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The Winter 2018-2019 Harvest

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THE WINTER 2018-2019 HARVEST



The end of the Year in Northern California is usually cool and wet; we badly need the rain. But this meteorological switch commands changes in daily life: I must spend much more time indoors –meaning reading, selecting, editing, writing. This winter has brought a flurry of exciting publications (mostly Essays) via a multitude of sources.

My selection is –as expected- arbitrary and quite limited and focused.

Economists are certainly NOT moral. They crunch numbers –hence real people(s), to make their manufactured theories gullible, then implemented. There are attempts for change (in goals, direction and methodology) but the results seem to always favor the ‘*haves,*’ and never the ‘*have nots.*’ I hope to be proven wrong –one day.

Income inequality –worst in Hong Kong and the US- affects development and health, and stunts the poor in all aspects of their lives –as well as their brain functions. Ricard M Sapolsky, in *Scientific American*, projects a flood light onto all –recently demonstrated- aspects, including the human, social and economic costs.

Some light is then being projected on the (multiple) founders of *Quantum Biology*. And there is news related to our emotional development: for better or (often) worse, *breast milk* might be the messenger that successfully plants the emotions that will rule our lives.

Leo Tolstoy was an adept of “*natural ways*” –starting in the womb, with safe pregnancy, and including nursing from the mother’s breast. *Breast milk* is the **only** food a newborn (and infant) should feed upon. But this natural miracle is much more complex than we thought; the work of Bruce German and Carlito Lebrilla, of UC Davis, has demonstrated the critical role of Human Milk Oligosaccharides –and, better, of the matching mother/infant- in immediate and life-lasting health. The short essay by Jena Pincott shows, with persuasion and humor, that our urbanized modern societies –where very late pregnancies are the rule- have veered away from the natural (primate) habit, where infants live virtually glued to the chest of their mother. Now, breast milk mirrors and reverberate the various stress of daily life.

Social, moral, intellectual, philosophical pieces, from *Love* and *Destiny* less-known volumes by Leo Tolstoy; our growing inequality when facing *Death*; opposing modern, prevailing, standard *Sainthood* compose that section, all compiled initially by Maria Popova.

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And Maria Popova (*again!*) is revisiting Hermann Hesse and his concept of *Solitude*: fascinating, and in his own words!

There are echoes of Tolstoy in *Henry-David Thoreau's* book *A Week on the Concord and Merrimack Rivers* as commented by Anna Popova (*YES!*) in a recent issue of *BrainPickings*.

Then there is the (endless) debate about *Creativity*; Sean D. Kelly, of Harvard throws himself into the fight –for humans!

Albert Einstein's historical papers of the *Miracle Year* demonstrate that there are **many** (neglected or ignored) ways to boost personal productivity; the one recommended is amiable.

A fish, the stickleback, is demonstrating an uncanny ability to adapt quickly, and this opens new horizons in adaptation: we could *arrive* as the fittest!

Finally, since the current, growing, amplified buzz is on Quantum Physics, *Quanta* details the new paradoxes, resulting from experiments conducted mostly in Zürich, that generate more questions –again; but some good news: we have a brand new Kingdom in our Tree of Life to explore!

Enjoy and expect the days to grow longer, the sun to shine more often and Spring to warm the planet (and you!) soon.



Economics as a Moral Tale



US President Bill Clinton standing in Red Square during a Moscow summit in January 1994.

Photo by Diana Walker/Time Life Pictures/Getty

Think of human development as a long journey. At the beginning, we live at the mercy of nature. Dependent on its bounty, we pray for rains and freedom from natural disasters and plagues. At the end of the journey, nature lives at our mercy. We use science and technology to release new wealth and remake the planet. Today, as humans implant themselves with microchips, install artificial organs and plan Mars colonies, we even aim for a *'singularity'* that will lift us out of nature once and for all. Economists began to compose the narrative of this odyssey, from subjection to dominion, in the 1700s. Once it became apparent that Europe had broken with millennia of stasis to begin a long period of rising growth – the same through which we are still living – political economists abandoned philosophical reflection to draft roadmaps to development.

Two broad types emerged. One approach described the walk, the other the walker. The first presumed that the context in which we made the journey – the natural environment, the institutions, the culture, the legal and political systems –



determined the direction of the path. In this model, the government bore responsibility to build the path so that it could accommodate as many people as possible. Progressive taxation was simply an investment in social prosperity, key to maintaining an ascendant society and a reasonable return payment from those who had most benefitted. The second approach took a more individualist perspective. It presumed that the walker determined his or her own success in the journey. It concentrated on the moral, intellectual and physical attributes it believed an individual needed to advance. In this model, the task of the government was to sweep aside obstacles impeding the gifted few from embarking on their personal journeys – restraints that ranged from restrictions on labour mobility to usury laws. Thus, liberated, gifted individuals would beat the path to prosperity. Progressive taxation on those who had completed the journey would only reduce incentives to make it, ultimately hampering the economic growth of society. The secret to success lay in a minimalist state. Presuming that nature selected some to lead and others to follow, this roadmap was essentially aristocratic – although, given aristocracy's association with feudalism, sociologists later coined the term 'meritocracy' to describe this principle of radical individualism.

Meritocracy loomed large over Victorian capitalism. However, during the 19th century, the free market largely failed to deliver the developmental goods, proving itself to be more adept at generating than distributing wealth. And so, in the early decades of the 20th century, stirred by both political and intellectual developments – the growing appeal of communism to a working class that had tasted comparatively few of the market's fruits, and the consequent rise of economic schools that aimed to renew capitalism, such as Keynesianism and the German social-market – the state gradually took on a much more active role in both society and the economy. Immediately after the Second World War, with Europe in ruins, the communist threat seemed to reach its peak. To spearhead reconstruction, Western states created institutions such as the World Bank to assist governments in their work, and private charities arose to join this crusade. Oxfam (1942), CARE International (1945) and UNICEF (a joint private-United Nations charity created in 1946) all came into being to provide famine relief to war-torn Europe.

Thus, a tremendously successful initiative that would come to be known as the development industry was born. By 1948, Western economies had emerged from



crisis, beginning a decades-long period of rising growth and prosperity. Rather than pack up and go home, the development industry now turned its attention to a new frontier. With Europe's overseas empires breaking up, dozens of new nation-states were coming into being, each of them eager to 'catch up' with its erstwhile colonial master. Amid this exciting atmosphere, the development industry could use its expertise to play a clear and prominent role, one captured in the subtitle to the then-Bible of development, Walt Rostow's *Stages of Economic Growth* (1960) – '*a non-communist manifesto*'. By now, statist economics was enshrined in theory and sanctified by practice. Turkey had successfully pioneered a mixed economy in the 1920s, and Latin American governments had used protectionist policies to build their industrial sectors to substitute for the loss of imports during the Great Depression. Thus, the conventional model for rapidly moving countries through the stages of which Rostow spoke was for the state to marshal resources and then spur private activity, with the development industry playing a supportive role in this essentially liberal, optimistic crusade.

But when growth slowed in the 1970s, governments began to turn away from state-led approaches and to free up the market. Leaders such as Ronald Reagan in the US and Margaret Thatcher in the UK, early proponents of this new libertarian approach, harkened back to the unbridled individualism of the Victorian age. Reagan told a 1981 development summit in Cancun that Third World countries ought to follow the model set by the US, whose economy, in this telling, had been built by self-sufficient, independent farmers. Reagan elided the roles of slavery and industrialization behind post-Civil War tariff-walls, major chapters in US history impossible to square with the libertarian ideal. But with a bit of editing of the historical record, the 'neoliberals' took a decidedly dim view of the government. They tended to think that those who can, do, while those who can't, administer, looking for ways to frustrate society's makers.

The '*less government, more growth*' approach became orthodoxy, but it brought back – with a vengeance – the challenges of distribution. By the end of the 20th century, social indicators in developing countries were going backwards, just as the tide was turning against conservative politics in the West. Unlike what happened after the Second World War, though, the pendulum this time did not swing back toward the more social roadmap to development. Instead, the development industry asserted its



autonomy from government, and assumed a new role. Rather than have the state build the bridge between accumulation and distribution, we now learned that philanthrocapitalism, a radically new approach to development, would offer a whole new way of doing things. Reagan and Thatcher and other exponents of free-market economics had been social conservatives. By the 1990s, a new generation had come along, represented by leaders such as Bill Clinton in the US and Tony Blair in the UK, who mixed conservative economics with social liberalism. As much as possible, they preferred a progressive politics that channeled private initiative, and the logic of philanthrocapitalism was pleasingly straightforward. Since the rich were getting richer, they had more money to throw around. The lure of yet more lucre could now be used to steer them into sinking some of this new wealth into the poorest communities, something touted by Clinton late in his presidency when he went on a four-day 'new markets' tour of deprived American neighborhoods. Urging the super-rich to do some good with a portion of their rapidly growing prosperity, Clinton told them that a better world would make them richer yet. *'Every time we hire a young person off the street in Watts and give him or her a better future,'* he said, *'we are helping people who live in the ritziest suburb in America to continue to enjoy a rising stock market.'*

In fact, in the two decades after Clinton took office, the number of charitable foundations doubled. A new problem arose, though. Due to the worsening inequality produced by free-market policies, this growing number of foundations and NGOs found themselves relying on a diminishing pool of wealthy donors. Inevitably, that forced them to cultivate the plutocrats, and reflect their views. However, even this supposed vice could be turned into a virtue. If the free market had in fact sorted the best from the rest and enabled them to use their ingenuity to enrich themselves, it followed that this same ingenuity could subsequently be applied to the solution of social problems. As the state withdrew behind the curtains, the development industry thus moved beyond its traditional supporting role in tackling social problems to take centre stage. If Rostow's *Stages of Economic Growth* had articulated the ideals of a liberal age, Matthew Bishop and Michael Green's *Philanthrocapitalism* (2008) did it for a neoliberal one. As Rostow's subtitle had done, theirs offered a pithy summation of the doctrine: *'How the Rich Can Save the World'*.

Meanwhile, the 1990s offered no shortage of laboratories in which to test this new



doctrine of development. The biggest prize of all was Russia, the country that had just chucked the most extensive state ever to build a market economy. After Mikhail Gorbachev's attempt to reform the communist state and economy finished with the Soviet Union's collapse, Boris Yeltsin took the reins of the newly independent Russia. Deciding that the only way to revive the economy was to start from scratch, Yeltsin oversaw a program of '*shock therapy*'. It aimed to release the phoenix of capitalism from the ashes of state communism. Western advisors flooded into Moscow, with the '*Harvard Boys*', led by the *wunderkind* economist Jeffrey Sachs, playing a central role. Coupled to crash-privatization was to be an efflorescence of civil society. Non-state actors would now assume the functions previously performed by a totalitarian state. Private foundations, such as Ford, MacArthur and Soros, pumped tens of millions of dollars into civil-society construction, helping to build political parties, independent media and NGOs. State actors, including the US government, supplemented the efforts.

Russia was merely the most ambitious instance of a trend then spreading globally. In one country after another, governments were withdrawing from the economy and liberalizing the environment in which NGOs and private charities worked. Western governments helped to fund the activism. At about the same time that Yeltsin was opting for shock therapy, the Indian finance minister was preparing to dismantle much of Indian *dirigisme*, abandoning the mixed model that had defined the Indian state since its independence in 1947. India's civil society, however, was far more vibrant and autonomous than Russia's had ever been. It proved able to step some way into filling the new gap in social welfare. The Indian government had never before encouraged NGOs, having previously seen them as something of a threat to its authority. But it too adapted and opted to give them more freedom to maneuver and operate.

In Beijing, the Communist leadership watched what was going on in Russia and India with real interest. Like the Russians, the Chinese took the advice of US-based economists, some of them Chinese. But they also looked elsewhere. A broad debate about China's future direction took place within the leadership. Some called for China to do like Russia and plunge into a more Westernized future. Others insisted that the state needed to tighten its political control to provide the stability necessary to absorb the profound economic changes about to occur. The statisticians looked for insight



less to the West than to China's own neighborhood – to South Korea, Taiwan and Singapore. In these East Asian '*tigers*', the market economy was developing under strong state guidance. In the end, the Chinese leadership opted to go with a hybrid: more political control and less democracy than in the tigers, but much less state than with either Maoism or Soviet central planning. At the time, many assumed that the Chinese '*developmental state*' approach was doomed to failure. Political science then took as axiomatic that an expanding class of independent businesspeople would demand the same liberties in the political sphere that they enjoyed in the market. It's true that there was a debate about which came first, democracy or development. But it was in a sense a chicken-and-egg debate, for few scholars saw economic development and political democracy as separable in the long run. The echoes of the Tiananmen Square massacre of 1989 were still sounding. Most analysts had seen Tiananmen as China's instalment in the 1989 democracy movement. They were confident that, in one form or another, such protests would recur, and recur, and China would eventually democratize.

The story that philanthrocapitalists told was a great one: history marching forward, heroes and villains, and a Hollywood ending. History has a way of surprising us, however, and most of the script ended up on the cutting-room floor, the actors left to ad-lib parts they weren't expecting to play. Russia's shock therapy didn't beget a flourishing capitalist democracy. Chinese autocracy didn't collapse under the weight of its contradictions – in fact, scholars today wonder if China gives the lie to the long-cherished rule that economic dynamism demands a lean state. As for the rich people who were meant to save the world, almost to a man, they chucked the script in the bin: for every billionaire funding a progressive cause, there would be dozens who used their wealth to support conservative campaigns to further roll back the state's social provisions.

Most importantly, the newly liberated development industry failed to resolve the tension at the heart of free markets. In short, they produced growth more effectively than development. While the ascent of the developing world has reduced global inequality over the past quarter-century, within countries, it has generally worsened, as a global plutocracy emerges to dominate the world's economy and politics. A wave of popular anger against disconnected '*elites*' has resulted, which authoritarian populists have skillfully exploited to launch crackdowns on the development



industry. Whether it be the Orthodox chauvinism of Russia's Vladimir Putin, the Hindu nationalism of India's Narendra Modi, or the Muslim fundamentalism of Turkey's Recep Tayyip Erdoğan, they are tapping into disillusionment with the old model to repress '*globalist elites*'. As they decry NGOs for their lack of patriotism, these governments are pushing them to fall into line behind government, or to leave the field altogether (as Hungary, for instance, has done with its notorious '*Stop Soros*' law).

Although the liberal reflex has been to defend civil society, the populists are addressing a real discontent. Take, for example, Russia, the one-time poster-child for philanthrocapitalism. Putin's repression of activists, journalists, NGOs and all critics apparently enjoys substantial support, in part because the NGOs of the 1990s had often been considered elitist. Many Russians saw them as closer to global civil society than to ordinary Russians, more loyal to their donors than to their supposed constituents, and too little preoccupied with the day-to-day struggle that was the lot of most Russians in that lost decade. In fact, the model of civil society emerging in today's Russia has converged somewhat with India's changing approach. There, the hiatus in the uneasy relationship between the government and civil society proved short-lived. Modi's government has turned to tightly regulating NGOs, regarding them as political opponents, and subjecting organizations that dissent too loudly to harassment and repression. And as disturbing as their conspiracy-theories of '*globalist*' or '*metropolitan*' elites can sound, the populists might be on to something. In 2011, the Swiss Federal Institute of Technology conducted a network analysis of the global corporate elite. What they found was a small web, made up of a few hundred tightly networked and extraordinarily wealthy individuals, dominated by bankers, and commanding vast pools of capital. If this was Davos man, then meritocracy was arguably its governing ethos – its mission, to replace the narrow, limiting confines of the old nation-state. Through compulsion and cajoling, much of the development industry got drawn into an alliance with this new global elite.

It might be that the industry suffered more harm than good from this alliance. Human-rights NGOs, in particular, which won hard-fought gains advancing transnational laws and norms, are now being forced to defend the advances they made against the new authoritarians. But rather than just stick up unconditionally for the development industry, liberals could benefit from returning their focus, at



least in part, to the old model of NGOs aligning themselves more with national than global goals. Because while the development industry can point to considerable progress, it can't claim all that much of the credit. Over the past 30 years, poverty and hunger across the planet have fallen dramatically. Exponents of the free-market model like to remind us that this happens to be the era in which neoliberal governments dismantled much of the social state. But such a correlation holds up only at the most aggregate level. Once you look at what was happening on the ground, the picture turns around. China is thriving under an autocratic state. Russia floundered under a minimalist one in the 1990s. India is doing relatively well at market reform – while pressing civil society to line up behind national rather than transnational goals. All told, the supposedly deadweight state doesn't look so dispensable after all.

