Biology

A totally blind process can by definition lead to anything; it can even lead to vision itself.

Jaques Monod [1]

Biology

Evolution Part One: Natural Selection and Extinction

Evolution Part Two: Adaptation Rate and the Red Queen Effect

Supporting Idea: Competition

Ecosystem

Niches

Self-Preservation

Replication

Cooperation

Supporting Idea: Dunbar's Number

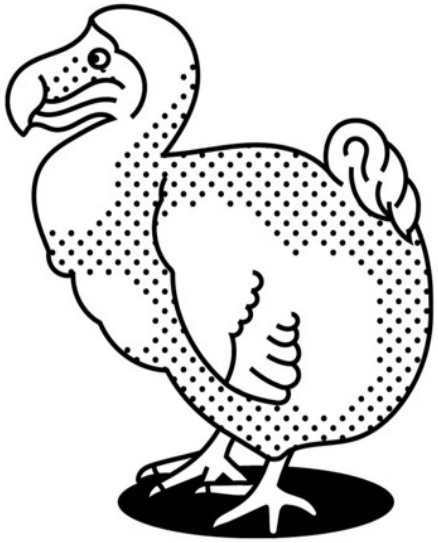
Hierarchical Organization

Incentives

Tendency to Minimize Energy Output

Biology

Evolution Part One: Natural Selection and Extinction



–

Adapt or die.

Evolution Part One: Natural Selection and Extinction

Evolution is a powerful mental model because it explains success and failure, the relationship between the environment and the individual, and why you had better plan for constant change. There are so many valuable applications of this concept, we have broken it down in two chapters.

The first, Evolution Part One, looks at natural selection and extinction. We show how environmental pressures shape groups, spurring them to evolve or die out. The second chapter goes into more detail on ways to adapt to the inevitable changes we face. Evolution as a mental model can be summed up as "adapt or die." We think, however, it is important to understand not only how we can adapt, but what it is we are responding to when we do.

Looking at natural selection and extinction together pushes us to consider the parameters that we must evolve in. We either respond to the changing demands of our environment, or we die out. Natural selection further teaches us that optimization for our environment is an ongoing and dangerous process. We are constantly trying to obtain advantages that will increase our chances of survival and avoid extinction as a species.

The word *selection* can be confusing, because its common usage implies choice: I'm selecting this over that. In reality, the concept means that the more favorable a trait is for a particular environment, the higher the chance of that organism living long enough to procreate. Biologist Geerat J. Vermeij describes it as "nonrandom elimination."

Charles Darwin spent decades studying the natural world, and he was one of the first to make the observation that nature played a significant role in shaping all organisms. As each generation contends with its environment, the struggle for the resources needed for survival means that any traits that promote survival will likely get passed on. Thus, over time, the frequency of traits within a population changes as a response to environmental conditions. This is the definition of natural selection.

Natural selection "is very much about advantages in the here and now, not in the distant future. Traits conferring long-term advantages emerge because they also work well in the lives of individuals and produce positive feedbacks."[1] For a mutation to be successful, it can't negatively impact an organism's ability to survive at that time. Natural selection does not preserve changes that may be useful in the future. It preserves changes that are useful now. For example, slow zebras are the ones who are eaten by the lions. The faster ones survive and reproduce. Over time, the entire zebra population becomes faster. A key element of natural selection then is the beneficial traits that are selected for by the environment increases the survival potential of the species. We can also apply an inversion lens, demonstrating that any adaptive response that is not useful will be selected against. As Rafe Sagarin notes in *Learning from the Octopus*, goes on to note, "Natural selection ... is an incredibly simple process requiring just three simple elements—variation between individuals, environmental conditions that favor or select certain variants over others, and a means to reproduce those variants that are better suited to the environment."[2]

« Organisms in nature have survived and thrived for billions of years because they have one powerful trait at their disposal—they are adaptive. »

Rafe Sagarin [3]

There are many ways to be successful in any given environment. It is not only the most successful trait that will reproduce in successive populations, but the entire upper echelon of successful traits. We can imagine that it's not only the faster zebras who will be more likely to reproduce, but also zebras that have a more powerful kick or better eyesight.

One of the key elements to selecting for positive traits is that they have to be repeatable. Either the genetic mutation or the learning must be able to be passed on to the next generation. If adaptive behaviors can be used and developed in a successive series of situations to increase the fitness of the individual, and the species, those behaviors will be selected for.

« New circumstances tend to be calamitous for an economic unit if they are either very large or very rare relative to the size and lifespan of that unit. »

Geerat Vermeij [4]

Every biological behavior and feature exists for the same reason: to survive long enough to reproduce and therefore avoid extinction. All living things are out to ensure the survival of their species. Organisms must adapt in order to not go extinct.

The vast majority of the species that have existed on earth since life first emerged are now extinct. In biology, extinction is defined as the moment when the last member of a species dies. For example, the last passenger pigeon, Martha, died in captivity in 1914. But the point where there is no possibility of a species surviving tends to occur earlier, when the population density of a species is below the threshold necessary to keep itself away from extinction, a set of circumstances known as Allee effects.[5] A species may also become extinct in the wild when the only survivors are in captivity and would be unlikely to repopulate their natural habitat if released. With too few individuals remaining, breeding may be impossible. This may occur because a species has died out by itself, or it may be the result of the activity of another species, as was the case with passenger pigeons. Once numbered in the billions, this species was entirely wiped out by human hunting within a few decades.

We can't ever identify the precise cause of an extinction. The influences are always complex and unique to the situation. Often, we can only infer causes from outcomes. In addition, extinctions are not always rapid. Sometimes they take place in increments over millennia. We do, however, know the most common causes.

One cause is competition. A species may die out because it must compete with a better adapted rival. Two species requiring the exact same resources cannot coexist in the same area. The

successful introduction of alien species sometimes leads to the extinction of native ones. Unable to adapt fast enough, the native species is deprived of the resources it needs. Another cause, and one of the most common, is a change in environment. This could be due to climate change, deforestation, a volcanic eruption or anything significantly disruptive.

To confuse matters, extinctions don't occur in isolation. Ecosystems are full of complex, nonlinear interdependencies. When one species dies out, it may take others with it. Sometimes, the interrelationships are straightforward. If a prey species goes extinct, it's logical for its main predator to do likewise if it lacks alternatives. Or the interrelationship may be less direct. If a predator goes extinct, its prey may be able to breed in greater numbers. This can put a strain on its own prey and drive this prey to extinction. Thus, we cannot predict the outcome of an extinction.

A further issue with classifying extinction is that it means we must be able to classify a distinct species. It can be hard to define what constitutes a species. If a dog interbreeds with a coyote, for example, is that a new species? We are far from identifying or even discovering all the species on this planet. Many have gone extinct without us ever knowing they existed in the first place. There are an estimated 10 million distinct species, of which fewer than 20%[6] have been catalogued.[7]

In any system, it's natural for parts to continuously wear and need replacing. This is true of ecosystems. Extinctions are a ubiquitous feature of life on earth, as a sort of meta natural selection. The same selection process that applies to individuals is true for species as a whole. The catch is that the same evolutionary

process that ensures a species' survival can also be its downfall. Natural selection within a stable environment tends to be a process of refinement. A species will become more and more tuned to the precise adaptations it needs to survive. This is ideal in reliable conditions, but it can mean a species lacks the resilience it needs to survive any changes. So while the best-adapted organisms may be the strongest during normal conditions, they may struggle to survive volatility. Generalist species are far more resilient than specialists. A rat or a cockroach can survive almost anywhere, a panda less so.

