innovation was planned or expected. For instance, when Twitter first emerged, it was widely derided as a frivolous distraction. And indeed, the majority of its early adopters used Twitter, and its famous 140-character limit, to "tweet" about rather frivolous matters, like what they had for lunch. Nobody anticipated that it would one day be used to organize and share news about the Iranian political protests, to provide customer support for large corporations, or as a means of communication between government and citizens. In Twitter's case, as with Facebook, YouTube and countless other open platform applications, users
are constantly using those foundations to build innovative new applications. And this is no accident, because the owners of those platforms actively encourage such creativity by exposing their API code (or application programming interface) to would-be innovators.

That said, not everyone is sold on the benefits of open platforms. "The premise that innovation prospers when digital platforms are open may seem like an obvious truth," writes Johnson, "but the strange fact is that a great deal of the past decade or so of legal thinking about online innovation has pursued the exact opposite approach." Johnson notes that some large American corporations, backed by our legal system, are still choosing to build 'walls' around their platforms (with Apple being the prime example), which prevents those platforms from fostering the kind of random, serendipitous connections that exist both online and in the organic realms of life. These walls go by many different names: patents, digital rights management, intellectual property and proprietary technology. But they all share the same basic argument: that in the long run, innovation will increase if you put restrictions on the spread of new ideas, because those restrictions will allow the creators to collect large financial rewards from their inventions. And those rewards will then attract other innovators to follow in their path.

Needless to say, Johnson does not subscribe to that line of thinking. "When you can build on something without having to ask for permission, that's when innovation thrives," he says.

Conclusion

Unless you're the President of the United States, the head of the U.S. Federal Reserve or perhaps the CEO of a huge multi-national firm like Microsoft, then chances are you're not going to be able to do too much, as an individual, to re-shape how innovation occurs (or fails to occur) at a macro level across our society. But according to Steven Johnson, there's no shortage of things we can do individually to influence the pace and scale of innovation in our workplaces, or our local communities.

In other words, we may not be able to flip a switch and turn all of America into a fertile "coral reef" of innovation overnight. But we can create comparable environments on the scale of our everyday lives, in part by applying Johnson's seven patterns of innovation. Each pattern is fairly simple. But taken together, they make for a whole that is far more innovative than the sum of its parts. And that, Friends, is where good ideas come from.