But then, we've known that for a long time. On the face of it, it seems puzzling that philanthrocapitalism ever got much of a hearing, because history had surely shown it would never work. If the rapid but unequal economic growth of the Victorian age failed to produce commensurate social development, what made anyone think that the rapid but unequal growth of the contemporary period would do any different? Moreover, the idea that the rich should be left to use their wealth to solve the world's problems because they have proved their merit in the market ignores the science behind success. Does anyone really believe that, if Steve Jobs had been born into a Bengali peasant family, he would have still created Apple? In fact, economists who've actually worked out scientifically what contribution our own initiative plays in our success have found it to occupy an infinitesimally small share: the vast majority of what makes us rich or not comes down to pure dumb luck, and in particular, being born in the right place and at the right time.

At heart, philanthrocapitalism offered not a new science of development, but an old-fashioned moral tale – one in which a hero, who would reveal himself by some magnificent achievement, would come along to save us from some peril. There is no shame in weaving moral tales. Economics has always given us moral narratives by which to live our lives – in fact, that's arguably its primary reason for being. But if it is to enter our canon, a story needs an audience that finds it rings sufficiently true to then retell it. Philanthrocapitalism failed that test. It will probably end up in history's remainder bin as a result, while storytellers devote themselves to crafting more compelling narratives.



How Economic Inequality Inflicts Real Biological Harm



The growing gulf between rich and poor inflicts biological damage on bodies and brains
Credit: **Andrea Ucini**

Western cultures have long cherished the notion that all people are created equal. But in the real world, our lives are not balanced with equal opportunities and resources. This distinction was noted mordantly in 1894 by author Anatole France, who wrote that “*the law, in its majestic equality, forbids the rich as well as the poor to sleep under bridges, to beg in the streets, and to steal bread.*” The rich, of course, need none of these things, whereas the poor often have little choice. And economic disparity has only gotten worse during the past several decades, particularly in the



U.S. In 1976 the richest 1 percent of U.S. citizens owned 9 percent of the country's wealth; today they own nearly 24 percent. This trend echoes around the globe. One of the consequences for the growing poor is worsening health, and the reasons are not as obvious as you might think. Yes, lower socioeconomic status (SES) means less access to health care and living in more disease-prone neighborhoods. And, yes, as the SES ladder's lower rungs have become more populated, the number of people with medical problems has climbed. This is not merely an issue of poor health for the poor and some version of better health for everyone else. Starting with Jeff Bezos at the top, every step down the ladder is associated with worse health.

But the link between socioeconomic inequality and poor health goes beyond simple access to care and living with more dangers. Less than half of the health changes along this SES/health ladder can be explained away by risks such as smoking, alcohol consumption and reliance on fast food or protective factors such as insurance and health club memberships. The large Whitehall Studies of risks in specific groups, led by epidemiologist Michael Marmot, demonstrated this clearly. Further, this ladder, or gradient, exists in countries with universal health care; if care availability was truly responsible, universal access should make the gradient vanish. Something else, something quite powerful, must be associated with inequities and be able to cause health problems. That factor seems to be the stressful psychosocial consequences of low SES. Psychologist Nancy Adler of the University of California, San Francisco, and her colleagues have demonstrated that how people rate how they are doing, relative to others, is at least as predictive of health or illness as are any objective measures such as actual income level. The research indicates that poor health is not so much about being poor as feeling poor. Epidemiologists Richard Wilkinson and Kate Pickett of the University of Nottingham and the University of York in England, respectively, have filled out this picture in detail, showing that while poverty is bad for your health, poverty amid plenty—inequality—can be worse by just about any measure: infant mortality, overall life expectancy, obesity, murder rates, and more. Health is particularly corroded by your nose constantly being rubbed in what you do not have.

Basically, more unequal societies have worse quality of life. Across countries and among U.S. states, more inequality, independent of absolute levels of income, predicts higher rates of crime, including homicide, and higher incarceration rates.



Add in higher rates of kids being bullied at schools, more teen pregnancies and lower literacy. There are more psychiatric problems, alcoholism and drug abuse, lower levels of happiness and less social mobility. And there is less social support—a steep hierarchy is the antithesis of the equality and symmetry that nourish friendship. This grim collective picture helps to explain the immensely important fact that when inequality increases, everyone's health suffers.

This is where the problem affects the rich, the haves as well as the have-nots. With increasing inequality, they typically expend more resources insulating themselves from the world underneath the bridges. Robert M. Sapolsky has heard economist Robert Evans of the University of British Columbia call this the “*secession of the wealthy*.” They spend more of their own resources on gated communities, private schools, bottled water and expensive organic food. And they give lots of money to politicians who help them maintain their status. It is stressful to construct thick walls to keep everything stressful out. Knowing that these psychological and social factors influence the biology of disease is one thing. Demonstrating just how these stressors do their dirty work inside the body is something else. How do SES and *inequality* “*get under the skin*”? It turns out that researchers have made significant strides toward an answer. We have learned a lot about how poverty affects biology, and the part of the growing inequality gap that worries people is the poverty end. Scientists have could trace physiological connections from external inequality to three key inner areas: chronic inflammation, chromosomal aging and brain function.

A Heavy Load

Thinking about the biology of disease was revolutionized in the 1990s, when Bruce McEwen of the Rockefeller University introduced the concept of allostatic load. Our bodies are constantly challenged by our environment, and we stay healthy when we meet those challenges and return to a baseline state, or homeostasis. Traditionally this view led scientists to focus on specific organs that solve specific challenges. Allostasis has a different perspective: physiological challenges provoke far-flung adaptations throughout the body. An infected toe, for instance, will produce not only inflammation at the tip of the foot but also wider changes in everything from energy taken from abdominal fat to the brain chemistry of sleepiness. As this biological grind



continues, it leads to an array of body parts functioning less than optimally, which can be as damaging to health as a single organ gone very wrong.

Teresa Seeman of the University of California, Los Angeles, took this idea and followed it through the body, measuring various biomarkers of wear and tear, including increases in blood pressure, cholesterol, blood lipids, body mass index, molecular indicators of chronic hyperglycemia, and levels of stress hormones. She showed that this group of disparate measures powerfully predicts physical health and mortality. Recent research by Seeman and others links low SES with heavy allostatic load because the body is in a constant and futile battle to return to a normal, nonstressed state. These findings highlight an important theme: whereas an adult's SES predicts allostatic wear and tear, childhood SES leaves a stronger lifelong mark. Low SES predisposes youngsters' bodies toward earlier "*aging*." The scientists also found protective factors. Although growing up in an impoverished neighborhood worsens the low SES/allostatic load link, lucking out with a mother who has the time and energy to be highly nurturing reduces the ill effects.

Stress in any form can produce these effects. It does not have to be related to money, but it is usually related to social situations. Sapolsky's own work with baboons living freely on the East African savanna has shown this effect. In baboon groups, an animal's place in the social hierarchy produces more or less stress. If you are a low-ranking baboon—a socially stressful situation—your body has unhealthy abnormalities in its secretion of glucocorticoids, which are stress hormones such as cortisol. The body also shows unhealthy changes in the gonadal, cardiovascular and immune systems.

In animal and human hierarchies, these stress-induced changes affect health through a key process: chronic inflammation. Few things are better examples of a double-edged biological sword than inflammation. After tissue injury, inflammation contains damage and initiates cell repair. Chronic widespread inflammation, however, causes molecular damage throughout the body, and studies have demonstrated that it contributes to diseases ranging from atherosclerosis to Alzheimer's. Recent work (including my own focusing on inflammation of the nervous system) indicates that chronic high stress levels can promote chronic inflammation. In people, childhood poverty upregulates the adult body's pro-inflammatory set point, with increased expression of inflammatory genes and increased levels of inflammatory markers



such as C-reactive protein, which is associated with a higher risk of heart attacks.

These are long-term effects: more financial losses in the Great Recession predict higher C-reactive protein levels six years later. Humans share such vulnerabilities with other primates that live in unequal circumstances. Work by Jenny Tung of Duke University shows more markers of chronic inflammation in low-ranking rhesus monkeys versus the socially dominant animals in a group. Studies such as this one highlights the directness of the link between social stress factors and unhealthy biology because it occurs in a species that lacks changes in lifestyle risk factors, such as increased rates of smoking and drinking that we often see in humans who are stuck in low-status situations.

Premature DNA Aging

Progress in understanding the routes into the body taken by the SES/health gradient has also come through a very sensitive measure of aging: the condition of telomeres, which are the stretches of DNA at the very tips of chromosomes. Telomeres help to keep our chromosomes stable—molecular biologists like to say that they resemble the plastic caps at the ends of shoelaces that prevent fraying. Every time chromosomes are duplicated for cell division, the telomeres shorten; when they get too short, cells can no longer divide, and they lose many of their healthy functions. Telomere shortening is countered by the enzyme telomerase, which rebuilds these tips. Thus, the state of a cell's telomeres tells much about its biological “*age*,” and shortened telomeres that produce frayed, vulnerable chromosomes seem to be a molecular version of wear and tear.



Inside Inequality

Life in societies with wide gaps between rich and poor creates ongoing social and psychological stresses. These grind down the body in a host of unhealthy ways, affecting our brains, our immune systems and our DNA, according to a broad range of research. Here are some effects that can lead to serious physical illnesses and mental problems.

Prefrontal cortex

Essential for good planning and decision making, this region is impaired by stress hormones.

Hippocampus

Activity here, key to learning and memory, is reduced, and the area shrinks in size.

Amygdala

Fear and anxiety are channeled through this region, and its activity is heightened.

Mesolimbic dopamine system

Neuron signals here are crucial for motivation, but they are disrupted, increasing risk of depression and addiction.

Chronic inflammation

This state, brought about through stress hormones and the immune system, damages molecules throughout the body, increasing the risk of heart disease and Alzheimer's, among many ailments.

Circulatory System

Blood pressure goes up, heightening atherosclerosis and stroke risks.

Metabolism

Cells throughout the body have reduced responses to insulin, and abdominal fat increases, leading to diabetes.

Reproductive organs

Abnormalities disrupt fertility and libido.

Chromosomes

DNA in our chromosomes is kept stable by little molecular caps at the ends, called telomeres (*red*). When people are stressed by social circumstances, telomeres get shorter, leading to frayed and vulnerable chromosomes—a kind of premature molecular aging.



Telomere



Credit: **Bryan Christie Design**



Telomere biology met stress physiology in a 2004 study by health psychologist Elissa Epel of U.C.S.F. and Elizabeth Blackburn of the Salk Institute for Biological Studies; Blackburn won the Nobel Prize for her pioneering work on telomeres. They examined 39 people who live with severe stress every day: women who are caregivers for chronically ill children. The landmark finding was that white blood cells in these caregivers had shortened telomeres, decreased telomerase activity, and elevated oxidative damage to proteins and enzymes. (Oxidation can disable telomerase.) The longer a child's illness, the more stress the women reported and the shorter their telomeres were, even after the researchers accounted for potentially confounding factors such as diet and smoking. Telomeres normally shorten at a more or less constant rate in people, and calculations showed that these women's telomeres had aged roughly an additional decade—and sometimes more—past those in the low-stress group. This discovery triggered a flood of supporting studies showing that stressors that included major depression, post-traumatic stress disorder and the experience of racial discrimination can all accelerate telomere shortening. Unsurprisingly, lower childhood SES also predicts shorter telomeres in adulthood; perceived poor neighborhood quality, witnessing or experiencing violence, family instability (such as divorce, death or incarceration of a parent), and other features of poor status early on are tied to these shrunken chromosome tips later in life. Spend your childhood in poverty, and by middle age your telomeres will probably be about a decade older than those with more fortunate childhoods.

Thus, from the macro level of entire body systems to the micro level of individual chromosomes, poverty finds a way to produce wear and tear. Most studies of telomere length compare “*poor*” with “*non-poor*,” as do the studies comparing allostatic load, but the few studies that examine the whole spectrum of inequality, step by low-status step, show that every rung down the SES ladder most likely worsens these biological markers of aging.



Out of Control

Slipping down these rungs also changes the brain and behavior, according to a slew of recent neurobiological studies. Sapolsky's laboratory has devoted a quarter of a century to studying what ongoing stress does to the brain in rodents, monkeys and humans. Along with other labs, they have learned that one hotspot is the hippocampus, a region critical to learning and memory. Sustained stress or exposure to excessive glucocorticoids impairs memory by lowering hippocampal excitability, retracting connections between neurons and suppressing the birth of new neurons. In the amygdala, a different brain area that is central to fear and anxiety, stress and glucocorticoids heighten those two reactions. Instead of damping things down as they do in the hippocampus, in this fear-promoting region they increase excitability and expand neuronal connections. Together these findings help to explain why post-traumatic stress disorder atrophies the hippocampus and enlarges the amygdala. Another affected area is the mesolimbic dopamine system, which is crucial to reward, anticipation and motivation. Chronic stress disrupts that system, and the result is a predisposition toward the anhedonia of depression and vulnerability to addiction. Bombardment by glucocorticoids also affects the prefrontal cortex (PFC), key to long-term planning, executive function and impulse control. In the PFC, social stress and elevated glucocorticoids weaken connections between neurons, making it harder for them to communicate. Myelination, the process that insulates cables between neurons and thus helps them pass signals faster, is impaired. Total cell volume in the region declines, and chronic inflammation is activated.

What happens when the PFC is impaired in this way? Lousy, impulsive decisions happen. Consider "*temporal discounting*": when choosing between an immediate reward and a bigger one if you wait, the appeal of waiting goes down as the time you must wait goes up. The PFC is normally good at combating this shortsightedness. But stress steepens temporal discounting; the more cumulative stress, the less PFC activation in experiments that call for gratification postponement. For people sliding further into inequality, the less active PFC makes it harder for the brain to choose long-term health over immediate pleasure. That neurological effect can explain why people with more total life stress gain more weight and smoke and drink more than people with fewer stressors. These changes in the PFC happen in children, too. In



separate studies, Martha Farah of the University of Pennsylvania and W. Thomas Boyce, now at U.C.S.F., observed that lower-SES kindergartners typically have elevated glucocorticoid levels, a thinner and less active PFC, and poor PFC-dependent impulse control and executive function. These effects increase as kids get older. By adolescence, lower SES predicts smaller PFC volume. By adulthood, low SES predicts steeper temporally discounted decisions.

Some of these observations present a tricky chicken-and-egg question. The brain changes could lead to poor choices, which in turn lead to deeper poverty, rather than the other way around. But the research suggests that causes and effects run in the other direction, with SES and inequality first influencing PFC function, and then other bad things happen. For example, kindergartners' SES predicted their PFC function; few five-year-olds plummet into poverty by squandering their paychecks on drink and horses. Further evidence comes from a 2013 study by Jiaying Zhao of the University of British Columbia and his colleagues. They examined Indian farmers whose economic fortunes vary seasonably. As individuals' SES went from being poorest during planting season to wealthiest after harvest, improvements in PFC function followed. To me, the most important evidence comes from research in which people's sense of their SES was lowered by the design of the experiment. Afterward these individuals did heavier temporal discounting. In one 2012 study, subjects played a game of chance against one another, with differing amounts of starting resources. "*Poor*" subjects became more likely to borrow against future earnings and less attuned to helpful clues about game strategy. In another study, subjects prompted to imagine scenarios of financial loss (versus neutral or advantageous ones) did steeper temporal discounting in an unrelated task. In still other research, subjects were primed to imagine their financial burdens by contemplating an expensive car repair; cognitive function was unchanged in high-SES subjects but declined in poorer individuals.

Why should a transient sense of lower SES induce cognitive changes typical of lower SES in the real world? One explanation is that it is a rational response because it is hard to think about squirreling away money for old age if you can barely buy groceries. Poverty makes the future a less relevant place. But there is also a powerful stress-related explanation: long-term planning and impulse control tires out the PFC. Increase subjects' cognitive "*load*" with taxing PFC-dependent tasks, and they



become more likely to cheat on their diet. Or you can—and scientists have done this—increase cognitive load by tempting dieting subjects with snacks, and then they do worse on PFC-dependent tests. How much this represents literal “*depletion*” of the PFC metabolically versus declining motivation is unclear. Either way, lower SES creates chronic financial worry that distracts and exhausts. It is hard to ace a psychological task of, say, subtracting a series of numbers or a more important task of reining in your drinking when you are worrying about paying your rent. One finding in the car-repair study supports this interpretation. When subjects contemplated a repair of negligible cost, low- and high-SES subjects performed equally well on cognitive tasks.