One of the main ways species guard against extinction is by having a lot of offspring, fast. The population can quickly restock after events like a new disease. Species that breed slowly are more vulnerable, although they can find ways around it, as humans have done.

While extinction is an extreme event, it's often normal for large numbers of a species to die out. Deer and elk starve in large numbers on a regular basis. Once the population in an area gets too big, there isn't enough food available. The periodic mass starvations end up benefiting the species. As brutal as this is, it's necessary for the whole species to endure. [8]

Extinctions happen all the time. This is when species are continuously dying out but at a steady pace and from a range of causes. By contrast, a mass extinction is when a lot of species disappear in one go. This involves the disappearance of a lot of species at once. It tends to be the result of a single cause, such as a sudden change in climate conditions like those caused by a meteor.

Thus, natural selection and extinction are two very important concepts from evolution. Together they explain why and how organisms respond to changing environments and what happens when the responses fail. These same principles can be used to look at the development and progression of nonliving things and to better understand why certain social or cultural artifacts change and thrive while others fall out of favor or disappear altogether.

« So how does a business survive in constantly changing environments?When change hits, a common response is denial or trying to adapt with a business model that no longer works. We can influence the outcome in changing environments more rapidly by first recognizing that we actually need to survive and then moving to survive with new ideas. »

Roberta Bondar [9]

The evolution of language

Why do some customs, products and social norms thrive, and others disappear from the landscape? Natural selection is a lens we can apply to understand how environmental pressures promote certain changes, leading to growth and dominance. And why the same process penalizes those populations that are unable to meet those pressures.

A fascinating example to illustrate the constant interaction between environment and species that leads to evolution is to look at how some languages grow and become global, and others go extinct.

Over human history, there have been thousands of languages used by humans to communicate. Some of these never spread beyond narrow regional dialects used only by a small group of people. Others spread far beyond their original environment to be used by people in all areas of the world. Languages are, in a sense, subject to the pressures of natural selection, which means they can also die out if they aren't well suited to their environment.

French is one of the successful languages. It evolved from the Romance languages spoken in the region of present-day France. The roots of the language that became modern French had remarkable adaptability. As it evolved, French picked up words from many of the different languages it came into contact with, so that even today it retains words that have origins in Norse, Gaulish, Frankish, Arabic, Spanish, and Italian.

Environmental pressures on languages predominantly come in the form of geopolitical changes. Shifts in power result in shifts of

language usage. Jean-Benoit Nadeau and Julie Barlow explain in *The Story of French* that "three main events pushed the language from one phase to the next: the fall of the Roman Empire, the conquest of England, and the rise and fall of Paris as a center of power."[10] Early French responded to these changes by mutating—picking up words from other languages—which helped it survive by keeping it useful.

For centuries, the development of the French language was a series of successful adaptations. Use of the language spread all over Europe through conquest and invasion, and thus speaking the language was desirable. It became the only real common language of the region. French was used as the language of administration, and gradually "people who wanted power knew they needed French."[11] The mutations it picked up spread throughout the population, reproducing as more and more people began teaching French to their children as their mother tongue.

The spread of French meant that the language faced more complex environmental pressures. It began to settle into the modern version of the language in response to these pressures. First, "by the 12th century writers from around Paris were making a conscious effort to eliminate dialectical characteristics in their writing so they could be understood by a larger number of people."[12] Second, as it became the pan-European language of business, its grammar, spelling and precise meanings had to be set so as to avoid disputes based on interpretation. Finally, the growing popularity of printed materials pressured the language to commit to rules and standards, as well as concise characters to save on cost.

French was able to adapt accordingly. Gothic characters were replaced with Roman ones, and dissemination of printed French materials helped communicate and solidify a common understanding of the language. French speakers furthered the use of French by creating dictionaries and grammars that increased utility. “Because it was defined, French in the seventeenth and eighteenth centuries was regarded as easier to learn.”[13] These measures served to create accessibility. The easier it is to learn a language, the more appeal there is in making the attempt.

When geopolitics shifted and colonialism became the goal of many European countries, French again was able to adapt and infiltrate new ecosystems. It continued to incorporate words from other languages confronted in new territories, thereby showing flexibility, which encouraged uptake. As Nadeau and Barlow explain, many French explorers and missionaries understood that communication was a key to relationship building and so taught French and correspondingly learned native languages all over the globe. When colonialism ended, French was often the only common language in an area that had multiple local dialects.

French, however, does not have a perfect record of adaptation. In many ways the language, although global, was heavily influenced by the culture of France. One of the impacts of this situation, for example, was that some cultural prejudices worked against the evolution of French in the colonial era. “An important segment of the [French] elite was simply not interested in questions of industry, science, technology, money or markets—issues that were vital to the development of a trading empire. The French Academy, of course, completely ignored scientific and

technical vocabulary, as well as new vocabulary from the colonies."[14] The bias of French culture limited the language. You aren't going to use a language to try to communicate your ideas if it has no words for the elements you need to express.

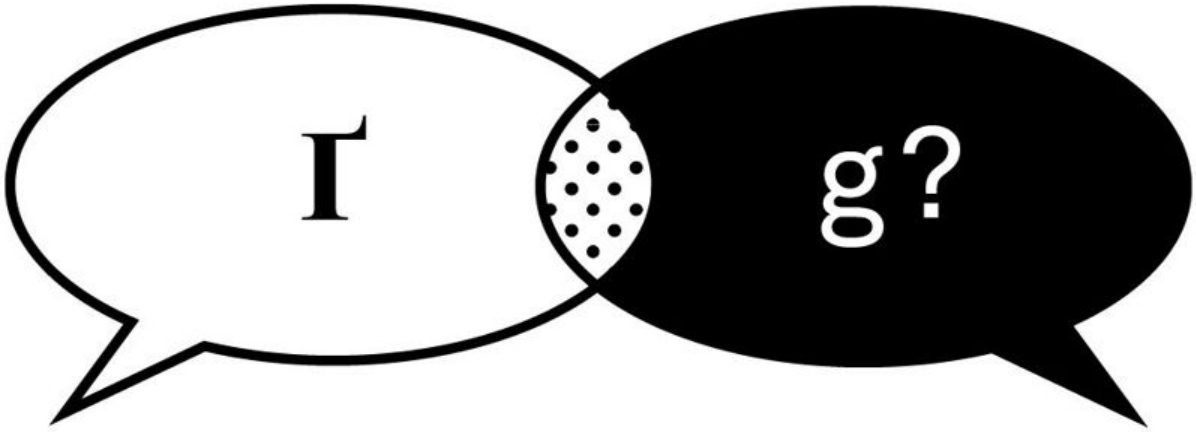
French eventually overcame the lack of words in scientific and technical fields and contributed many inventions and innovations to the world. But the point is that in order for languages to evolve, they must have the flexibility to adapt. Any measures that try to constrain flexibility risk the language becoming unusable and eventually extinct.