Of course, we need to better understand the biological consequences of inequality and learn better ways to heal its health scars. But frankly, right now we know quite a bit. We know enough to prompt moral outrage at the situation. It is outrageous that if children are born into the wrong family, they will be predisposed toward poor health by the time they start to learn the alphabet. It should not require us to measure inflammation or the length of chromosomes to prove this is wrong, but if it does, more power to this science.



When Stress Comes with Your Mother's Milk



Credit: **Risa Kerlake**

Jena Pincott is a science writer and author of [Do Chocolate Lovers Have Sweeter Babies? The Surprising Science of Pregnancy](#). Her essay was published in January 2019, in [Nautil.us](#). It has been edited and formatted for this inclusion

Years ago, when my oldest daughter was still nursing, I went through a panicky phase. I had committed to a run of public-speaking engagements, and I constantly worried that I would flub them. Before each event, I pumped milk for the baby and left her with the sitter, who eventually confided that she dreaded my departures as much as I did. While I was away, she told me, my daughter was irritable and inconsolable. She would cry in the stroller; she would cry when held. Refusing to nap after feeding, she back-arched and bawled. “*We’re like quantum particles!*” I marveled. My daughter felt how I felt -from across the city. “*No,*” the sitter insisted, “*it’s the milk.*”

I flashed on all those times I had pumped between nervous preparations, my heart racing. Had I passed my stress on to my daughter through my breast milk? When I posed this question to Laura Glynn, a psychologist at Chapman University, she said it was plausible. Along with the proteins, minerals, vitamins, fats, and sugars that

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nourish an infant, the antibodies that help fight infection, and the growth factors that aid in tissue development, milk contains a cocktail of hormones, including the stress hormone cortisol. The body circulates cortisol during trying or fearful situations - spats, traffic jams, sports competitions, deadlines. The hormone orchestrates aspects of metabolism and behavior, including triggering the release of sugars into the bloodstream, giving us that burst of energy we might need to fight or flee. In nursing babies, cortisol gets a red-carpet welcome. An infant's intestinal tract responds to its mother's milk by sprouting receptors that detect the hormone, activating neurochemical signals that can travel all the way to the brain. These signals may influence a baby's stress response and the development of brain regions that regulate emotions such as fear and anxiety. Breastfed babies also have an average 40 percent more cortisol in their system than their formula-fed peers, suggesting that the increase comes from milk. Scientists don't yet know the long-term effects of secondhand cortisol, or even whether its presence in nursing babies can be described as stress. I can't say, for instance, whether the cortisol in my milk, possibly spiked by my own anxiety, caused my daughter to feel anxious. That's probably too simplistic a view.

But increasingly, studies by Glynn and others are showing that a mother's milk, in one way or another, helps to shape her child's behavior and temperament, and may



Studies suggest a link between high levels of stress hormones in breast milk and nervous, fussy babies. Credit: **Alex Linghorn/Getty Images**



deliver useful information about the environment she's growing up in. Perhaps my milk was sending my daughter a message: *Here's what you need to know about the world. Act accordingly.*

Most evidence for the link between milk cortisol and cognition comes from animals. Experiments on rats dating back to the 1980s show beneficial effects. When researchers spiked nursing mothers' water with corticosterone (the rodent equivalent of cortisol), mimicking mild stress, their pups learned faster, had better memories, and were less anxious and more exploratory during stress tests, suggesting a better ability to cope. One experiment found that male pups from corticosterone-dosed mothers grew extra cortisol receptors in a brain region involved in regulating the body's reaction to stress, which may help temper this response. In rodents, at least, stress during motherhood seems to embolden offspring. In primates, however, it appears to do the opposite. In a 2014 study, Katie Hinde, a behavioral biologist at Arizona State University, and her colleagues tested how cortisol levels in the milk of over 100 mother rhesus macaques correlated with their babies' temperament when put in a novel environment. Previous research suggests that human babies who cry or become agitated in unfamiliar situations are more likely than less-reactive babies to develop timid, shy personalities. Could cortisol be partly responsible? Hinde's study nudges the answer toward "yes." The higher the level of milk cortisol, her team found, the more nervous and timid a baby monkey acted in the presence of new things, such as a new toy or a stranger's face. Glynn has observed a similar connection in humans. In studies published in 2007 and 2013, she and her colleagues tested cortisol levels in nursing mothers' blood and milk, respectively, and then surveyed them about their infants' behavior and temperament: How often during the past week did the baby startle to a loud new sound or sudden noise? When frustrated, how often did the baby calm down within five minutes? As in Hinde's macaque study, the results showed a significant association between high cortisol levels and nervous, jittery babies. (For unclear reasons, the second study found this trend only among girls, who also seem to be more sensitive to cortisol exposure in the womb.) Of course, a link doesn't necessarily imply a cause. Maybe mother and child share genes that make both vulnerable to stress. Maybe stressed-out moms are more likely to rate their babies



as fearful, or to treat their kids in a way that makes them more high-strung. Or maybe a fussy baby simply gives mom more stress, causing her cortisol levels to rise, rather than the other way around. Glynn considered these confounding factors and devised a solution: She tested and surveyed mothers with formula-fed babies, too. In this control group, the link between cortisol and temperament vanished.

The message, it seemed, was in the milk.

“Don’t let these findings stress you out,” Hinde insists. She doesn’t want anxious moms like me to feel uneasy about breastfeeding. Cortisol levels don’t always match feelings of psychological stress, she points out. And even the most zen-like nursing women have cortisol in their milk, which rises and falls with the rhythms of the day, as do the temperaments of their Buddha-like babies. On the contrary, she suspects that formula-fed babies may be missing out on important signals that hormones like cortisol convey. By better understanding these signals, scientists could create better formulas for mothers who can’t nurse or choose not to. The current consensus among those who study milk cortisol is that it serves an evolutionary purpose: to help babies adapt, physiologically and behaviorally, to the world in which they are born. Cortisol reflects a mother’s circumstances -her resources, her social conflicts, and physical threats- and calibrates her baby’s behavior accordingly. In the macaque study, for instance, Hinde’s team found that monkey mothers with high levels of milk cortisol -those who tended to have more fearful babies- were also more likely to be new mothers. (Hormone levels were much lower in mothers who already had four or more children.) The reason for this, Hinde suspects, should do with energy. Young mothers’ bodies, including their mammary glands, are still developing, and so they have fewer resources than older moms to devote to milk production. As a result, their milk contains less energy. Perhaps the cortisol in it provides a warning: *Conserve energy by prioritizing growth, not play.* In other words, *be fearful.* Cautious babies are less likely to spend precious calories exploring, and instead will use most of this energy to grow and stay healthy. Even in modern human societies, there may be conditions in which a wary vigilance could be advantageous. *“Living in a very dangerous household or neighborhood, it might be safer than having a very surgent, outgoing temperament,”* Glynn says. And if a short-term spike in milk cortisol causes some stormy behavior in a baby -as my own experience might suggest- that, too, may have a silver lining. *“A stressed mom may have a lot on her mind, and being fussy may*



be one of the tactics a baby uses to get the attention he or she needs from Mom and other caretakers,” Hinde says. In our evolutionary past, this syncing may have meant survival.

Some experts suspect that moderate amounts of milk cortisol (in what’s considered a normal range), together with the nurturing nature of breastfeeding, could help protect babies against the negative effects of stress later in life. A 2006 study of nearly 5,700 10-year-olds found that those who had been breastfed as infants were less anxious when confronted with a major stressor, such as parental divorce or separation. This link persisted even after the researchers adjusted for confounding factors, such as social class and education level.

There is some evidence that this resiliency stems from the fact that cortisol acts on the brain pathway responsible for blunting pain. Cortisol is also involved in the development of the body’s central stress-response system, known as the hypothalamic–pituitary–adrenal axis. Low levels of the hormone during infancy may help habituate this system to mild stress, thereby training it to “*dial down*” the body’s reaction to adversity.

If low or intermittent doses of milk cortisol can act as an inoculant against stress, what happens when mom’s cortisol meter is chronically “*turned to 11 with the knob broken off,*” as Hinde puts it? She hopes to get an answer when her young macaque subjects reach maturity. “*When the data are in,*” she speculates, “*we’ll find that there are indeed some signatures that last a lifetime -or are even transmitted to the next generation.*”

However, she is quick to add that even if constant exposure to large amounts of cortisol during infancy turns out be harmful, other contributions to development - such as nurturing and genetics- could compensate for or override any negative impacts. At the same time, other ingredients in breast milk may work alongside cortisol to influence infant temperament. For example, studies suggest that certain strains of *Bifidobacteria* and *Bacteroides*, which are transferred live in milk, produce molecules that may have a calming effect. Babies with more of these bacteria in their gut tend to be less anxious and fussy. Milk also contains complex sugars, known as human milk oligosaccharides, that feed a baby’s microbiome, and each nursing mother has her own heritable, diet-dependent, ever-changing mix of 50 or so types. It’s possible that this custom concoction further shapes her baby’s disposition and



mood by manipulating the gut flora.

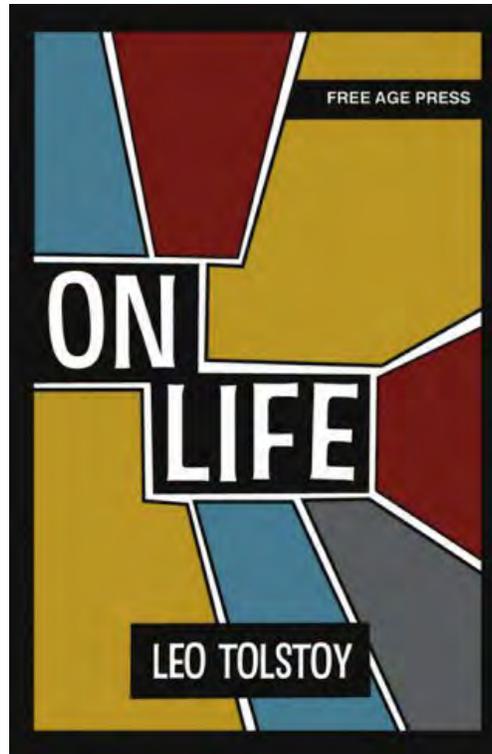
A mother's stress, in other words, may nudge her baby one way or another, but cortisol alone doesn't dictate destiny. *"This one hormone, in one aspect of parenting, is just one of the rivets holding the plane wing on. One rivet can break, and the plane still flies,"* Hinde writes in her blog *"Mammals Suck ... Milk."* *"Development is a multi-factorial system, and rarely is any one single aspect the linchpin."*

After Jena Pincott's stint as a public speaker ended, her daughter's fussiness subsided. She has since grown into a sweet, spirited 5-year-old, no harm done. Still, Jena can't help but wonder: Could her fluctuating stress during her nursing days have anything to do with her abundant caution on the jungle gym? Or her composure during her first violin recital, despite a raging ear infection?

She wishes for her children to encounter hardship in just the right doses: not so much that they become too fearful, nor so little that they become overconfident. But sooner or later, she knows, life will throw some tough punches. It's comforting to think that her breast milk may have given her kids some of the first lessons on how to cope.



Leo Tolstoy on Love and Its Paradoxical Demands



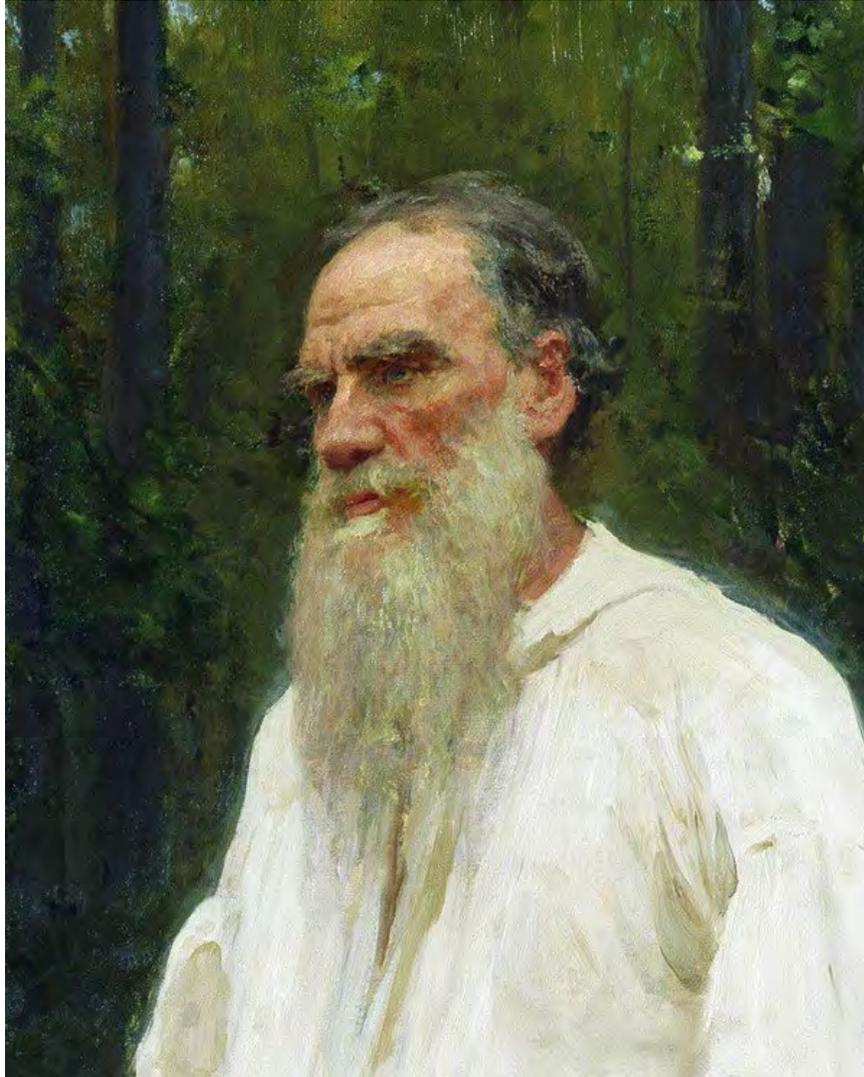
On Life – Leo Tolstoy – Free Age Press. Centenary Edition

Leo Tolstoy (September 9, 1828–November 10, 1910) began tussling with the grandest questions of existence from an early age. As a young man, he struggled through his search for himself, learned the hard way about the moral weight of immoral motives, and confronted the meaning of human existence. By late middle age, his work had gained him worldwide literary acclaim, but had also managed to antagonize both church and state at home - the Russian government found his social, political, and moral views so worrisome that they censored him heavily and threatened imprisonment, while the Orthodox Church was so offended by his spiritual writings that they eventually excommunicated him.

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What his homeland withheld the world gave and gave heartily - especially England, where a small but spirited Tolstoy fan base had mushroomed. The author's devoted secretary and supporter, Vladimir Chertkov, who had landed in London in 1897 after



Portrait of Tolstoy – Courtesy of EBay

being exiled from Russia, invested his resources and his enthusiasm for Tolstoy's writing in the Free Age Press - a visionary publishing outfit he founded in Dorset, as spiritually and morally idealistic as Tolstoy himself, dedicated to promoting "*reason, justice, and love*" and "*spreading the deepest convictions of the noblest spirits of every*

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age and race.” The Free Age Press operated from the belief that life has an essential spiritual dimension and that “man’s true aim and happiness consists in unity in reason and love in place of the present insane and unhappy struggle which is bringing and can bring real good to no one.” The Free Age Press was also a pioneering model for a culture built on sharing rather than ownership and on the understanding, that sharing itself is what gives rise to culture. Their original mission statement read:

We earnestly trust that all who sympathize will continue to assist us in circulating these books. No private person has benefited or will benefit financially by the existence of The Free Age Press; the books are issued free of copyright, so that anyone may reprint them who wishes; and any profits made (necessarily small) will go to assist the same work in the Russian language. For the hundreds of kindly letters received from all parts of the world, and the practical help in publicity which has enabled us to circulate upwards of 200,000 booklets and 250,000 leaflets since July 1900, we are very grateful, and tender our hearty thanks.



Vladimir Chertkov working at the Free Age Press workshop, 1902 -
(<https://www.brainpickings.org/2016/09/09/leo-tolstoy-on-love/>)



The press began publishing Tolstoy's spiritual and moral writings -works bowdlerized or entirely unpublished in Russia in his lifetime- standing as a powerful testament to Neil Gaiman's assertion that "*repressing ideas spreads ideas*" — Among the most widely circulated of these works was Tolstoy's *On Life** (public library), originally written as Tolstoy approached his sixtieth birthday in 1888.

In one of the most poignant chapters of the book, Tolstoy examines our gravest misconceptions about love -what he bemoans as "*the confused knowledge of men that in love there is the remedy for all the miseries of life,*" which stems from our insufficient curiosity about the true meaning of our lives. At the center of his argument is a conceptual parallel to the ethos of the Free Age Press -the insight that sharing only increases the sum total of goodness; that the ownership-based impulse to withhold diminishes it; that love, in its grandest sense, is never a zero-sum game wherein the love we extend to one being is at the expense of another.

He writes:

Every man knows that in the feeling of love there is something special, capable of solving all the contradictions of life and of giving to man that complete welfare, the striving after which constitutes his life. "But it is a feeling that comes but rarely, lasts only a little while, and is followed by still worse sufferings," say the men who do not understand life.

To these men love appears not as the sole and legitimate manifestation of life, as the reasonable consciousness conceives it to be, but only as one of the thousand different eventualities of life; as one of the thousand varied phases through which man passes during his existence.

[...]

For such people love does not answer to the idea which we involuntarily attach to the word. It is not a beneficent activity which gives welfare to those who love and for those who are loved.

Our self-harming delusions about the nature of love, Tolstoy argues, spring from our over-reliance on reason, which is invariably an imperfect faculty and can be led astray by our misbeliefs. (His compatriot Dostoyevsky had addressed this in a beautiful letter to his brother half a century earlier.) Tolstoy writes:

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The activity of love offers such difficulties that its manifestations become not only painful, but often impossible. “One should not reason about love” — those men usually say who do not understand life — “but abandon oneself to the immediate feeling of preference and partiality which one experiences for men: that is the true love.”

They are right in saying that one should not reason about love, and that all reasoning about love destroys it. But the point is, that only those people need not reason about love who have already used their reason to understand life and who



One of Maurice Sendak's illustrations for Tolstoy's book '**Nikolenka's Childhood**'
(<https://www.brainpickings.org/2013/06/19/maurice-sendak-illustrates-tolstoy/>)

have renounced the welfare of the individual existence; but those who have not understood life and who exist for the welfare of the animal individuality, cannot



help reasoning about it. They must reason to be enabled to give themselves up to this feeling which they call love.

Every manifestation of this feeling is impossible for them, without reasoning, and without solving unsolvable questions.

Tolstoy turns to the central paradox of reconciling our inherent solipsism with the ethos of universal love. (Twenty years later, he would explore these issues in his little-known correspondence with Gandhi, with whom Tolstoy shared a profound spiritual kinship.) He writes:

In reality, every man prefers his own child, his wife, his friends, his country, to the children, wives, friends, and country of others, and he calls this feeling love. To love means in general to do good. It is thus that we all understand love, and we do not know how to comprehend it in any other way. Thus, when I love my child, my wife, my country, I mean that I desire the welfare of my child, wife, and country more than that of other children, women, and countries. It never happens, and can never happen, that I love my child, wife, or country only. Every man loves at the same time his child, wife, country, and men in general. Nevertheless, the conditions of the welfare which he desires for the different beings loved, in virtue of his love, are so intimately connected, that every activity of love for one of the beings loved not only hinders his activity for the others but is detrimental to them.

In a passage that calls to mind Hannah Arendt on the humanizing value of unanswerable questions, Tolstoy considers the inquiries that result from this paradox:

In the name of which love should I act and how should I act? In the name of which love should I sacrifice another love? Whom shall I love the most and to whom do the most good - to my wife, or to my children- to my wife and children, or to my friends? How shall I serve a beloved country without doing injury to the love for my wife, children, and friends?

Finally, how shall I solve the problem of knowing in what measure I can sacrifice my individuality, which is necessary to the service of others? To what extent can I occupy myself with my own affairs and yet be able to serve those I love? All these questions seem very simple to people who have not tried to explain this feeling



they call love - but, far from being simple, they are quite unsolvable.

Out of these unanswerable questions, he suggests, arises an awareness and, finally, an acceptance of the multiplicity and variousness of love. This, in turn, furnishes the understanding of love's essential nature not as a hypothetical conceit but as an active state of being -or, to borrow the great Zen teacher Thich Nhat Hahn's term, "interbeing with others"- necessarily grounded in the present moment:

The demands of love are so many, and they are all so closely interwoven, that the satisfaction of the demands of some deprives man of the possibility of satisfying others. But if I admit that I cannot clothe a child benumbed with cold, on the pretense that my children will one day need the clothes asked of me, I can also resist other demands of love in the name of my future children.

[...]

If a man decides that it is better for him to resist the demands of a present feeble love, in the name of another, of a future manifestation, he deceives either himself or other people, and loves no one but himself.

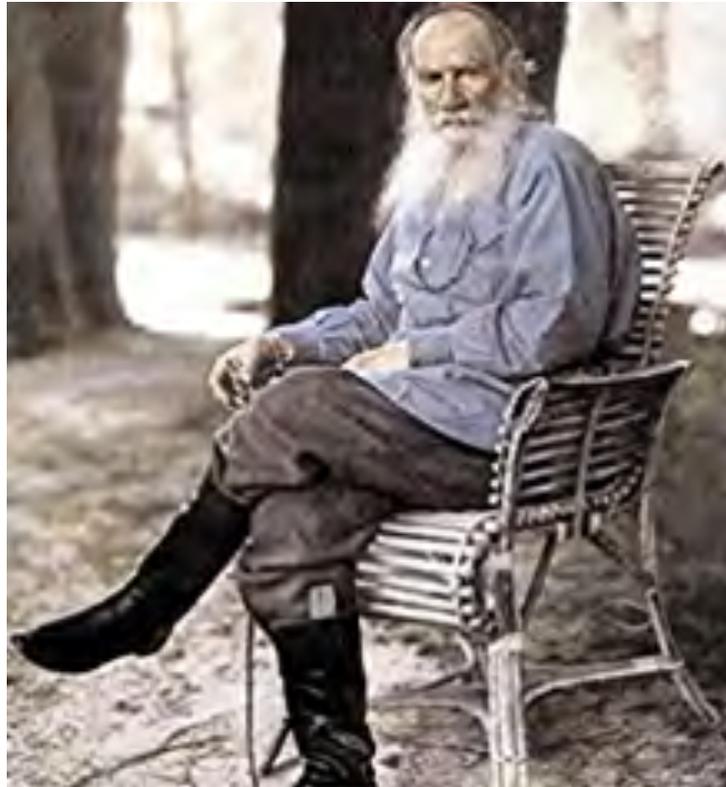
Future love does not exist. Love is a present activity only. The man who does not manifest love in the present has not love.

On Life is a spirit-rousing read in its totality. Complement it with Tolstoy on personal growth, human nature, how to find meaning when life seems meaningless, what separates good art from bad, and his reading list of essential books for every stage of life, then revisit the great humanistic philosopher and psychologist Erich Fromm on what is keeping us from mastering the art of and Martin Luther King, Jr.'s timeless experiment in love.

** Curiously, the 2009 digital edition of "On Life" by an English publisher called White Crow Books bears this affront to the spirit and explicit anti-copyright ethos of the Free Age Press: "All rights reserved. Unauthorized reproduction, in any manner, is prohibited."*



Leo Tolstoy on Finding Meaning in a Meaningless World



Cover of "A Confession and Other Religious Writings" by Leo Tolstoy – Credit: Penguin Books

Shortly after turning fifty, **Leo Tolstoy** (September 9, 1828–November 10, 1910) succumbed to a profound spiritual crisis. With his greatest works behind him, he found his sense of purpose dwindling as his celebrity and public acclaim billowed, sinking into a state of deep depression and melancholia despite having a large estate, good health for his age, a wife who had born him fourteen children, and the promise of eternal literary fame. On the brink of suicide, he made one last grasp at light amidst the darkness of his existence, turning to the world's great religious and philosophical traditions for answers to the age-old question regarding the meaning of life. In 1879, a decade after *War and Peace* and two years after *Anna Karenina*, and a decade



before he set out to synthesize these philosophical findings in his *Calendar of Wisdom*, Tolstoy channeled the existential catastrophe of his inner life in *A confession* (public library) -an autobiographical memoir of extraordinary candor and emotional intensity, which also gave us Tolstoy's prescient meditation on money, fame, and writing for the wrong reasons. He likens the progression of his depression to a serious physical illness -a parallel modern science is rendering increasingly appropriate. Tolstoy writes:

Then occurred what happens to everyone sickening with a mortal internal disease. At first trivial signs of indisposition appear to which the sick man pays no attention; then these signs reappear more and more often and merge into one uninterrupted period of suffering. The suffering increases, and before the sick man can look round, what he took for a mere indisposition has already become more important to him than anything else in the world -it is death!

The classic symptoms of anhedonia engulfed him -he lost passion for his work and came to dismiss as meaningless the eternal fame he had once dreamt of. He even ceased to go out shooting with his gun in fear that he might be too tempted to take his own life. Though he didn't acknowledge a "someone" in the sense of a creator, he came to feel that his life was a joke that someone had played on him — a joke all the grimmer for the awareness of our inescapable, and all the more despairing:

Today or tomorrow sickness and death will come (they had come already) to those I love or to me; nothing will remain but stench and worms. Sooner or later my affairs, whatever they may be, will be forgotten, and I shall not exist. Then why go on making any effort? . . . How can man fail to see this? And how go on living? That is what is surprising! One can only live while one is intoxicated with life; as soon as one is sober it is impossible not to see that it is all a mere fraud and a stupid fraud! That is precisely what it is: there is nothing either amusing or witty about it, it is simply cruel and stupid.

[...]

Had I simply understood that life had no meaning I could have borne it quietly, knowing that that was my lot. But I could not satisfy myself with that. Had I been like a man living in a wood from which he knows there is no exit, I could have lived; but I was like one lost in a wood who, horrified at having lost his way,



rushes about wishing to find the road. He knows that each step he takes confuses him more and more, but still he cannot help rushing about. It was indeed terrible. And to rid myself of the terror I wished to kill myself.

And yet he recognized that the inquiry at the heart of his spiritual malady was neither unique nor complicated:

My question ... was the simplest of questions, lying in the soul of every man from the foolish child to the wisest elder: it was a question without an answer to which one cannot live, as I had found by experience. It was: "What will come of what I am doing today or shall do tomorrow? What will come of my whole life?" Differently expressed, the question is: "Why should I live, why wish for anything, or do anything?" It can also be expressed thus: "Is there any meaning in my life that the inevitable death awaiting me does not destroy?"

Seeking to answer this seemingly simple yet paralyzingly profound question, Tolstoy first turned to science, but found that rather than recognizing and answering the question, science circumvented it and instead asked its own questions, then answered those. Most of all, he found it incapable of illuminating the infinite and instead reducing its questions and answers to finite. He writes:

These are all words with no meaning, for in the infinite there is neither complex nor simple, neither forward nor backward, nor better or worse.

[...]

One who sincerely inquires how he is to live cannot be satisfied with the reply — "Study in endless space the mutations, infinite in time and in complexity, of innumerable atoms, and then you will understand your life" — so also a sincere man cannot be satisfied with the reply: "Study the whole life of humanity of which we cannot know either the beginning or the end, of which we do not even know a small part, and then you will understand your own life."

A century and a half before Alan Lightman tussled, elegantly, with the same paradox, Tolstoy captured the Catch-22 of the predicament:

The problem of experimental science is the sequence of cause and effect in material phenomena. It is only necessary for experimental science to introduce



the question of a final cause for it to become nonsensical. The problem of abstract science is the recognition of the primordial essence of life. It is only necessary to introduce the investigation of consequential phenomena (such as social and historical phenomena) and it also becomes nonsensical. Experimental science only then gives positive knowledge and displays the greatness of the human mind when it does not introduce into its investigations the question of an ultimate cause. And, on the contrary, abstract science is only then science and displays the greatness of the human mind when it puts quite aside questions relating to the consequential causes of phenomena and regards man solely in relation to an ultimate cause.

He then turned to philosophy, but found himself equally disillusioned:

Philosophy not merely does not reply but is itself only asking that question. And if it is real philosophy all its labour lies merely in trying to put that question clearly.

Instead of an answer, he finds in philosophy “*the same question, only in a complex form.*” He bemoans the inability of either science or philosophy to offer a real answer:

One kind of knowledge did not reply to life’s question, the other kind replied directly confirming my despair, indicating not that the result at which I had arrived was the fruit of error or of a diseased state of my mind, but on the contrary that I had thought correctly, and that my thoughts coincided with the conclusions of the most powerful of human minds.

Frustrated, Tolstoy answers his own question:

“Why does it exist?” “Because it exists.”

It’s a sentiment that John Cage would second a century later (“*Not why. Just here.*”) and George Lucas would also echo (“*There is no why. We are. Life is beyond reason.*”) –a proposition that comes closest to the spiritual tradition of Buddhism. And, indeed, Tolstoy turns to spirituality in one final and desperate attempt at an answer -first by surveying how those in his social circle lived with this all-consuming inquiry. He found among them four strategies for managing the existential despair, but none that resolved it:

I found that for people of my circle there were four ways out of the terrible



position in which we are all placed. The first was that of ignorance. It consists in not knowing, not understanding, that life is an evil and an absurdity. From [people of this sort] I had nothing to learn -one cannot cease to know what one does know.

The second way out is epicureanism. It consists, while knowing the hopelessness of life, in making use meanwhile of the advantages one has, disregarding the dragon and the mice, and licking the honey in the best way, especially if there is much of it within reach... That is the way in which the majority of people of our circle make life possible for themselves. Their circumstances furnish them with more of welfare than of hardship, and their moral dullness makes it possible for them to forget that the advantage of their position is accidental ... and that the accident that has today made me a Solomon may tomorrow make me a Solomon's slave. The dullness of these people's imagination enables them to forget the things that gave Buddha no peace -the inevitability of sickness, old age, and death, which today or tomorrow will destroy all these pleasures.

The third escape is that of strength and energy. It consists in destroying life, when one has understood that it is an evil and an absurdity. A few exceptionally strong and consistent people act so. Having understood the stupidity of the joke that has been played on them, and having understood that it is better to be dead than to be alive, and that it is best of all not to exist, they act accordingly and promptly end this stupid joke, since there are means: a rope round one's neck, water, a knife to stick into one's heart, or the trains on the railways; and the number of those of our circle who act in this way becomes greater and greater, and for the most part they act so at the best time of their life, when the strength of their mind is in full bloom and few habits degrading to the mind have as yet been acquired...

The fourth way out is that of weakness. It consists in seeing the truth of the situation and yet clinging to life, knowing in advance that nothing can come of it. People of this kind know that death is better than life, but not having the strength to act rationally -to end the deception quickly and kill themselves- they seem to wait for something. This is the escape of weakness, for if I know what is best and it is within my power, why not yield to what is best? ... The fourth way was to live like Solomon and Schopenhauer — knowing that life is a stupid joke played upon us, and still to go on living, washing oneself, dressing, dining, talking,



and even writing books. This was to me repulsive and tormenting, but I remained in that position.

Finding himself in the fourth category, Tolstoy begins to question *why* he hadn't killed himself. Suddenly, he realizes that a part of him was questioning the very validity of his depressive thoughts, presenting "*a vague doubt*" as to the certainty of his conclusions about the senselessness of life.

Humbled by the awareness that the mind is both puppet and puppet-master, he writes:

It was like this: I, my reason, have acknowledged that life is senseless. If there is nothing higher than reason (and there is not: nothing can prove that there is), then reason is the creator of life for me. If reason did not exist there would be for me no life. How can reason deny life when it is the creator of life? Or to put it the other way: were there no life, my reason would not exist; therefore, reason is life's son. Life is all. Reason is its fruit, yet reason rejects life itself! I felt that there was something wrong here.

And he discovers the solution not in science or philosophy or the life of hedonism, but in those living life in its simplest and purest form:

The reasoning showing the vanity of life is not so difficult and has long been familiar to the very simplest folk; yet they have lived and still live. How is it they all live and never think of doubting the reasonableness of life?