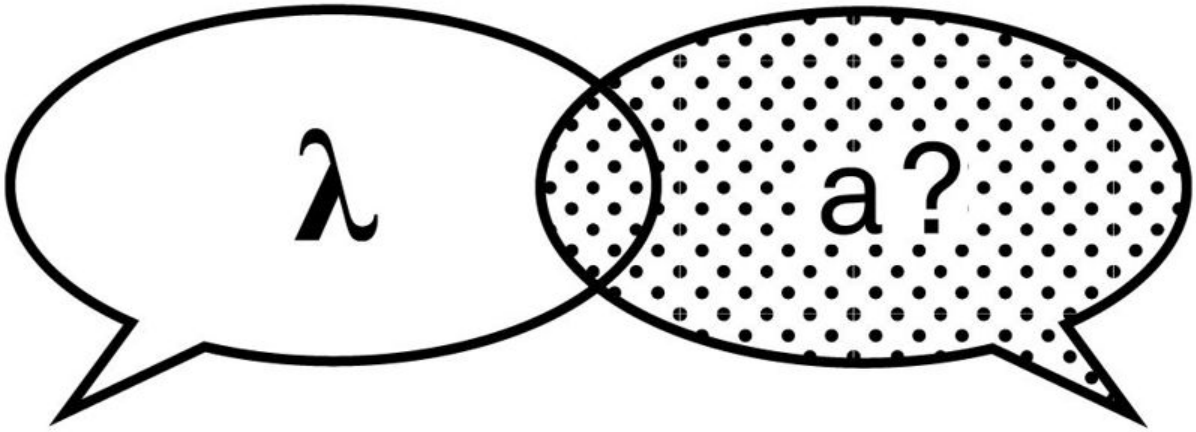
To this day France responds to the pressures on French created by the global prominence of English (and Mandarin, and Spanish) by trying to make it easy for people to learn French. "French lexicographers do their spring cleaning regularly so that the language doesn't hold on to words it doesn't need."[15] And more significantly, there are French schools all over the globe. Many are part of the private Alliance Française, and others are run by the French government, but the vast majority are open to anyone who wants to learn French.

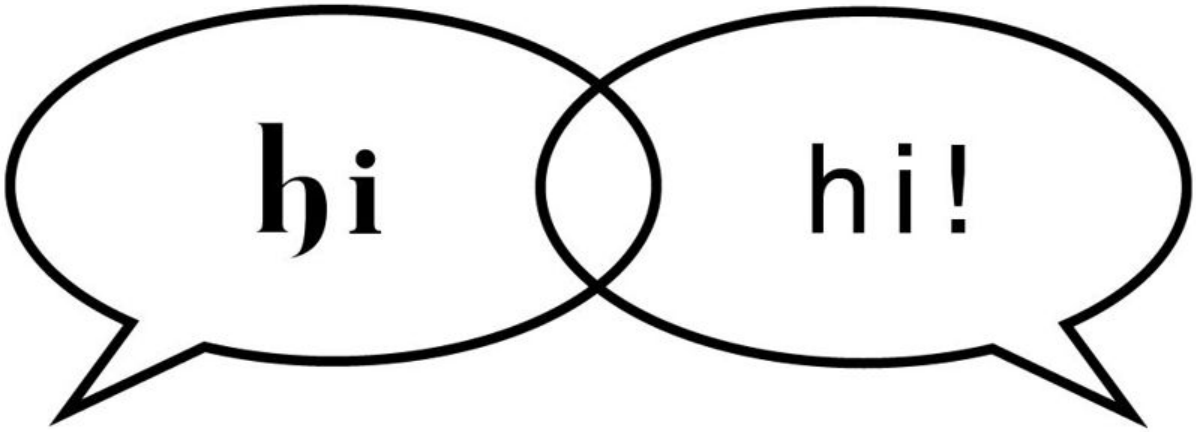
Other concentrations of French speakers, such as those in North America and Africa, actively promote the use of French through language laws and cultural associations. Mandating usage is one way of keeping a language useful.

Evolution can be threatening if you can glimpse some of it happening. The changes you observe can suggest that your own fitness may be lacking, and that the products of the evolution of your species will be unrecognizable. The evolution of language faces a similar challenge—will it still be French if the language

evolves in such a way as to be incomprehensible to contemporary speakers?


ɾ
g?


ʎ
a?


ɧi
hi!

–
Letters evolve, and so do languages.

Part of the tension in French is about trying to resolve the conflicting pressures placed on the language by changes in the environment. Nadeau and Barlow write that entire tenses have been dropped from usage, and slang is being adopted at a rate that makes it hard for dictionaries to keep up. Some people react by fighting to keep the language "pure" and consistent with centuries-old usage. They advocate a top-down approach to language development. Others accept changes and innovations and view them as a source of creativity and way of staying relevant.[16] The lens of evolution and natural selection suggests that trying to freeze a language, or trying to maintain tight control on its evolution, is the exact wrong reaction in terms of preventing extinction. If a language cannot adapt it will cease to be useful. If it ceases to be useful, it will go extinct.

The story of the evolution of French can be contrasted with that of Latin. Latin is perhaps the best-known dead language. The debate over what makes a dead language and whether any particular language falls in that category is endless. By the strictest definition, a language is only dead when no living people speak it. The more typical definition is when a language is no longer native to any community who would speak it as their mother tongue.

Latin originated in Rome then spread across Europe and Africa as the Romans took over the surrounding areas. The oldest surviving example of written Latin dates back to the 7th century BCE. According to legend, Rome was founded about half a century

earlier. In an era when most people spent their entire lives close to where they were born and had little reason to interact much with anyone outside of their own community, Italy was home to numerous small languages, of which Latin was just one. It was pure luck that Latin ended up taking on such significance. By most estimates, Latin ceased to be anyone's mother tongue and diverged entirely into separate languages by the 7th century CE.[17] While geopolitical changes after the fall of the Roman Empire strengthened French, they gradually killed Latin.

This doesn't mean no one knows it or that it is not in use in any manner. Latin remains the official language of Vatican City and has a significant role in Catholicism, often used in writing by officials. It's used in some traditional, ceremonial situations, like the graduation ceremonies at Oxford University in England.

In addition, a significant portion of the technical terminology used in medicine, epistemology, taxonomy, law, and other fields is Latin. This is partly tradition and partly to give these fields a universal language to facilitate ease of communication across borders. Some schools still offer Latin classes, and many people still choose to study it. For scholars who study old texts, a knowledge of Latin is useful so they don't need to rely on translations, which may be subjective. For these reasons, Latin is unlikely to disappear altogether. But the fact that it is not spoken as a native language puts it into the dead category.

Just as a species that goes extinct can have descendant species that survive, incorporating some of its traits, dead languages can be the ancestors of living ones. Latin formed the basis many of the existing languages in nations that once fell under

the Roman Empire, including Italian, French, Portuguese, Romanian, and Spanish.

The main reason Latin fell out of use is its complexity. Learning Latin is far more arduous than learning any of the languages it spawned as there are numerous ways to modify each word depending on the context. The selection pressures on languages tend to push them toward whatever form is easiest to learn. A language is well adapted to its environment if people can learn it and if they have a strong enough reason to learn it. Much like, in everyday use, we often contract words or drop syllables to make our speech easier, Latin evolved into a simpler form known as Vulgar Latin. Seeing as no central authority existed to codify and define the proper use of Latin, its simpler form diverged in different parts of what was once the Roman Empire, becoming a range of different languages. As humans, we have a tendency to minimize energy output, which gives us a preference for languages that are easy to use and understand. That doesn't mean the simplest languages become the most popular. But it does mean that in the absence of formal, enforced standards, languages drift toward greater ease of use. This is part of what happened to Latin; it wasn't best suited to its environment. In addition, there were no laws requiring the use of Latin in particular areas. French, by comparison, was more formalized, with defined standards for its usage. Being easier to learn likewise gave it an advantage in surviving long term.

Beyond the languages that have direct links to its structures and grammar, other languages use Latin words or ones derived from them. It's estimated that more than 60% of English words are

derived from Latin or Greek. For instance, “antique” and “ancient” come from *antiqua*, meaning “old.” Likewise, French uses numerous words of Latin origin, like *agir* (to act) which comes from *agere*, and *bouteille* (bottle) which comes from *butticula*. Thus, although Latin is a dead language, it has had a lasting and widespread influence on many languages that are still in use and spoken by millions of people.

The contrast between French and Latin shows us how languages are subject to the pressures of natural selection. Languages also need to evolve to survive in a changing environment, or they decline in use and eventually go extinct.

Conclusion

Natural selection and extinction are not just about plants and animals. It is important to understanding how the world changes over time, and how these changes force an adaptive response. If we resist adapting, we ultimately contribute to our own end.

There is a constant interplay between environmental changes and a species' response to them. The value of how a species responds is evaluated simply by survival. If we want to understand why some traits stick around, why some customs carry through many generations, and why some ideas take root and spread through a population, we have to look at their usefulness in their environment.

Biology

Evolution Part Two: Adaptation Rate and the Red Queen Effect

–

Getting better all the time.

Evolution Part Two: Adaptation Rate and the Red Queen Effect

We have to deal with the environment we are in, not the one we wish we were in. Adaptations are successful relative to their performance in a specific environment, relative to the pressure and competition the organisms face. We don't have to be objectively best, just better than those we are competing against. "In other words, living things do only as well as they have to rather than optimize." [1]

Adaptation refers to both the trait that is useful and the process of change it undergoes as it is passed on. It is both a noun and a verb. Adaptations start as genetic variations that occur in the right time and place to be useful—"Adaptability controls the sweet spot between reaction and prediction, providing an inherent ability to respond efficiently to a wide range of potential challenges, not just to those that are known or anticipated." [2]

« Adaptation is as good as it has to be; it need not be the best that could be designed. Adaptation depends on context. »

Geerat Vermeij [3]

The story of the peppered moth in Britain is a textbook example of adaptive change to specific environmental pressures. Normally very light, there were nonetheless variations produced that resulted in dark coloring. However, against the normal

backdrop of their environment, they stood out and were quickly eaten. At least at first. However, during the Industrial Revolution, what was once a negative trait became a positive one.

When blankets of sooty pollution were covering everything for miles, the lighter moths now stood out and became an easy target for their predators. The dark variants became far more successful at camouflaging in the dark soot and were therefore better able to survive and produce significantly more offspring.

When gene mutation confers an advantage, the frequency of that mutation in the population increases. Mutations are constantly being tested in the environment. It's interesting that now, with more efforts at pollution control due to the deleterious effects of smog, the lighter moth is making a comeback.

Populations of organisms adapt in response to changes in both the organic and nonorganic environment. Less sunlight or warmer temperatures influence the process of adaptation, as do changes in the other organisms that occupy the same environment. Predators adapt to changes in prey, and they also adapt to changes in their competitors. When it comes to adapting to environmental change, "remember that nature is limited to the raw materials at hand, and there's only so much you can do with them." One consequence is that there might be the same solution for different problems in different species. [4]

Adaptations can arise in multiple places, basically simultaneously. Consider that "humans had earned a living by hunting and gathering wild foods for 10,000 generations, but in just a few, brief millennia, food production sprung up across the globe. It happened separately in at least a dozen places." [5] Which brings up

the full context of the word adaptation. There are genetic mutations that allow for direct adaptation, then there are the mutations that allow for learning and thus adaptation on a much shorter timescale.

« Adaptation requires leaving or being forced from your comfort zone and into a place where you observe and experience new threats to your security. »

Rafe Sagarin [6]

Identifying opportunities to adapt

When we think about World War II, most of us know that France was occupied by the Germans early on. The Nazis rolled into Paris in the spring of 1940, and not until D-Day four years later did the Allies get a toe back in the country. The French toiled under the Vichy government for the rest of the war, and some supported the allied effort through a small but potent resistance. Have you ever asked why France fell so fast?

It's interesting to think about. After all, when the Treaty of Versailles concluded World War I, it was the Germans, not the French, who were greatly reduced militarily. Despite this, the French continued to be anxious about future German aggression. They maintained their military. They built the Maginot Line as a defensive structure in eastern France. They strategized on how to protect their country. They bought tanks and kept up drills and vowed they would not suffer a repeat of World War I.

Germany was in an entirely different situation. After the First World War, "Germany was left, as even the Allies admitted, with something closer to a police force than an army. When the promise of reductions in all armies failed to materialize in later years, it added to British unease about the German treaty and to German resentment. With an army of 100,000 men and a navy of 15,000, and with no air force, tanks, armored cars, heavy guns, dirigibles or submarines, Germany was to be put in a position where it could not wage an aggressive war." [7]

Germany's munitions were destroyed, and the country was not allowed to import anything that could be used as "war material."

They couldn't have cadets' and veterans' societies and "couldn't do anything of a military nature."[8] Further, they were ordered to pay huge sums of money to the Allies, reducing their ability to rearm. Of course, later events showed that the Germans ignored many of the terms, and the Treaty of Versailles has been widely criticized for creating the conditions that led to World War II. However, the point here is that given the circumstances leading up to 1939, it is by no means obvious why the Germans were so successful in invading France.

At the outbreak of the war, France had 110 divisions, "of which no less than 65 were active divisions." The Germans, on the other hand, "had 98 divisions, 36 of which were untrained and unorganized." Explaining the technical capacity of each military in 1939, B. H. Liddell Hart says, "On the surface, it would appear that the French had ample superiority to crush the German forces in the west."[9] So why didn't they even come close?

Warfare in 1939 had many new components. It was a changed environment to which the French had not adapted. They hadn't undergone the selective pressures needed to be prepared for the German army.

The Treaty of Versailles had, in a sense, been about maintaining the adaptive status quo. The hints World War I gave that warfare had fundamentally changed and thus required new thinking were largely ignored by the leaders of Europe. In France there was both "an incomprehension of the new idea of warfare, and official resistance to it."[10] The French were twenty years out of date in their thinking. They had modern equipment, but "lacked

modern organization."[11] And they had not invested in air power to support their ground troops.

On the human timescale, adaptability is about recognizing when the way you have done things in the past is becoming less and less successful in a changing environment. It requires you to innovate, like mutations in the evolution timescale, to see if you can come up with ideas that will improve your chances of success.

In the 1930s the French prepared themselves for a war they had already fought. Hart writes that "the French High Command still regarded tanks through 1918 eyes—as servants of the infantry, or else as reconnaissance troops to supplement cavalry. Under the spell of this old-fashioned way of thought they had delayed organizing their tanks in armored divisions—unlike the Germans."[12]

To be fair, the Germans had not fully worked out how to succeed in this new environment either. It wasn't like they had perfected which adaptations were going to work the best. They were "still far from being a really efficient and modernly designed force....At the same time the German High Command had, rather hesitatingly, recognized the new theory of high speed warfare and was willing to give it a try. "[13] And it was this willingness to adapt, even in only a few individuals at first, that was one of the reasons they were so successful in the early part of the campaign.

Like genetic mutations, improved fitness doesn't require everyone to adapt at the same time. At the outset of the war many in the German High Command were remarkably similar to the French in how they thought the invasion would play out in terms of tactics and timing. There were just a few more Germans in positions of sufficient power who were willing to try new tactics. One of the

more notable of these is General Guderian.* Hart writes that "the Battle of France is one of history's most striking examples of the decisive effect of a new idea, carried out by a dynamic executant."[14]

Hart's explanation of Guderian's actions is a chronicle of adaptation in action. "Guderian has related how, before the war, his imagination was fired by the idea of deep strategic penetration by independent armored forces—a long-range tank drive to cut the main arteries of the opposing army far back behind its front. A tank enthusiast, he grasped the potentialities of this idea, arising from that new current of military thought in Britain after the First World War....When war came Guderian seized the chance to carry it out despite the doubts of his superiors."[15]

Guderian's adaptations took him right through the French defenses, giving him an unobstructed path to the Channel. It was his series of actions that the Germans built on to complete the occupation of France a year later. Guderian led an adaptive German response to the changes in the warfare environment. Like the color of the peppered moth, the changes were successful only in very specific environment. The German responses to other environmental conditions were significantly less beneficial and contributed to their eventually losing the war and returning France to the French.