My knowledge, confirmed by the wisdom of the sages, has shown me that everything on earth — organic and inorganic — is all most cleverly arranged — only my own position is stupid. And those fools — the enormous masses of people — know nothing about how everything organic and inorganic in the world is arranged; but they live, and it seems to them that their life is very wisely arranged! . . .

And it struck me: "But what if there is something I do not yet know? Ignorance behaves just in that way. Ignorance always says just what I am saying. When it does not know something, it says that what it does not know is stupid. Indeed, it appears that there is a whole humanity that lived and lives as if it understood the meaning of its life, for without understanding it could not live; but I say that all this life is senseless and that I cannot live.



Awake to what Stuart Firestein would call “*thoroughly conscious ignorance*” some 130 years later, Tolstoy sees his own blinders with new eyes:

In the delusion of my pride of intellect it seemed to me so indubitable that I and Solomon and Schopenhauer had stated the question so truly and exactly that nothing else was possible — so indubitable did it seem that all those milliards consisted of men who had not yet arrived at an apprehension of all the profundity of the question — that I sought for the meaning of my life without it once occurring to me to ask: “But what meaning is and has been given to their lives by all the milliards of common folk who live and have lived in the world?”

I long lived in this state of lunacy, which, in fact if not in words, is particularly characteristic of us very liberal and learned people. But thanks either to the strange physical affection I have for the real laboring people, which compelled me to understand them and to see that they are not so stupid as we suppose, or thanks to the sincerity of my conviction that I could know nothing beyond the fact that the best I could do was to hang myself, at any rate I instinctively felt that if I wished to live and understand the meaning of life, I must seek this meaning not among those who have lost it and wish to kill themselves, but among those milliards of the past and the present who make life and who support the burden of their own lives and of ours also. And I considered the enormous masses of those simple, unlearned, and poor people who have lived and are living, and I saw something quite different. I saw that, with rare exceptions, all those milliards who have lived and are living do not fit into my divisions, and that I could not class them as not understanding the question, for they themselves state it and reply to it with extraordinary clearness. Nor could I consider them epicureans, for their life consists more of privations and sufferings than of enjoyments. Still less could I consider them as irrationally dragging on a meaningless existence, for every act of their life, as well as death itself, is explained by them. To kill themselves they consider the greatest evil. It appeared that all mankind had a knowledge, unacknowledged and despised by me, of the meaning of life. It appeared that reasonable knowledge does not give the meaning of life but excludes life: while the meaning attributed to life by milliards of people, by all humanity, rests on some despised pseudo-knowledge.

He considers the necessary irrationality of faith and contemplates its unfair ask of



forsaking reason:

Rational knowledge presented by the learned and wise, denies the meaning of life, but the enormous masses of men, the whole of mankind receive that meaning in irrational knowledge. And that irrational knowledge is faith, that very thing which I could not but reject. It is God, One in Three; the creation in six days; the devils and angels, and all the rest that I cannot accept as long as I retain my reason.

My position was terrible. I knew I could find nothing along the path of reasonable knowledge except a denial of life; and there — in faith — was nothing but a denial of reason, which was yet more impossible for me than a denial of life. From rational knowledge, it appeared that life is an evil, people know this and it is in their power to end life; yet they lived and still live, and I myself live, though I have long known that life is senseless and an evil. By faith it appears that in order to understand the meaning of life I must renounce my reason, the very thing for which alone a meaning is required...

A contradiction arose from which there were two exits. Either that which I called reason was not so rational as I supposed, or that which seemed to me irrational was not so irrational as I supposed.

And therein he finds the error in all his prior reasoning, the root of his melancholia about life's meaninglessness:

Verifying the line of argument of rational knowledge, I found it quite correct. The conclusion that life is nothing was inevitable; but I noticed a mistake. The mistake lay in this, that my reasoning was not in accord with the question I had put. The question was: "Why should I live, that is to say, what real, permanent result will come out of my illusory transitory life — what meaning has my finite existence in this infinite world?" And to reply to that question I had studied life.

The solution of all the possible questions of life could evidently not satisfy me, for my question, simple as it at first appeared, included a demand for an explanation of the finite in terms of the infinite, and vice versa.

I asked: "What is the meaning of my life, beyond time, cause, and space?" And I replied to quite another question: "What is the meaning of my life within time, cause, and space?" With the result that, after long efforts of thought, the answer



I reached was: "None."

In my reasonings I constantly compared (nor could I do otherwise) the finite with the finite, and the infinite with the infinite; but for that reason, I reached the inevitable result: force is force, matter is matter, will is will, the infinite is the infinite, nothing is nothing — and that was all that could result.

[...]

Philosophic knowledge denies nothing, but only replies that the question cannot be solved by it — that for it the solution remains indefinite.

Having understood this, I understood that it was not possible to seek in rational knowledge for a reply to my question, and that the reply given by rational knowledge is a mere indication that a reply can only be obtained by a different statement of the question and only when the relation of the finite to the infinite is included in the question. And I understood that, however irrational and distorted might be the replies given by faith, they have this advantage, that they introduce into every answer a relation between the finite and the infinite, without which there can be no solution.

So, that besides rational knowledge, which had seemed to me the only knowledge, I was inevitably brought to acknowledge that all live humanity has another irrational knowledge — faith which makes it possible to live. Faith still remained to me as irrational as it was before, but I could not but admit that it alone gives mankind a reply to the questions of life, and that consequently it makes life possible.

Tolstoy notes that, whatever the faith may be, it “gives to the finite existence of man an infinite meaning, a meaning not destroyed by sufferings, deprivations, or death,” and yet he is careful not to conflate faith with a specific religion. Like Flannery O’Connor, who so beautifully differentiated between religion and faith, Tolstoy writes:

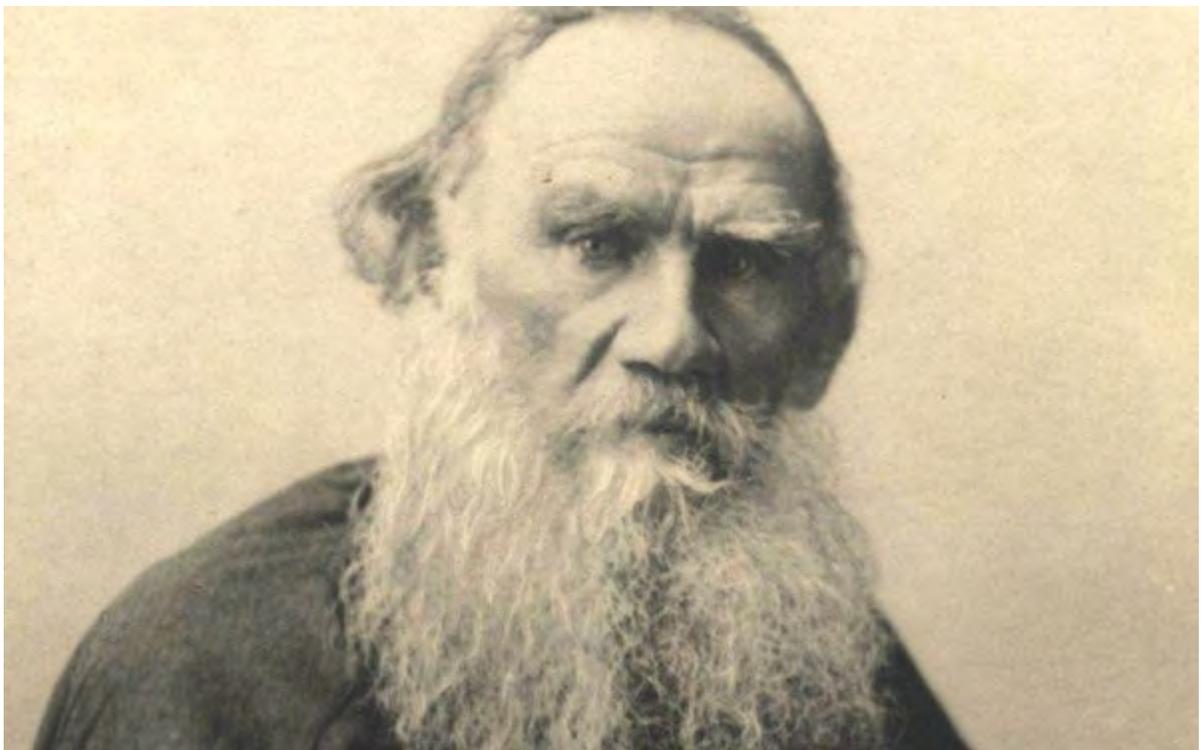
I understood that faith is not merely “the evidence of things not seen”, etc., and is not a revelation (that defines only one of the indications of faith, is not the relation of man to God (one has first to define faith and then God, and not define faith through God); it is not only agreement with what has been told one (as faith is most usually supposed to be), but faith is a knowledge of the meaning of human life in consequence of which man does not destroy himself but lives. Faith is the

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strength of life. If a man lives, he believes in something. If he did not believe that one must live for something, he would not live. If he does not see and recognize the illusory nature of the finite, he believes in the finite; if he understands the illusory nature of the finite, he must believe in the infinite. Without faith, he cannot live...

For man to be able to live he must either not see the infinite or have such an explanation of the meaning of life as will connect the finite with the infinite.



Tolstoy, ***"A Confession and Other Religious-Writings"*** – Penguin Books

And yet the closer he examines faith, the more glaring he finds the disconnect between it and religion, particularly the teachings of the Christian church and the practices of the wealthy. Once again, he returns to the peasants as a paragon of spiritual salvation, of bridging the finite with the infinite, and once again seeing in their ways an ethos most closely resembling the Buddhist philosophy of acceptance:

In contrast with what I had seen in our circle, where the whole of life is passed in idleness, amusement, and dissatisfaction, I saw that the whole life of these people



was passed in heavy labour, and that they were content with life. In contradistinction to the way in which people of our circle oppose fate and complain of it on account of deprivations and sufferings, these people accepted illness and sorrow without any perplexity or opposition, and with a quiet and firm conviction that all is good. In contradistinction to us, who the wiser we are the less we understand the meaning of life, and see some evil irony in the fact that we suffer and die, these folk live and suffer, and they approach death and suffering with tranquility and in most cases, gladly...

In complete contrast to my ignorance, [they] knew the meaning of life and death, labored quietly, endured deprivations and sufferings, and lived and died seeing therein not vanity but good...

[...]

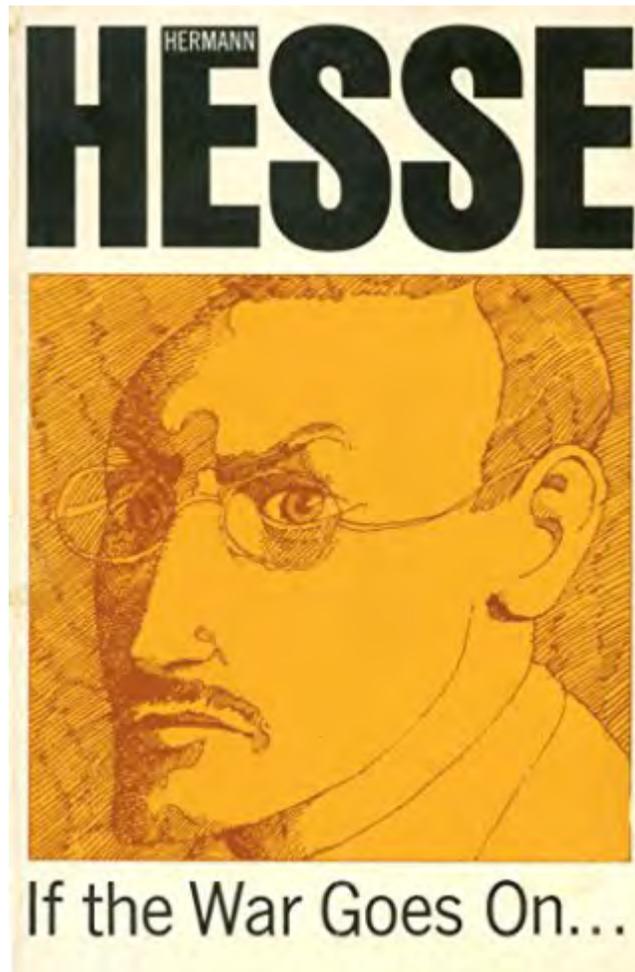
I understood that if I wish to understand life and its meaning, I must not live the life of a parasite, but must live a real life, and — taking the meaning given to live by real humanity and merging myself in that life — verify it.

A Confession is a remarkable read in its entirety. Complement it with Tolstoy's subsequent opus of philosophical inquiry, *A Calendar of Wisdom*, exploring the object of life shortly before his death.



On the Value of Solitude

“Solitude is not chosen; any more than destiny is chosen. Solitude comes to us if we have within us the magic stone that attracts destiny.” A vibrant analysis by Maria Popova.



Credit MacMillan Publishers

“No one can build you the bridge on which you, and only you, must cross the river of life,” the young Nietzsche wrote as he contemplated what it takes to find oneself. Somehow, this man of stark contradiction, cycling between nihilistic despondency and electric buoyancy along the rim of madness, has managed to inspire some of

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humanity's most surefooted spirits — among them, the great German poet, novelist, painter, and Nobel laureate **Hermann Hesse** (July 2, 1877–August 9, 1962), who drew from Nietzsche's philosophy the most humanistic ideas, then magnified them with his own transcendent humanity.



Hermann Hesse – Credit Maria Popova/Brainpickings

Some of Hesse's most emboldening ideas about our human responsibility to ourselves and the world unfold in his "*Letter to a Young German*," written to a dispirited youth in 1919 and later included in his 1946 anthology ***If the Was Goes On...*** (public library), published the year he received the Nobel Prize — the same stirring piece that gave us Hesse on hope, the difficult art of taking responsibility, and the wisdom of inner voice.

Decades before E.E. Cummings asserted that "*to be nobody but yourself –in a world which is doing its best, night and day, to make you everybody else- means to fight the hardest battle which any human can fight*," Hesse writes:



You must unlearn the habit of being someone else or nothing at all, of imitating the voices of others and mistaking the faces of others for your own.

[...]

One thing is given to man which makes him into a god, which reminds him that he is a god: to know destiny.

[...]

When destiny comes to a man from outside, it lays him low, just as an arrow lays a deer low. When destiny comes to a man from within, from his innermost being, it makes him strong, it makes him into a god... A man who has recognized his destiny never tries to change it. The endeavor to change destiny is a childish pursuit that makes men quarrel and kill one another... All sorrow, poison, and death are alien, imposed destiny. But every true act, everything that is good and joyful and fruitful on earth, is lived destiny, destiny that has become self.

Echoing Nietzsche's insistence that a fulfilling life requires embracing rather than running from difficulty, Hesse exhorts the young to treat their suffering with respect and curiosity, and adds:

Might your bitter pain not be the voice of destiny, might that voice not become sweet once you understand it?

[...]

Action and suffering, which together make up our lives, are a whole; they are one. A child suffers its begetting, it suffers its birth, its weaning; it suffers here and suffers there until in the end it suffers death. But all the good in a man, for which he is praised or loved, is merely good suffering, the right kind, the living kind of suffering, a suffering to the full. The ability to suffer well is more than half of life — indeed, it is all life. Birth is suffering, growth is suffering, the seed suffers the earth, the root suffers the rain, the bud suffers its flowering.

In the same way, my friends, man suffers destiny. Destiny is earth, it is rain and growth. Destiny hurts.

Long before Simone Weil contemplated how to make use of our suffering, Hesse holds up hardship as “*the forge of destiny*” and adds:

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It is hard to learn to suffer. Women succeed more often and more nobly than men. Learn from them! Learn to listen when the voice of life speaks! Learn to look when the sun of destiny plays with your shadows! Learn to respect life! Learn to respect yourselves! From suffering springs strength...

Writing fifteen years after he made his exquisite case for breaking the trance of busyness, Hesse returns to the sandbox of selfhood — solitude:

True action, good and radiant action, my friends, does not spring from activity, from busy bustling, it does not spring from industrious hammering. It grows in the solitude of the mountains; it grows on the summits where silence and danger dwell. It grows out of the suffering which you have not yet learned to suffer.

[...]