Long live the Red Queen

The Red Queen Effect is a compelling principle of evolutionary biology and vivid image to help understand the pressures that all organisms face just in surviving.

The least fit of a species dies first. You can't stop adapting, because no one around you is stopping. If you do, your competitive position declines, bringing your survival into question. Every living thing is constantly on the lookout for opportunity, the place to accrue advantage, and thus adaptation is also driven as a response to changes in those with whom we share our environment. Staying the same as we are often means falling behind.

The Red Queen Effect was first used in the context of evolutionary biology by Leigh Van Valen in 1973. In his research, he noticed something interesting: that at no point was a species protected from extinction. Evolution is an ongoing process, and all species must continually respond to pressures in their environment or die off. What's more, constant adaptation is something that everyone is doing, all the time. Hence the use of the Lewis Carroll character from *Alice's Adventures in Wonderland*. The Red Queen tells Alice, "Now, *here*, you see, it takes all the running you can do, to keep in the same place." [16]

At the biological level, organisms don't choose to adapt. A leopard doesn't sit up one day and say, "Wow, the antelope are getting faster. I need to do something about that." Rather, the increased speed of the prey means that only the fastest predators will get food and live long enough to reproduce. Thus, over time, the average speed of the predator species increases. The pressures on

Red Queen Effect

It takes all the running you can do, **to keep in the same place**

"Now, here, you see, it takes all the running you can do just to keep in the same place. If you want to get somewhere else, you must run at least twice as fast!"

- Red Queen from *Through the Looking Glass*

both the predator and prey are constant, which is what produces the Red Queen Effect.

However, this principle applies to the much smaller timescale of our lives as well. And, importantly, we can choose to do something about it. There are so many humans on the planet that even if only 20% were trying to move ahead, it's enough that they wouldn't leave much behind for the rest of us. There are enough people trying to get smarter, better, and more of the limited resources that are available, that it puts direct pressure on everyone to keep up.

« If feedback is positive, or reinforcing, cause and effect together unleash a runaway process with all the characteristics of an arms race. If negative, or stabilizing and self-limiting, feedback acts as a brake, muting change and damping fluctuations. »

Geerat Vermeij [17]

The Red Queen Effect is often applied to business strategy and human conflict. These two areas bookend the spectrum of the use of this model. Applied to business, it is an argument against complacency. As noted above, the originator of the hypothesis, Leigh Van Valen, observed that longevity does not protect species from extinction. No matter how long a species has survived, a failure to adapt can result in extinction. There is no plateau a

species can reach when it gets to say, “Okay, the hard work is done. I can coast now, getting by on what I have.” Because all species are continually adapting, the pressure is constant.

The same dynamic exists in business. Your competitors are always working to get ahead, and thus you must as well. Your customers’ needs are always changing, and you need to be able to identify and meet these. Considering the actions of your competitors and the desires of your customers are part of the core, daily functions that your business must always perform.

Some organisms exist within an aggressive Red Queen Effect, which is the situation for many bacteria, while for others, like cockroaches, the pace is less intense. It is possible that high capacity in both flexibility and learning can slow one’s particular experience of the effect. Overall, when applied in business, this principle can promote an environment where there is an infinite capacity for innovation.

At the other end of the spectrum we may apply the Red Queen Effect to human conflict. As in an arms race, where one side invests resources to outdo the other, eventually the cost of the resources is immense, but no advantage is gained. An arms race points to the limits of using the Red Queen Effect as a model. In some scenarios, namely those where there is an end to beneficial adaptation, it is better to look at changing parts of the environment in which you are trying to survive instead of trying to keep up in a race that is undermining your overall ability to adapt. Actions that put the existence of an individual or a species in danger are not the goal of adaptation and not supported by the Red Queen Effect.

—Sidebar: Vestigial Structures

Vestigial Structures

Natural selection happens in imperceptible increments over vast periods of time. That means that sometimes we can see traces of its path.

It's a misconception that organisms are perfectly formed and adapted to their environments. We can see the traces of natural selection, a slow and imperfect process, in vestigial structures. These are traits that are present in a species or some members of a species, but no longer have any function or value. Vestigial structures may only be present during the embryonic stage or they may be a permanent feature. In the past, they served an important purpose that helped a species survive.

For example, flightless birds like ostriches usually have small, useless wings that are the leftovers from the ones that once gave them flight. The human goosebump reaction to stress or fear is a vestigial response, based on how our ancestors would have fluffed up their fur to look bigger when confronted with a predator. Some snakes have the remnants of a pelvis from the time when they had legs, as do whales.[1] The presence or absence of pelvic remains is one way we classify snake species. Pigs have useless toes raised off the ground. The parasite responsible for malaria contains the vestiges of a chloroplast in its single cell. Moles have skin-covered, de-evolved eyes hidden beneath their fur, despite being blind.[2]

So why don't vestigial structures just go away? It all comes down to natural selection. An organism's traits are only selected for or against by natural selection if they have any impact on its chances of survival. If a vestigial structure confers no benefit but causes no harm, there is no reason for it to disappear. Getting goosebumps during a horror movie isn't likely to reduce an individual's chances of reproducing, nor does it require enough energy to be a meaningful hindrance. So goosebumps will probably stick around for a good while longer unless random mutations eliminate the response or it becomes detrimental.

Even when vestigial structures do go away, it happens gradually over many generations. At a certain point, they cease to be relevant to the process of natural selection. There are even instances when further shrinking or eliminating a vestigial structure would be more detrimental than leaving it in a diminished form, so it remains. For them to disappear completely may require overall structural changes in an organism which are not feasible, or not important enough to exert selective pressure. Scientists are always learning more and sometimes a feature that seems to serve no purpose has one we haven't discovered yet. Vestigial structures can be helpful for learning about evolution and determining if species have a common ancestor.

Success is measured by persistence.

— Geerat Vermeij [3]

One of the interesting problems for humans is that the pressures we face from each other are not isolated and often require a complex response. We are not just trying to run faster than an antelope. We are trying to be better in so many ways that we often feel like we are failing at everything. So we burnout or we give up.

However, similar to velocity, the "speed of adaptation is not the same thing as effective adaptation....The point is that what matters is not the speed of adaptation, but what problems it helps you solve and what problems arise as a result of an enemy's adaptations." [18]

First of all, the principle of adaptation is that it is useful. Useful adaptations are well suited to life, and they increase your ability to be successful in that life. They have to improve your functioning. Also, adaptations come with tradeoffs. Increasing your fitness in one way will mean a decrease in fitness in other areas. Humans have big brains. A benefit is unmatched problem-solving ability. We can survive in a wide variety of situations for which we have no direct experience. The tradeoff? The bodies that house these big brains can't be fully grown inside the womb. So, we are vulnerable for many years after birth.

Adaptations are further constrained by the fact that an organism must be viable at all stages of the adaptation process. What this means on the human life timescale is that if you are compromising your physical health or your sanity, you are not adapting. You are instead weakening your ability to successfully respond to changes in your environment.

Adaptations are about being successful in your environment, so it becomes critical to define success. For animals it means living

long enough to pass on your genetics and, depending on your species, getting your young through the early vulnerable stages. Mammals, in particular, don't just need to have offspring, but need to teach them how to successfully navigate their environment.

But beyond our biology, there is no universal definition of success that all humans would agree to. For some it's about power and recognition, for others it's about the freedom of choice, and others still would emphasize spiritual enlightenment and peace. However, a fundamental component of success must be that it involves benefit. You gain when you succeed. Anything that compromises your ability to succeed is not justified by this model. Running as fast as you can to stay in place is not a euphemism for 16-hour workdays. It should not be the reason you don't see your children or used to justify ignoring the needs of your body or soul.

« No innovation comes into existence perfectly hewn. Error is thus necessary for the generation of variation. »

Geerat Vermeij [19]

Don't reinvent the wheel, repurpose it

There is a lot of opportunity that already exists in your world. You don't have to start from scratch with adaptation. In evolutionary biology, making use of things you already have is sometimes referred to as an exaptation.

The term "exaptation" was first proposed by Stephen Jay Gould and Elisabeth Vrba in 1982 [20] to make the point that a trait's current use does not necessarily explain its historical origin. In other words, just because A is used for B by species C does not necessarily mean that species C evolved A for the purpose of doing B. It may very well be the case that B is something that this species learned to do after the adaptation of A.

For example, although today most birds use their feathers to fly, it would be incorrect to say that this means that feathers emerged in these birds specifically for flight. In fact, feathers first emerged in dinosaurs for the purposes of insulation or attracting mates, not flight. Natural selection selected for dinosaurs that had feathers because they better allowed them to survive and reproduce. This is the adaptation: feathers first provided heat and attractiveness. Later on, however, feathers also became useful for flight as observed in the modern bird. Once the structure was present, the function of flying became possible. The structure did not emerge for the purposes of flying, but it was repurposed to support this new use. It was an exaptation.

There are many other examples of exaptation in the animal world. All of them demonstrate that exaptations are useful to survival because they expand our options in responding to changing

environmental conditions. Pandas have a wrist bone, the radial sesamoid, that allows them to easily manipulate bamboo stems, their primary source of food. Most mammals and reptiles have this same bone, yet none eat bamboo or otherwise use the bone to assist in feeding. The bone is available to all of them, but only the panda needs it. Should the environment put certain kinds of pressure on the other species requiring them to adapt their feeding habits, this bone is available as an exaptation that would aid in survival.

« Increased autonomy allows parts to take on new, often specialized functions. »

Geerat Vermeij [21]

In other words, structures that arise for the purposes of fulfilling an associated function, like echolocation in bats, are adaptations, while structures that arise that are then used for a function other than the one they originally performed, like feathers in birds, are exaptations. The distinction between adaptation and exaptation is not always a clear one, which is why we put them together as a model. What we can get out of this overlap is insight into repurposing already acquired skills and knowledge.

The surprising evolution of the self-playing piano

About 1200 years ago in Baghdad there lived three brothers: Muhammad, Ahmad, and al-Hasan, collectively known as the Banu Musa. They were scholars who wrote many books on topics such as mathematics and astronomy. One of their most fascinating works was *The Book of Ingenious Devices*. This book was a catalogue of machines, including a self-trimming lamp, an automatic flute player, and a programmable machine.[22] This last was "the Instrument Which Plays by Itself," a detailed design for a hydraulic organ which played music notes triggered by small divots in a pinned cylinder. Thus, a human did not interact with the machine directly; instead they "programmed" the machine via the instructions on the cylinder.

In *Wonderland: How Play Made the Modern World*, Steven Johnson traces the technology of the musical machine devised by the Banu Musa through music boxes and mechanical toys and player pianos, and shows how the innovations generated in the pursuit of this entertainment were the foundation of the frequency-hopping technology so essential to our wireless age in the form of cellular phones, Bluetooth, and Wi-Fi.[23]

How did the technology make this leap?

In 1940, near the beginning of World War II, the Battle of the North Atlantic was raging. German submarines were sinking boats with regularity, resulting in a devastating loss of both military and civilian life. Hedy Lamarr,* Hollywood actress, and George Antheil,* composer, teamed up to try to do something about it. Their goal was to invent a remote-controlled torpedo to attack German

submarines.[24] One of the main challenges was the vulnerability of the frequency used to control the torpedo. Using one frequency meant that it could be easily discovered and jammed. They needed to find a way for the remote controller and the torpedo to "frequency hop" in synchrony. This way it would be near impossible to find, and the Allies could direct their torpedo without interference.

When faced with a challenge, where does one look for inspiration? Usually you start with concepts you already understand, and materials you already have. This is the essence of exaptation.

Lamarr and Antheil were faced with the challenge of synchronizing the movement of frequencies. Antheil looked into his current store of knowledge and realized he'd faced a similar challenge before—trying to synchronize the musical notes of multiple player pianos in a composition of his called the *Ballet Mécanique*. "This is where Antheil's experience...supplied the missing element that completed Lamarr's invention...He proposed a control system whereby the instruction for frequencies were encoded in two perforated ribbons. Where the holes in the piano roll signaled a musical note, the holes in the ribbons signaled a frequency change."[25]

What was invented or learned for one purpose stays available to be used for entirely different functions. "For almost a thousand years we had that meta-tool [programmability] in our collective toolbox and we did nothing with it other than play music."[26] And then we branched out with this tool. We started programming textile looms, torpedoes and computers. Programmability in all the

functions in which we use it today has become indispensable, and we can pretty much guarantee this wasn't what the Banu Musa had in mind when they came up with that original ingenious device.

« Inventions are almost never solitary, isolated creatures; they depend on other inventions that complete them or endow them with new applications that their original inventors never considered. »

Steven Johnson [27]

扩展适应 [编辑]

维基百科，自由的百科全书

扩展适应（英語：exaptation）是指在演化过程中一种特征的功能发生了变化。例如，如果一个特征最初演化出来是为了实现某种特定的功能，但后来它又有了另一种其他用途，就可称之为"扩展适应"。鸟类羽毛的演化便是一个经典的例子：羽毛最初是为了保温而演化出来的，但在后来羽毛变得开始适应于飞翔。对扩展适应的兴趣与进化的过程和产物都息息相关：创造复杂特征的过程和可能不完善的产物（功能，解剖结构，生化试剂等等）[1][2]。扩展适应是由美国古生物学家斯蒂芬·古尔德（Stephen Jay Gould）和伊丽莎白·弗巴（Elisabeth Vrba）提出的，以取代他们认为是目的论的术语"预适应"（英語：pre-adaptation）[3]。

目录 [隐藏]

1 历史和定义
2 实例
3 注释
4 参考文献
5 资料来源
6 参阅

各种颜色的鸟羽毛。

exaptation 对我的启发是：前人已经有了无数尝试，我们任何一个问题和苦恼都可以在前任的经验里找到启发。我们拥有的解决方案其实有很多，只是我们容易陷入 functional fixedness，总是以 reinvent the wheel 的方式解决问题，最后费力又不讨好。

生活和学习中多一些「顺便」之事。顺便学点英语、顺便多做一步、顺便做个头脑实验、学都学了顺便多读多写一点……这些顺便之事会激发更多的跨界思考和 repurposing。「天生我材必有用」，你的才华在哪里有用呢？专业技能和环境很重要，更重要的是 design 技能的用途和 adapt 环境变化，向每个人学习，也跳出盒子思考做微创新，找到一条自己的路。

Innovation without a plan

Exaptations in evolution do not necessarily have to be new uses from current adaptations—traits that already have a purpose. They can develop from bits lying around that were started for no particular use at all, which has a parallel in technology. Sometimes people invent things solely for the sake of the invention. They don't have a fundamental social use or business model in mind. There are far more patents than things we use on a regular basis. Sometimes, those isolated inventions provide a foundation for innovations that were not at all anticipated.

What we learn from exaptation is that we don't always know the value of something at the outset, and there doesn't always have to be a justification for doing everything.