Photograph by Maria Popova

Solitude is the path over which destiny endeavors to lead man to himself. Solitude is the path that men most fear. A path fraught with terrors, where snakes and

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toads lie in wait... Without solitude, there is no suffering, without solitude there is no heroism. But the solitude I have in mind is not the solitude of the blithe poets or of the theater, where the fountain bubbles so sweetly at the mouth of the hermit's cave.

Learning to be nourished by solitude rather than defeated by it, Hesse argues, is a prerequisite for taking charge of our destiny:

Most men, the herd, have never tasted solitude. They leave father and mother, but only to crawl to a wife and quietly succumb to new warmth and new ties. They are never alone, they never commune with themselves. And when a solitary man crosses their path, they fear him and hate him like the plague; they fling stones at him and find no peace until they are far away from him. The air around him smells of stars, of cold stellar spaces; he lacks the soft warm fragrance of the home and hatchery.

[...]

A man must be indifferent to the possibility of falling, if he wants to taste of solitude and to face up to his own destiny. It is easier and sweeter to walk with a people, with a multitude — even through misery. It is easier and more comforting to devote oneself to the “tasks” of the day, the tasks meted out by the collectivity.

In a sentiment the poet May Sarton would echo in her stunning ode to solitude two decades later, Hesse adds:

Solitude is not chosen; any more than destiny is chosen. Solitude comes to us if we have within us the magic stone that attracts destiny.

Two millennia after Seneca admonished that “*all your sorrows have been wasted on you if you have not learned how to be wretched*”, Hesse exults:

Blessed be he who has found his solitude, not the solitude pictured in painting or poetry, but his own, unique, predestined solitude. Blessed be he who knows how to suffer! Blessed be he who bears the magic stone in his heart. To him comes destiny, from him comes authentic action.

In consonance with Seamus Heaney's lyrical insight that “*the true and durable path in to and through experience involves being true...to your own solitude, true to your*

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own secret knowledge,” you were made to be yourselves. You were made to enrich the world with a sound, a tone, a shadow.



Photograph by Maria Popova

[...]

In each one of you there is a hidden being, still in the deep sleep of childhood. Bring it to life! In each one of you there is a call, a will, an impulse of nature, an impulse toward the future, the new, the higher. Let it mature, let it resound, nurture it! Your future is not this or that; it is not money or power, it is not

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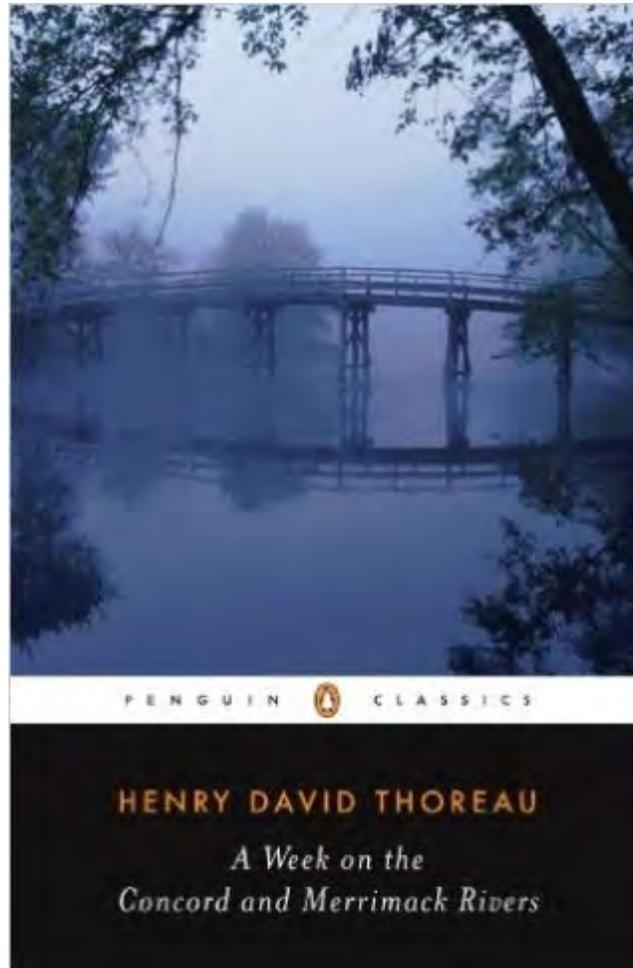


*wisdom or success at your trade — your future, your hard dangerous path is this:
to mature and to find God in yourselves.*

A century later, the entire piece remains a spectacular and deeply insightful read, as does the whole of Hesse's ***If the War Goes On***. Complement this particular fragment with Louise Bourgeois on how solitude enriches creative work and Elizabeth Bishop on why everyone should experience at least one long period of solitude in life, then revisit Hesse on the discipline of savoring life's little joys, why books will survive all future technology, the three types of readers, and what trees teach us about belonging and life.



Thoreau on Social Changes and Politics vs. Progress



“We made the world we’re living in and we have to make it over,” James Baldwin insisted in examining the building blocks of a juster future. “The present is not a potential past; it is the moment of choice and action,” Simone de Beauvoir wrote across the Atlantic as she was advancing the era’s other great human rights cause.

A century before Baldwin and De Beauvoir, **Henry David Thoreau** (July 12, 1817–May 6, 1862) explored this question of how the choices we make in the present

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liberate the future from the past and make the world over in *A Week in on the Concord and Merrimack Rivers* (*public library*) — his first book, published when he was only thirty-two, a disaffected public school teacher who had become one of the country's most promising young writers with the stern yet generous of his first and best editor, Margaret Fuller.



Henry David Thoreau - (Daguerreotype by Benjamin D. Maxham, 1856)

This was an era of immense cultural upheaval, in which the air of revolution was saturated with the urgencies of abolition and women's emancipation. Ensclosed in the woods of Concord, attuned to the elements that far predated and would far



outlive the turmoils of the present — the trees, the rivers, the cycles of the seasons — Thoreau spent his days contemplating the most elemental questions of human existence and our civilizational conscience. It was with this widest possible perspective that he focused his precocious wisdom on the pressing issues of social change, using this long lever of insight to make the present a fulcrum for elevating the future.

Bedeveled by his disgust with slavery and the Mexican-American War, having just modeled for his country how to use civil disobedience to advance justice — a model that would come to influence Gandhi and Martin Luther King, Jr. — he considers the tectonics of change on the scale of society and civilization:

“As in geology, so in social institutions, we may discover the causes of all past change in the present invariable order of society. The greatest appreciable physical revolutions are the work of the light-footed air, the stealthy-paced water, and the subterranean fire... We are independent of the change we detect. The longer the lever the less perceptible its motion. It is the slowest pulsation which is the most vital. The hero then will know how to wait, as well as to make haste. All good abides with him who waiteth wisely.”

If history teaches us one thing about the origins and originators of the greatest social change — an animating question in *Figuring* — it is that those who ignite the profoundest revolutions are themselves often blind to their own spark. Thoreau’s contemporary and kindred revolutionary spirit Elizabeth Barrett Browning would articulate this with stunning succinctness in her groundbreaking 1956 book-length poem *Aurora Leigh*:

*“The best men, doing their best,
Know per adventure least of what they do...”*

The young Thoreau channels this sentiment in his own lyrical prose, suspended as always between the buoyant and the melancholy:

“A man is not his hope, nor his despair, nor yet his past deed. We know not yet what we have done, still less what we are doing. Wait till evening, and other parts of our day’s work will shine than we had thought at noon, and we shall discover the real purport of our toil. As when the farmer has reached the end of the furrow and looks back, he can tell best where the pressed earth shines most.”

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Illustration from Henry Hikes to Fitchburg - a children's book about Thoreau's philosophy.

One of Thoreau's most countercultural yet incisive points is that true social reform has little to do with politics, for genuine cultural change operates on cycles far longer and more invisible than the perpetual churning of immediacies with which the political state and the political conscience are occupied. Rather than dueling with petty surface facts, as politics is apt to, the true revolutionary and reformer dwells in humanity's largest truths, aiming to transfigure the deepest strata of reality. In consonance with the need for a telescopic perspective, Thoreau writes:

To one who habitually endeavors to contemplate the true state of things, the political state can hardly be said to have any existence whatever. It is unreal, incredible, and insignificant to him, and for him to endeavor to extract the truth from such lean material is like making sugar from linen rags, when sugar-cane may be had. Generally speaking, the political news, whether domestic or foreign, might be written to-day for the next ten years, with sufficient accuracy. Most



revolutions in society have not power to interest, still less alarm us; but tell me that our rivers are drying up, or the genus pine dying out in the country, and I might attend. Most events recorded in history are more remarkable than important, like eclipses of the sun and moon, by which all are attracted, but whose effects no one takes the trouble to calculate.

Change, Thoreau reminds us, begins when we finally choose to critically examine and then recalibrate the ill-serving codes and conventions handed down to us, often unquestioned, by the past and its power structures. It is essentially an act of the imagination first. Long before Ursula K. Le Guin asserted that “we will not be free if we do not imagine freedom,” Thoreau calls for imagining nobler alternatives to the dicta and mindsets we have inherited:

In my short experience of human life, the outward obstacles, if there were any such, have not been living men, but the institutions of the dead. It is grateful to make one's way through this latest generation as through dewy grass. Men are as innocent as the morning to the unsuspecting... I love man-kind, but I hate the institutions of the dead un-kind. Men execute nothing so faithfully as the wills of the dead, to the last codicil and letter. They rule this world, and the living are but their executors.

A century before Hannah Arendt considered the most extreme and gruesome manifestation of this tendency in her classic treatise on the normalization of evil, informed by the Holocaust and its incomprehensible phenomenon of ordinary people “just following orders” to murder, Thoreau writes:

Herein is the tragedy; that men doing outrage to their proper natures, even those called wise and good, lend themselves to perform the office of inferior and brutal ones. Hence come war and slavery in; and what else may not come in by this opening? But certainly, there are modes by which a man may put bread into his mouth which will not prejudice him as a companion and neighbor.

Most of our errors, Thoreau observes, stem not from being unwitting of the right choice but from being unwise in the willingness or unwillingness to choose it:

Men do not fail commonly for want of knowledge, but for want of prudence to give wisdom the preference. What we need to know in any case is very simple.

To unmoor ourselves from the burdens of the past, he reminds us, we must be

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engaged in an act of continual and conscious self-renewal:

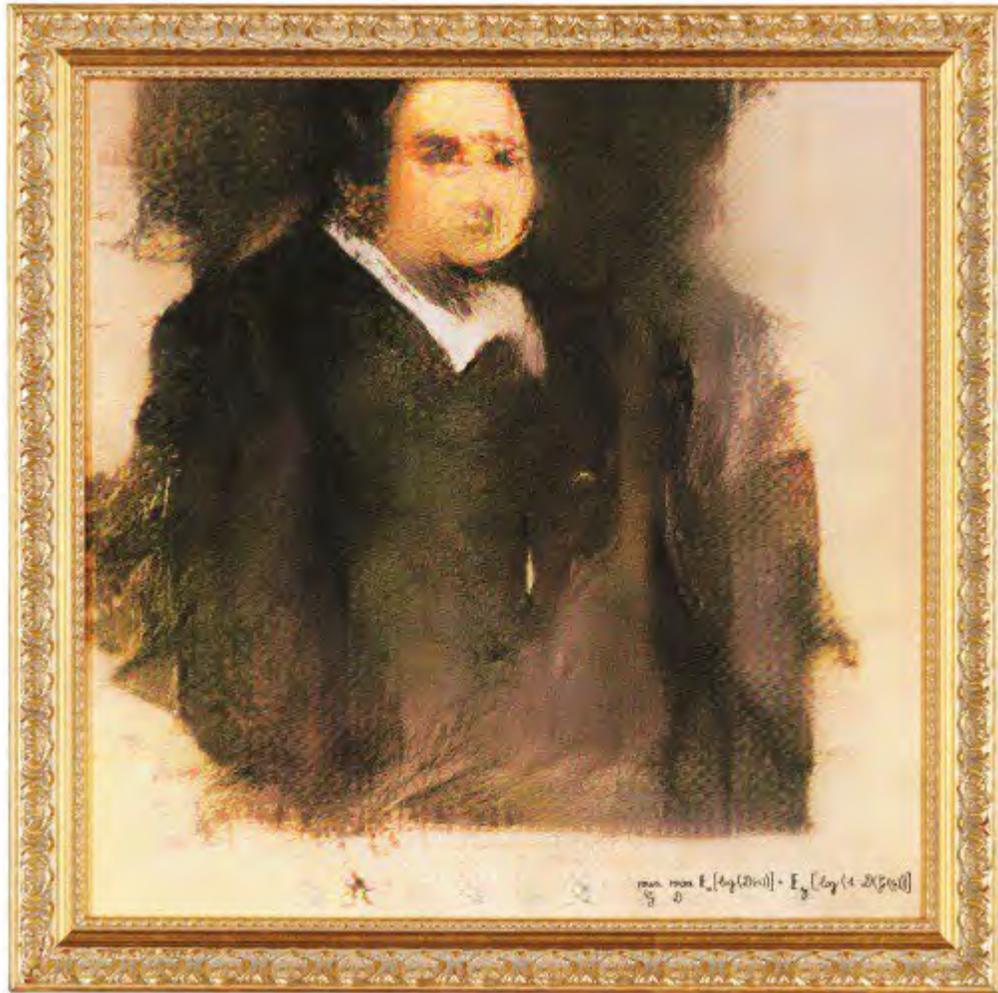
All men are partially buried in the grave of custom, and of some we see only the crown of the head above ground. Better are the physically dead, for they more lively rot. Even virtue is no longer such if it be stagnant. A man's life should be constantly as fresh as this river. It should be the same channel, but a new water every instant.

A century later, Bertrand Russell — himself a humanist of the highest order and a rare seer of elemental truth — would liken the optimal human existence to a river

Couple this particular fragment of Thoreau's abidingly insightful ***A Week on the Concord and Merrimack Rivers***- which also gave us his wisdom on the difference between an artisan, an artist, and a — with his contemporary Frederick Douglass on art as a tool of social change, then revisit Thoreau on nature as prayer, the myth of productivity, knowing vs. seeing, and defining your own success.



A Philosopher Claims that AI Can't Be an Artist



Portrait of Edmond Bellamy (2018) Created with AI algorithms called GANs by Parisian art collective Obvious, sold for \$432,500.



Creativity is, and always will be, a human endeavor.

In the February 21, 2019 issue of the MIT TECHNOLOGY REVIEW Sean Dorrance Kelly, Philosophy Professor at Harvard, published this advocacy for humans in creativity. It is worth considering – before it is too late.

On March 31, 1913, in the Great Hall of the Musikverein concert house in Vienna, a riot broke out in the middle of a performance of an orchestral song by Alban Berg. Chaos descended. Furniture was broken. Police arrested the concert's organizer for punching Oscar Straus, a little-remembered composer of operettas. Later, at the trial, Straus quipped about the audience's frustration. The punch, he insisted, was the most harmonious sound of the entire evening. History has rendered a different verdict: the concert's conductor, Arnold Schoenberg, has gone down as perhaps the most creative and influential composer of the 20th century.

You may not enjoy Schoenberg's dissonant music, which rejects conventional tonality to arrange the 12 notes of the scale according to rules that don't let any predominate. But he changed what humans understand music to be. This is what makes him a genuinely creative and innovative artist. Schoenberg's techniques are now integrated seamlessly into everything from film scores and Broadway musicals to the jazz solos of Miles Davis and Ornette Coleman.

Creativity is among the most mysterious and impressive achievements of human existence. But what is it? Creativity is not just novelty. A toddler may hit a novel sequence of notes, but they're not, in any meaningful sense, creative. Also, creativity is bounded by history: what counts as creative inspiration in one period or place might be disregarded as ridiculous, stupid, or crazy in another. A community must accept ideas as good for them to count as creative. As in Schoenberg's case, or that of any number of other modern artists, that acceptance need not be universal. It might, indeed, not come for years—sometimes creativity is mistakenly dismissed for generations. But unless an innovation is eventually accepted by some community of practice, it makes little sense to speak of it as creative.

Advances in artificial intelligence have led many to speculate that human beings will soon be replaced by machines in every domain, including that of creativity. Ray Kurzweil, a futurist, predicts that by 2029 we will have produced an AI that can pass for an average educated human being. Nick Bostrom, an Oxford philosopher, is more



circumspect. He does not give a date but suggests that philosophers and mathematicians defer work on fundamental questions to “*superintelligent*” successors, which he defines as having “*intellect that greatly exceeds the cognitive performance of humans in virtually all domains of interest.*” Both believe that once human-level intelligence is produced in machines, there will be a burst of progress—what Kurzweil calls the “*singularity*” and Bostrom an “*intelligence explosion*”—in which machines will very quickly supersede us by massive measures in every domain. This will occur, they argue, because superhuman achievement is the same as ordinary human achievement except that all the relevant computations are performed much more quickly, in what Bostrom dubs “*speed superintelligence.*”

So, what about the highest level of human achievement—creative innovation? Are our most creative artists and thinkers about to be massively surpassed by machines?

No.

Human creative achievement, because of the way it is socially embedded, will not succumb to advances in artificial intelligence. To say otherwise is to misunderstand both what human beings are and what our creativity amounts to. This claim is not absolute: it depends on the norms that we allow to govern our culture and our expectations of technology. Human beings have, in the past, attributed great power and genius even to lifeless totems. It is entirely possible that we will come to treat artificially intelligent machines as so vastly superior to us that we will naturally attribute creativity to them. Should that happen, it will not be because machines have outstripped us. It will be because we will have denigrated ourselves. Human creative achievement, because of the way it is socially embedded, will not succumb to advances in artificial intelligence. Also, I am primarily talking about machine advances of the sort seen recently with the current deep-learning paradigm, as well as its computational successors. Other paradigms have governed AI research in the past. These have already failed to realize their promise. Still other paradigms may come in the future, but if we speculate that some notional future AI whose features we cannot meaningfully describe will accomplish wondrous things, that is mythmaking, not reasoned argument about the possibilities of technology.

Creative achievement operates differently in different domains. I cannot offer a complete taxonomy of the different kinds of creativity here, so to make the point I will sketch an argument involving three quite different examples: music, games, and mathematics.



Music to my ears



In *Imaginary Landscape (2018)*

Nao Tokui uses a machine-learning algorithm to create panoramas from images found in Google Street View and complements them with soundscapes created with artificial neural networks.

Can we imagine a machine of such superhuman creative ability that it brings about changes in what we understand music to be, as Schoenberg did?

That's what I claim a machine cannot do. Let's see why.

Computer music composition systems have existed for quite some time. In 1965, at the age of 17, Kurzweil himself, using a precursor of the pattern recognition systems that characterize deep-learning algorithms today, programmed a computer to compose recognizable music. Variants of this technique are used today. Deep-



learning algorithms have been able to take as input a bunch of Bach chorales, for instance, and compose music so characteristic of Bach's style that it fools even experts into thinking it is original. This is mimicry. It is what an artist does as an apprentice: copy and perfect the style of others instead of working in an authentic, original voice. It is not the kind of musical creativity that we associate with Bach, never mind with Schoenberg's radical innovation.

So, what do we say? Could there be a machine that, like Schoenberg, invents a whole new way of making music? Of course, we can imagine, and even make, such a machine. Given an algorithm that modifies its own compositional rules, we could easily produce a machine that makes music as different from what we now consider good music as Schoenberg did then.

But this is where it gets complicated.

We count Schoenberg as a creative innovator not just because he managed to create a new way of composing music but because people could see in it a vision of what the world should be. Schoenberg's vision involved the spare, clean, efficient minimalism of modernity. His innovation was not just to find a new algorithm for composing music; it was to find a way of thinking about what music *is* that allows it to speak to *what is needed now*. Some might argue that I have raised the bar too high. Am I arguing, they will ask, that a machine needs some mystic, unmeasurable sense of what is socially necessary in order to count as creative? I am not—for two reasons.

First, remember that in proposing a new, mathematical technique for musical composition, Schoenberg changed our understanding of what music is. It is only creativity of this tradition-defying sort that requires some kind of social sensitivity. Had listeners not experienced his technique as capturing the anti-traditionalism at the heart of the radical modernity emerging in early-20th-century Vienna, they might not have heard it as something of aesthetic worth. The point here is that radical creativity is not an "accelerated" version of quotidian creativity. Schoenberg's achievement is not a faster or better version of the type of creativity demonstrated by Oscar Straus or some other average composer: it's fundamentally different in kind.

Second, my argument is not that the creator's responsiveness to social necessity must be conscious for the work to meet the standards of genius. I am arguing instead



that *we must be able to interpret the work as responding that way*. It would be a mistake to interpret a machine's composition as part of such a vision of the world. The argument for this is simple.

Claims like Kurzweil's that machines can reach human-level intelligence assume that to have a human mind is just to have a human brain that follows some set of computational algorithms—a view called computationalism. But though algorithms can have moral implications, they are not themselves moral agents. We can't count the monkey at a typewriter who accidentally types out *Othello* as a great creative playwright. If there is greatness in the product, it is only an accident. We may be able to see a machine's product as great, but if we know that the output is merely the result of some arbitrary act or algorithmic formalism, we cannot accept it as the expression of a vision for human good. For this reason, it seems to me, nothing but another human being can properly be understood as a genuinely creative artist. Perhaps AI will someday proceed beyond its computationalist formalism, but that would require a leap that is unimaginable now. We wouldn't just be looking for new algorithms or procedures that simulate human activity; we would be looking for new materials that are the basis of being human.

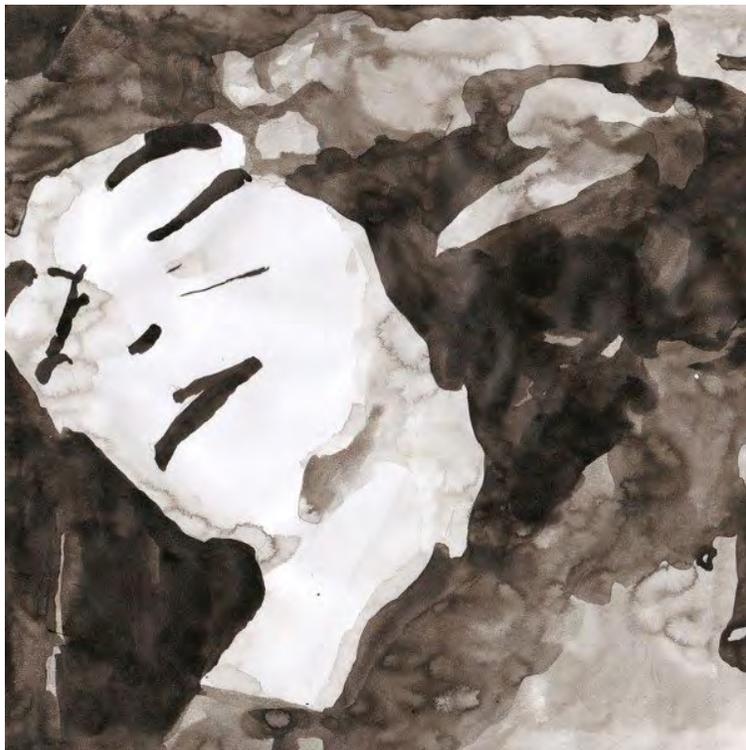
A molecule-for-molecule duplicate of a human being would be human in the relevant way. But we already have a way of producing such a being: it takes about nine months. Now, a machine can only do something much less interesting than what a person can do. It can create music in the style of Bach, for instance—perhaps even music that some experts think is better than Bach's own. But that is only because its music can be judged against a preexisting standard. What a machine cannot do is bring about changes in our standards for judging the quality of music or of understanding what music is or is not. This is not to deny that creative artists use whatever tools they have at their disposal, and that those tools shape the sort of art they make. The trumpet helped Davis and Coleman realize their creativity. But the trumpet is not, itself, creative. Artificial-intelligence algorithms are more like musical instruments than they are like people. Taryn Southern, a former *American Idol* contestant, recently released an album where the percussion, melodies, and chords were algorithmically generated, though she wrote the lyrics and repeatedly tweaked the instrumentation algorithm until it delivered the results she wanted. In the early 1990s, David Bowie did it the other way around: he wrote the music and used a Mac



app called Verbalizer to pseudo-randomly recombine sentences into lyrics. Just like previous tools of the music industry—from recording devices to synthesizers to samplers and loopers—new AI tools work by stimulating and channeling the creative abilities of the human artist (and reflect the limitations of those abilities).

Games without frontiers

Much has been written about the achievements of deep-learning systems that are now the best Go players in the world. AlphaGo and its variants have strong claims to having created a whole new way of playing the game. They have taught human experts that opening moves long thought to be ill-conceived can lead to victory. The program plays in a style that experts describe as strange and alien. *“They’re how I imagine games from far in the future,”* Shi Yue, a top Go player, said of AlphaGo’s play.



Anna Ridler’s The Fall of the House of Usher (2017)

A 12-minute animation based on Watson and Webber’s 1928 silent film. Ridler created the stills using three separate neural nets: one trained on her drawings, a second trained on drawings made of the results of the first net, and a third trained on drawings made of the results of the second.



The algorithm seems to be genuinely creative. In some important sense, it is. Game-playing, though, is different from composing music or writing a novel: in games, there is an objective measure of success. We know we have something to learn from AlphaGo because we see it win.

But that is also what makes Go a “*toy domain*,” a simplified case that says only limited things about the world.

The most fundamental sort of human creativity changes our understanding of ourselves because it changes our understanding of what we count as good. For the game of Go, by contrast, the nature of goodness is simply not up for grabs: A Go strategy is good if and only if it wins. Human life does not generally have this feature: there is no objective measure of success in the highest realms of achievement. Certainly not in art, literature, music, philosophy, or politics. Nor, for that matter, in the development of new technologies.

In various toy domains, machines may be able to teach us about a certain very constrained form of creativity. But the domain’s rules are pre-formed; the system can succeed only because it learns to play well within these constraints. Human culture and human existence are much more interesting than this. There are norms for how human beings act, of course. But creativity in the genuine sense is the ability to change those norms in some important human domain. Success in toy domains is no indication that creativity of this more fundamental sort is achievable.

It’s a knockout

A skeptic might contend that the argument works only because I’m contrasting games with *artistic* genius. There are other paradigms of creativity in the scientific and mathematical realm. In these realms, the question isn’t about a vision of the world. It is about the way things actually are.

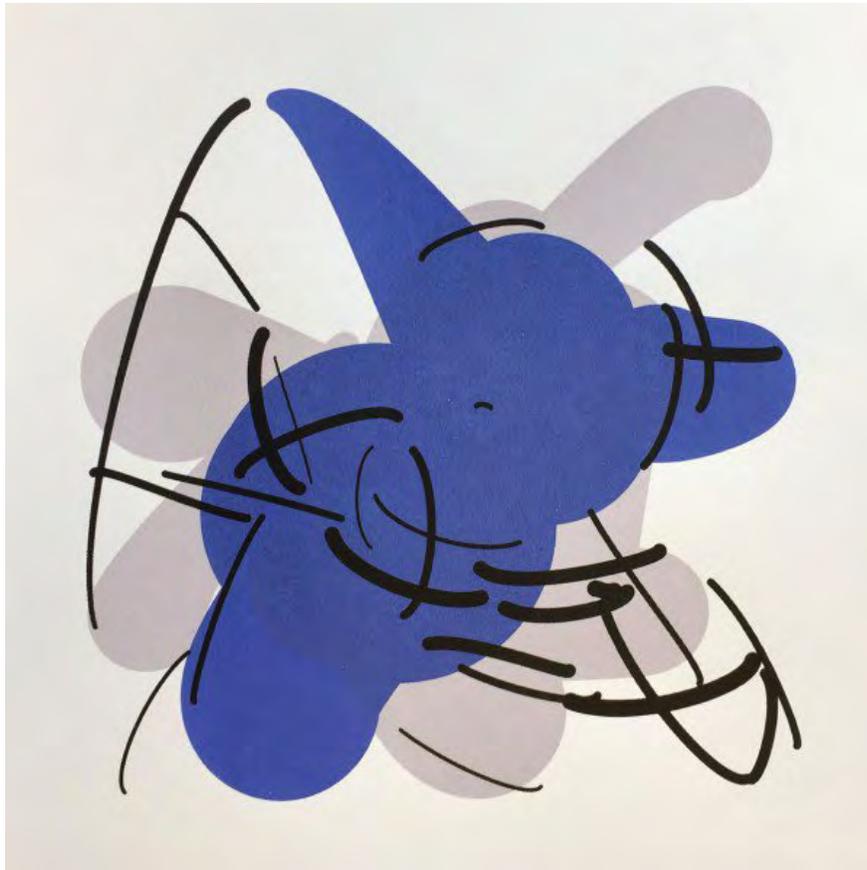
Might a machine come up with mathematical proofs so far beyond us that we simply must defer to its creative genius? **No.**

Computers have already assisted with notable mathematical achievements. But their contributions haven’t been particularly creative. Take the first major theorem proved using a computer: the four-color theorem, which states that any flat map can



be colored with at most four colors in such a way that no two adjacent “countries” end up with the same one (it also applies to countries on the surface of a globe).

Nearly a half-century ago, in 1976, Kenneth Appel and Wolfgang Haken at the University of Illinois published a computer-assisted proof of this theorem. The computer performed billions of calculations, checking thousands of different types of maps—so many that it was (and remains) logistically unfeasible for humans to verify that each possibility accorded with the computer’s view. Since then, computers have assisted in a wide range of new proofs.



Electric Fan (2018)

Tom White uses “perception engines,” algorithms that distill the data collected from thousands of photographs of common objects, to synthesize abstract shapes. He then tests and refines the results until they are recognizable by the system. Courtesy of Tom White, mas ’98, drib.net

But the supercomputer is not doing anything creative by checking a huge number of cases. Instead, it is doing something boring a huge number of times. This seems like



almost the opposite of creativity. Furthermore, it is so far from the kind of *understanding* we normally think a mathematical proof should offer that some experts don't consider these computer-assisted strategies mathematical proofs at all. As Thomas Tymoczko, a philosopher of mathematics, has argued, if we can't even verify whether the proof is correct, then all we are really doing is trusting in a potentially error-prone computational process. Even supposing we do trust the results, however, computer-assisted proofs are something like the analogue of computer-assisted composition. If they give us a worthwhile product, it is mostly because of the contribution of the human being. But some experts have argued that artificial intelligence will be able to achieve more than this. Let us suppose, then, that we have the ultimate: a self-reliant machine that proves new theorems all on its own.

Could a machine like this massively surpass us in mathematical creativity, as Kurzweil and Bostrom argue? Suppose, for instance, that an AI comes up with a resolution to some extremely important and difficult open problem in mathematics. The capacity for genuine creativity, the kind of creativity that updates our understanding of the nature of being, is at the ground of what it is to be human.

There are two possibilities. The first is that the proof is extremely clever, and when experts in the field go over it they discover that it is correct. In this case, the AI that discovered the proof would be applauded. The machine itself might even be considered to be a creative mathematician. But such a machine would not be evidence of the singularity; it would not so outstrip us in creativity that we couldn't even understand what it was doing. Even if it had this kind of human-level creativity, it wouldn't lead inevitably to the realm of the superhuman.

Some mathematicians are like musical virtuosos: they are distinguished by their fluency in an existing idiom. But geniuses like Srinivasa Ramanujan, Emmy Noether, and Alexander Grothendieck arguably reshaped mathematics just as Schoenberg reshaped music. Their achievements were not simply proofs of long-standing hypotheses but new and unexpected forms of reasoning, which took hold not only on the strength of their logic but also on their ability to convince other mathematicians of the significance of their innovations. A notional AI that comes up with a clever proof to a problem that has long befuddled human mathematicians is akin to AlphaGo and its variants: impressive, but nothing like Schoenberg.

That brings us to the other option. Suppose the best and brightest deep-learning



algorithm is set loose and after some time says, “*I’ve found a proof of a fundamentally new theorem, but it’s too complicated for even your best mathematicians to understand.*”

This isn’t actually possible. A proof that not even the best mathematicians can understand doesn’t count as a proof. Proving something implies that you are proving it to *someone*. Just as a musician must persuade her audience to accept her aesthetic concept of what is good music, a mathematician must persuade other mathematicians that there are good reasons to believe her vision of the truth. To count as a valid proof in mathematics, a claim must be understandable and endorsable by some independent set of experts who are in a good position to understand it. If the experts who should be able to understand the proof can’t, then the community refuses to endorse it as a proof. For this reason, mathematics is more like music than one might have thought. A machine could not surpass us massively in creativity because either its achievement would be understandable, in which case it would not massively surpass us, or it would not be understandable, in which case we could not count it as making any creative advance at all.