« We must not forget that when radium was discovered no one knew that it would prove useful in hospitals. The work was one of pure science. And this is a proof that scientific work must not be considered from the point of view of the direct usefulness of it. It must be done for itself, for the beauty of science, and then there is always the chance that a scientific

No.1 科学新知图书一周热门榜

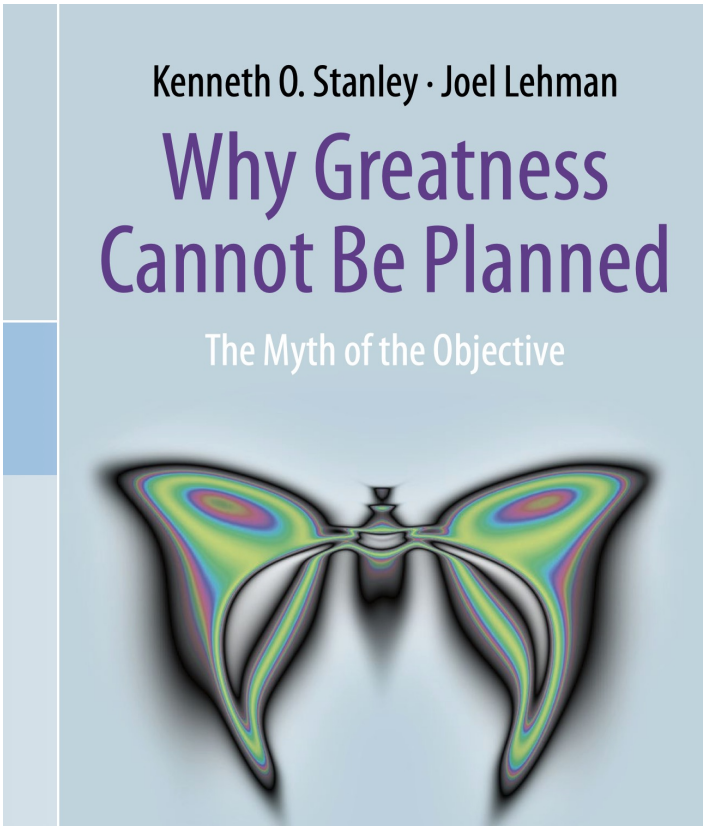
为什么伟大不能被计划

作者: [美] 肯尼斯·斯坦利 / [美] 乔尔·雷曼
出版社: 中译出版社
副标题: 对创意、创新和创造的自由探索
原作名: Why Greatness Cannot Be Planned: The Myth of the Objective
译者: 彭相珍
出版年: 2023-4
页数: 320
定价: 79.00元
装帧: 精装
ISBN: 9787500173625

豆瓣评分

8.5 278人评价

5星 42.8%
4星 32.4%
3星 17.6%
2星 4.3%
1星 2.9%



2 Victory for the Aimless 19

Whether you're looking for a career, for love, or trying to start companies, there is ample evidence that sticking to objectives just isn't part of the story in many of the biggest successes. Instead, in those successes there is a willingness to serve serendipity and to follow passions or whims to their logical conclusions. But is there any proof beyond just a set of inspiring anecdotes? In fact, it turns out that we stumbled upon this principle originally through a scientific experiment, as the next chapter reveals, involving hundreds of users on the internet breeding pictures.

discovery may become like the radium a benefit for humanity. »

Marie Curie [28]

Sometimes things that have no apparent purpose at the outset can later be co-opted into use. Having to know the benefit of everything before you begin leads to missed opportunities. No one has a crystal ball—you can't anticipate all that will be required or have use as our global environment changes.

The history of commercial products is littered with exaptations. Bubble wrap was invented in 1957 by Alfred W. Fielding and Marc Chavannes by sealing two shower curtains together and capturing bubbles of air on the inside. Obvious use? No. They first tried to sell it as wallpaper, but there were no takers. Then they tried marketing it as greenhouse insulation, but this failed. Then the company took it to IBM as a way to protect all their new business computers while in transit. The usage took off and the product developed into the bubble wrap we have today. [29]

Time and place also matter for exaptation. A use that might be perfect in one country might seem irrelevant in another. Or a product marketed at one point in history may fall flat but succeed at another time. If they'd tried marketing bubble wrap as wallpaper in the 1970s when wacky wallpaper and plastic clothing were a trend, it might have taken off. Exaptation is all about context. If birds hadn't faced environmental pressures to fly, feathers may have remained as a form of insulation or evolved to serve a different function.

There's also Play-Doh. It had a 20-year career as wallpaper cleaner, in the days when coal was the primary home fuel. Using coal turned the walls sooty, and the substance that became Play-Doh was used to remove that soot. But then coal began to be replaced by heating systems based on electricity or natural gas, and Play-Doh wasn't needed anymore to clean walls. Developed by Cleo McVicker and his brother Noah, Play-Doh was a product without a future. But McVicker's sister-in-law, a teacher, had been using Play-Doh as a craft medium in her primary classes. She convinced him to investigate marketing it as a child's toy. It was fun, nontoxic, and lasted a while if sealed properly in between uses. McVicker got prime product placement with children's show star Captain Kangaroo, and sales exploded, making it one of the most popular children's products of all time.[30]

Or there is the story of Botox. It's a toxin and "is a naturally occurring by-product of the microorganism that causes botulism, a potentially lethal paralytic disease caused by eating contaminated preserved food."[31] The bacteria have likely been around a long time and have killed a lot of people. It wasn't until the 19th century that the anaerobic bacteria that cause botulism were isolated and identified.

In the 1970s, a form of the toxin was used to treat eye disorders, including uncontrollable blinking and crossed eyes. By the 1980s "the toxin was widely applied by both ophthalmologists and neurologists as a remedy for...facial, eyelid, and limb spasms."[32] In 1987, Jean Carruthers, an ophthalmologist, inadvertently discovered cosmetic uses for Botox when a patient mentioned how her eye treatments were relaxing her face. It took a

few more years for Botox to hit the mainstream, but it eventually achieved widespread cosmetic application.

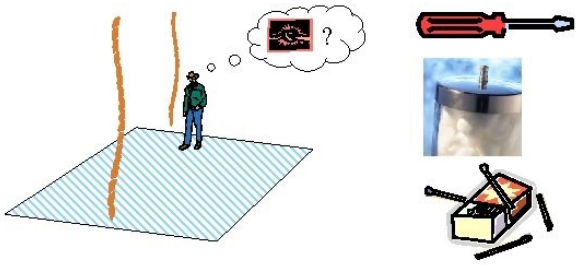
Thus, what exaptation is fundamentally about is flexibility. We cannot know the exact pressures we will face in the future. So what we need is a box of diverse tools that can be used and combined in almost a limitless number of ways to meet the challenges we face. Some of these pieces will never have any use, and some will be complete game changers. But no one can divine this ahead of time. Survival of a business often depends on being able to change quickly. You can't do that if you have to start from a blank slate every time environmental pressures push you to develop and innovate.

It also teaches us that as individuals we must not underestimate the options we have at our disposal. Too often we get stuck in "functional fixedness," a mindset where we see in things only their intended use, rather than their potential use. A fork doesn't have to be just a tool to put food in your mouth. It could also be a hook, tack, or hair detangler. It may be combined with other household objects to fulfill even more purposes. As the saying goes: do what you can, with what you've got, where you are. In fact, one of the tests used to measure creativity by psychologists is to ask people to come up with as many uses as possible for an everyday object like a brick. The more exaptations someone can envision, the more creative they're considered.

The knowledge we've accrued, the lessons we've learned, are all available to us at any given moment to forge new paths in the environments we are in. The most amazing part of this concept is that it happens on two levels. There is the conscious one, where you

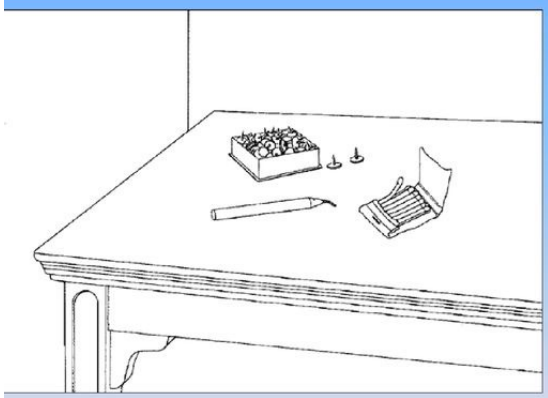
Functional Fixedness

A tendency to think only of the familiar functions of an object.

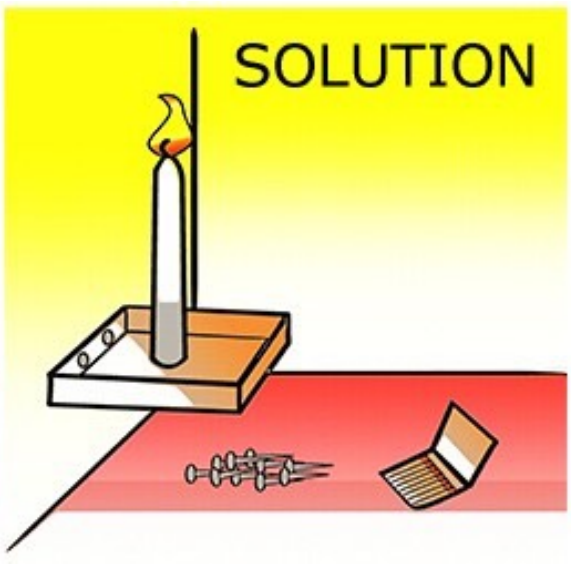


Problem: Tie the two ropes together.
Use a screw driver, cotton balls and a matchbox.

The Candle Problem



The Candle Problem is a classic test of creative problem solving developed by psychologist Karl Duncker in 1945. Subjects are given a candle, a box of thumbtacks, and a book of matches, and asked to affix the lit candle to the wall so that it will not drip wax onto the table below. The test challenges functional fixedness, a cognitive bias that makes it difficult to use familiar objects in abnormal ways.



worst都能打错，就你还教英语呢😉

哎妈呀

我赶紧喊人家帮我改一下

其实也不用改

😆自由之路上永远都可能有更坏的情况发生

你就说：这就是我的worst-case senario，一个教英语的英语都拼错了

学会了！就这么搞

张海露 Eric: 你就说：这就是我的worst-case senario，一个教英语的... >

然后说这也很正常，自己也会有这种shame，但写错了又能代表什么呢？

能代表我不认真，我态度有问题吗？它只是拼错了，我没注意到，即使再仔细也会有这样的小错误，我们改过来就好了，甚至可以利用它，希望大家通过这个例子记住了一个常见的英文说法hh

how's yori debut coming along?

Saturday 17:15

我觉得挺好！

尤其那个 worse-scenario 是高光时刻

look around at what you have and actively search out what you can repurpose. But these abilities also manifest on an unconscious level. Like the bird, who did not say, “Hey, maybe I can use these feathers to fly,” but instead had feathers that influenced its behavior in situations they were not originally selected for, we too navigate our world differently the more knowledge and skills we can draw on in any given situation.

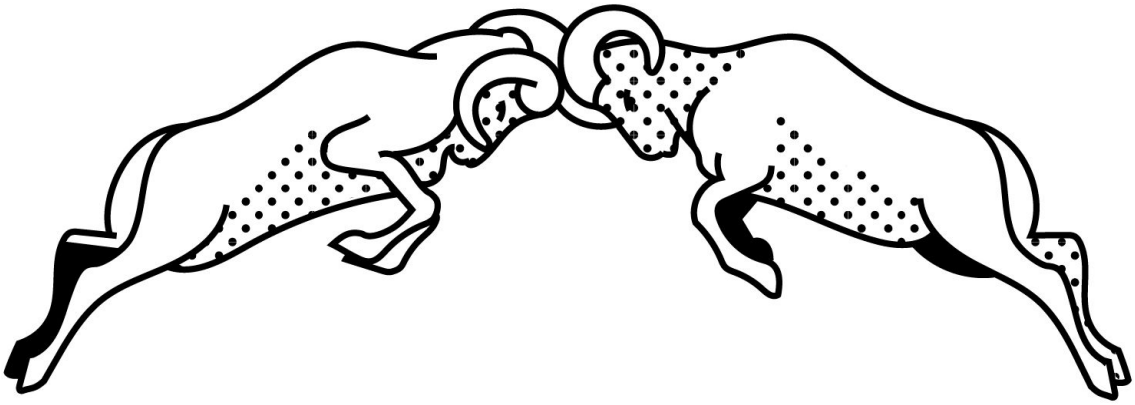
Conclusion

Adaptations, and their counterpart exaptations, are part of a continuous process. Adaptations for one function can be used for another, and exaptations further refined through an adaptive process. When you look for ways to apply what you already know in new contexts, understand that the knowledge can and will still develop for the situation you are in.

Complacency will kill you. The stronger we are relative to others, the less willing we generally are to change. We see strength as an immediate advantage that we don't want to compromise. However, it's not strength that survives, but adaptability. Strength becomes rigidity. Eventually your competitors will match your strength or find innovative ways to neutralize it. Real success comes from being flexible enough to change, to let go of what worked in the past, and to focus on what you need to thrive in the future.

Supporting Idea:

Competition



Competition is a driving force of the biological world. All living things are out to survive and breed as much as possible. This puts them in competition for finite resources like food, status, territory, and mates. This may be between whole species or individuals. The fight for resources is a zero-sum game.[1] The more one individual receives, the less there is for others. So competition is inherently harmful to the losers. If a species cannot attain the resources it needs, it will go extinct. The availability of resources dictates the type and intensity of competition. The scarcer the resource, the more aggressive the competition.

Intraspecific competition occurs within species when members fight for the same resource. For example, male zebras engage in vicious fights over females. The urge to spread their genes is so strong that losers may die in the process. Male zebras will also kill the offspring of rivals. Interspecific competition occurs between species. If they live in the same area and need the same resources, they're forced to compete. Trees in a forest compete to grow the tallest and get the most sunlight. All species are constantly engaged in both types of competition.

The distinction is not as clear-cut as it might seem. Everything a species does impacts others within the same ecosystem. Competition can be direct or indirect. If living things must actively fight each other for a resource, it's direct. If there is no confrontation, it's indirect.

We cannot understand any of the biological mental models without also considering competition. It's the reason the natural world is so diverse. As Darwin recognized, all life is a struggle for survival. Species that are able to fight for the resources they need to survive and reproduce are the successful ones. The type and intensity of competition is dictated by the availability of resources. The scarcer a resource is within a region, the more aggressively organisms must compete for it. When resources are more abundant, competition may be less intense. This, however, typically allows a species to breed until its numbers reach a level where individuals are forced to compete. [2]

Competition doesn't just occur in biology. It's also the driving force behind many human systems. The upside of competition is that it forces improvements. Competition is an important concept in business. Companies are constantly fighting for market share. This process is beneficial for consumers, because it forces companies to keep prices low and quality high whenever possible. Monopolies—when one company dominates an entire market and customers have no other option—are discouraged because they allow for abuse and create stagnation.