The eye of the beholder

Engineering and applied science are, in a way, somewhere between these examples. There is something like an objective, external measure of success. You can’t “*win*” at bridge building or medicine the way you can at chess, but one can see whether the bridge falls or the virus is eliminated. These objective criteria come into play only once the domain is fairly well specified: coming up with strong, lightweight materials, say, or drugs that combat particular diseases. An AI might help in drug discovery by, in effect, doing the same thing as the AI that composed what sounded like a well-executed Bach cantata or came up with a brilliant Go strategy. Like a microscope, telescope, or calculator, such an AI is properly understood as a tool that enables human discovery—not as an autonomous creative agent.

It’s worth thinking about the theory of special relativity here. Albert Einstein is remembered as the “*discoverer*” of relativity—but not because he was the first to come up with equations that better describe the structure of space and time. George Fitzgerald, Hendrik Lorentz, and Henri Poincaré, among others, had written down



those equations before Einstein. He is acclaimed as the theory's discoverer because he had an original, remarkable, and true understanding of what the equations *meant* and could convey that understanding to others.

For a machine to do physics that is in any sense comparable to Einstein's in creativity, it must be able to persuade other physicists of the worth of its ideas at least as well as he did. Which is to say, we would have to be able to accept its proposals as aiming to *communicate their own validity to us*. Should such a machine ever come into being, as in the parable of Pinocchio, we would have to treat it as we would a human being. That means, among other things, we would have to attribute to it not only intelligence but whatever dignity and moral worth is appropriate to human beings as well. We are a long way off from this scenario, it seems to me, and there is no reason to think the current computationalist paradigm of artificial intelligence—in its deep-learning form or any other—will ever move us closer to it.

Creativity is one of the defining features of human beings. The capacity for genuine creativity, the kind of creativity that updates our understanding of the nature of being, that changes the way we understand what it is to be beautiful or good or true—that capacity is at the ground of what it is to be human. But this kind of creativity depends upon our valuing it, and caring for it, as such. As the writer Brian Christian has pointed out, human beings are starting to act less like beings who value creativity as one of our highest possibilities, and more like machines themselves.

How many people today have jobs that require them to follow a predetermined script for their conversations? How little of what we know as real, authentic, creative, and open-ended human conversation is left in this eviscerated charade? How much is it like, instead, the kind of rule-following that a machine can do? And how many of us, insofar as we allow ourselves to be drawn into these kinds of scripted performances, are eviscerated as well? How much of our day do we allow to be filled with effectively machine-like activities—filling out computerized forms and questionnaires, responding to click-bait that works on our basest, most animal-like impulses, playing games that are designed to optimize our addictive response? We are in danger of this confusion in some of the deepest domains of human achievement as well. If we allow ourselves to say that machine proofs we cannot understand are genuine "*proofs*," for example, ceding social authority to machines, we will be treating the achievements of mathematics as if they required no human understanding at all. We will be taking



one of our highest forms of creativity and intelligence and reducing it to a single bit of information: yes or no.



The Butcher's Son (2018)

Mario Klingemann used two GANs, one trained on a data set of human poses and one trained on pornography, to render thousands of composite images. After evaluating each for pose and detail, he chose one to refine into the finished work. Courtesy of the Artist

Even if we had that information, it would be of little value to us without some understanding of the reasons underlying it. We must not lose sight of the essential character of reasoning, which is at the foundation of what mathematics is.

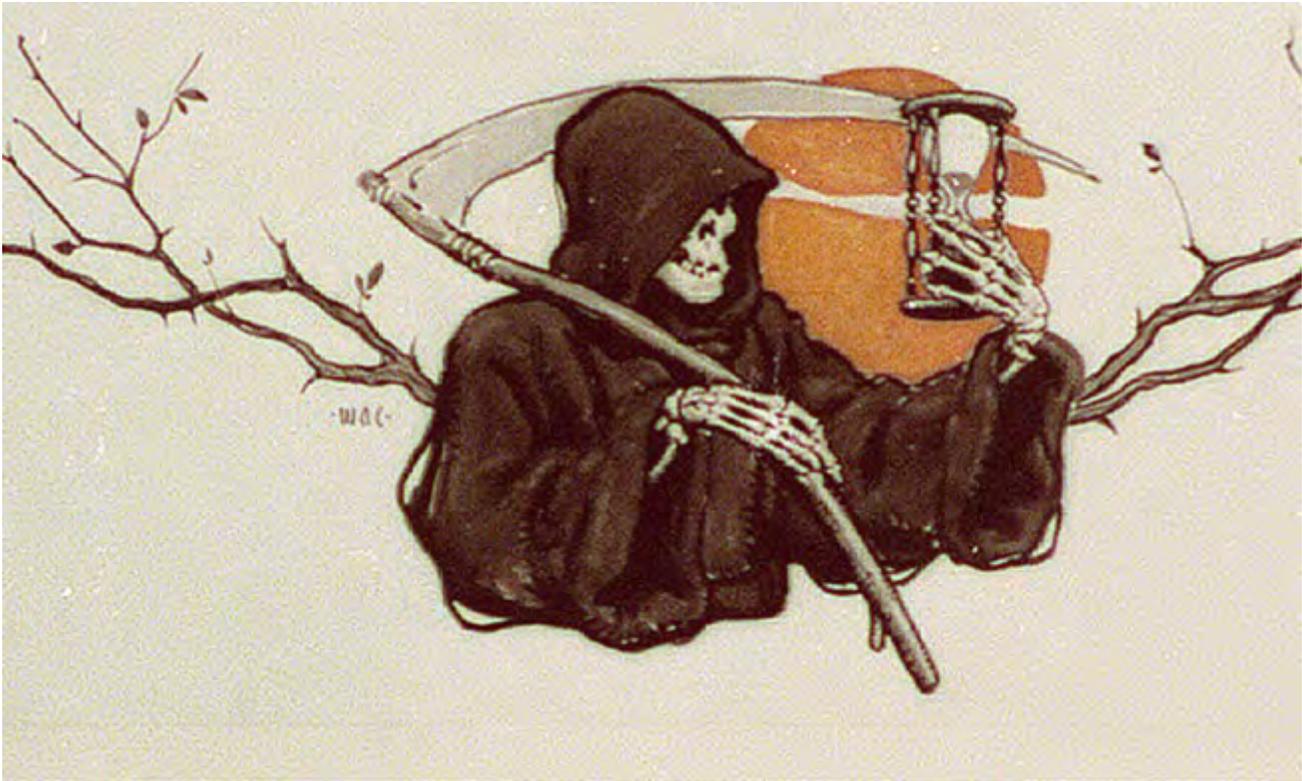
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So too with art and music and philosophy and literature. If we allow ourselves to slip in this way, to treat machine “*creativity*” as a substitute for our own, then machines will indeed come to seem incomprehensibly superior to us. But that is because we will have lost track of the fundamental role that creativity plays in being human.



Death is no leveler if some live much longer than others



The Grim Reaper against a Red Sunset. 1905, by Walter Appleton Clark.
Credit: Library of Congress

As long as there has been inequality among humans, death has been seen as the great leveler. Just like the rest of us, the rich and powerful have had to accept that youth is fleeting, that strength and health soon fail, and that all possessions must be relinquished within a few decades. It's true that the better-off have, on average, lived longer than the poor (in 2017, the least deprived 10th of the UK population had a life expectancy seven to nine years longer than the most deprived one), but this is because the poor are more exposed to life-shortening influences, such as disease and bad diet, and receive poorer healthcare, rather than because the rich can extend their lives. There has been an absolute limit on human lifespan (no one has lived more than 52 years beyond the biblical threescore and ten), and those who have



approached that limit have done so thanks to luck and genetics, not riches and status. This inescapable fact has profoundly shaped our society, culture and religion, and it has helped to foster a sense of shared humanity. We might despise or envy the privileged lives of the ultrarich, but we can all empathize with their fear of death and their sadness at the loss of loved ones.

Yet this might soon change dramatically. Ageing and death are not inevitable for all living things. For example, the hydra, a tiny freshwater polyp related to jellyfish, has an astonishing capacity for self-regeneration, which amounts to '*biological immortality*'. Scientists are now beginning to understand the mechanisms involved in ageing and regeneration (one factor seems to be the role of FOXO genes, which regulate various cellular processes), and vast sums are being invested in research into slowing or reversing ageing in humans. Some anti-ageing therapies are already in clinical trial, and though we should take the predictions of life-extension enthusiasts with a pinch of salt, it is likely that within a few decades we will have the technology to extend the human lifespan significantly. There will no longer be a fixed limit on human life.

What effects will this have on society? As Linda Marsa pointed out in an Aeon essay, life extension threatens to compound existing inequalities, enabling those who can afford the latest therapies to live increasingly longer lives, hoarding resources and increasing the pressure on everyone else. If we don't provide equitable access to anti-ageing technology, Marsa suggests, a '*longevity gap*' will develop, bringing with it deep social tensions. Life extension will be the great unleveler.

Some think this fear is well founded and want to highlight another aspect of it. A longevity gap would involve a difference, not only in the quantity of life, but in its very nature. Life extension will transform the way we think of ourselves and our lives, creating a profound psychological gap between those who have it and those who don't. Here's what I mean. We are, in a fundamental sense, *transmitters*, who preserve what we inherit and pass it on to the next generation. From a biological perspective, we are transmitters of genes – '*gigantic lumbering robots*', in Richard Dawkins's colorful phrase, built by natural selection to replicate our DNA. We are also transmitters of cultural artifacts– words, ideas, knowledge, tools, skills and so on –and any civilization is the product of the gradual accumulation and refinement of such artifacts over many generations. We are not narrowly bound by these roles,



however. Our genes and culture have enabled us to create societies in which we can pursue personal interests and projects of no direct reproductive or survival value. (As the psychologist Keith Stanovich puts it we lumbering robots can *rebel* against the genes that created us.) We can become consumers, collectors and creators – indulging our sensual appetites, amassing possessions and knowledge, and expressing ourselves through art and physical activity. But even so, we soon realize that our time is limited and that, if we want our projects, possessions and memory to endure, we must find people who will care for them when we are gone. Death encourages the most self-absorbed of us to become transmitters of one kind or another. Readers of George Eliot’s novel *Middlemarch* (1871) will remember her portrait of the self-centered scholar Edward Casaubon, who as death approaches becomes pathetically desperate for his young wife to continue his researches.

Life extension will change this. Those with extended lives will not have the same sense of transience that we have. They will be able to indulge themselves without worrying that they are wasting precious years, since they can expect plenty of time ahead in which to get around to less frivolous things. They probably won’t feel any urgency to share their projects with others, knowing that they are likely to possess them for many more years, and they might hoard knowledge and culture as well as material possessions. They could spend years cultivating their minds, bodies and aesthetic sensibilities, and become obsessed with perfecting themselves, not worrying that old age and death will soon undermine all this effort. They might also feel themselves superior to those with natural lifespans. They could see their extended life as a symbol of high status, like a luxury home or a yacht. They might feel self-important in a deeper way, too. The philosopher Daniel Dennett has described the self as a kind of *fiction*– the imagined narrator of the unfolding story we tell about our attitudes, experiences, motives, projects and careers. These narratives are in fact constructed on the fly, by a collection of somewhat disunified brain systems, but we interpret them as reports of a unified persisting self. Those with extended lives will be able to spin much richer and more optimistic life stories, full of self-improvement and self-cultivation, and containing far fewer incidents of loss and grief (assuming their loved ones have extended lives too). Thus, they might see their selves –the implied narrators of these fascinating multivolume narratives– as more intrinsically valuable than the selves of people with unextended lives, who can tell only sad short stories.

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Of course, even the longevity-rich will eventually have to face up to their own mortality, but for many decades they will be able to live as possessors and accumulators rather than as transmitters. By the individualistic standards of modern Western society, they will be hugely privileged over those with unextended lives – members of an alien species almost. It is not too hard to imagine violent scenarios in which the impoverished transients rise up against the sybaritic extended class. Fritz Lang’s movie *Metropolis* (1927) will look prophetic. This doesn’t mean that life extension will inevitably be a bad thing. It’s what we do with our extended lives that matters. The danger lies in removing the check on self-indulgence that death provides, and in the deep new inequalities that its removal could create. Perhaps we will be able to mitigate the latter by making life-extension technology widely available, though that would itself bring risks of overpopulation and resource depletion. At any rate, if we want to maintain a stable society, we will need to find some way of counterbalancing the loss of the levelling influence that death exerts, and of maintaining the sense of humility and shared humanity that it fosters.



Credit: Tumblr



Against Moral Sainthood

'I am glad,' wrote the acclaimed American philosopher Susan Wolf, 'that neither I nor those about whom I care most' are 'moral saints'. This declaration is one of the opening remarks of a landmark essay in which Wolf imagines what it would be like to be morally perfect. If you engage with Wolf's thought experiment, and the conclusions she draws from it, then you will find that it offers liberation from the trap of moral perfection. Wolf's essay '*Moral Saints*' (1982) imagines two different models of the moral saint, which she labels the Loving Saint and the Rational Saint. The **Loving Saint**, as described by Wolf, does whatever is morally best in a joyful spirit: such a life is not fun-free, but it is unerringly and unwaveringly focused on morality. We are to think of the Loving Saint as the kind of person who cheerfully sells all of her or his possessions in order to donate the proceeds to famine relief. **The Rational Saint** is equally devoted to moral causes, but is motivated not by a constantly loving spirit, rather by a sense of duty.

The Loving Saint might be more fun to be around than the Rational Saint, or more maddening, depending on your own personal temperament. Would the constant happiness of the Loving Saint make being with her easier, or would it drive you around the bend? There is an instruction associated with Buddhism –in fact, coined by the American scholar Joseph Campbell– that asks you to '*participate joyfully in the sorrows of the world*', and the Loving Saint does this to the maximum: but perhaps you would find such joy sustained in the face of the world's worst horrors inane or inappropriate. On the other hand, the Rational Saint, with his relentless commitment to duty, might be very grating company, too. Both types of moral saint are likely to present difficulties if you are not a saint yourself. Would they be constantly bothering you and urging you to give more? Perhaps they have joined the effective altruism movement and are repeatedly suggesting the most effective ways that you can use your time and disposable income to help. How does such a person make you feel when you give much of your spare time and attention not to Oxfam but to video games? And when you give a sizeable chunk of your spare income to luxuries such as wine and chocolate rather than providing others with basic nutrition? Do you want to be friends with someone whose 100 per cent moral focus always seems, in effect, to be encouraging you to feel guilty?



The aspiration to be a moral saint, Wolf suggests, might turn someone into a nightmare to live with and be around. The British writer Nick Hornby offers a comic version of this scenario in his novel *How to be Good* (2001). But perhaps a true saint, being as decent a person as possible, wouldn't want you to feel bad all the time: what would be good about that? In fact, wouldn't true moral saints be as sensitive about their effect on your life as they are about their effect on the world at large? Wolf suggests that the problem then would be that the moral saint would have to hide her true thoughts about your degree of moral commitment. Moreover, can a moral saint laugh sincerely at your cynical jokes when they cut, as Wolf says, against the moral grain? And, in any case, when would they have the time to hang out with you? If they are morally perfect, then they have far more morally important things to be doing.

It's not only friends that don't really fit into a life devoted to maximum moral achievement. Can the moral saint, if perfect, 'waste' time watching films and television? How about spending any money on fine food or travel? Or expending energy on sport rather than seriously important causes? Or going birdwatching or hiking? No time either for theatre or the pleasures of curling up with a good book. The problem with extreme altruism, as Oscar Wilde is reported to have said about socialism, is that it takes up too many evenings. Moral saints might be able to find time for some of these activities when they happen to coincide with their ethical projects: watching sport, for example, at a charity fundraiser; or admiring the scenery *en route* to a troubled hotspot in need of aid. But these experiences must be seen as lucky extras if the only aim in life is to do as much moral good as possible. If you don't have enough time for friendship or fun, or works of art or wildlife, then you are missing out on what Wolf calls the non-moral part of life. Wolf does not mean to suggest that non-moral equals immoral: just because something doesn't have anything to do with morality (playing tennis, for instance) it does not follow that it is therefore morally bad. The point is that morality is, intuitively, focused on issues such as treating others equally, and on trying to relieve suffering. And good things these are: but so is holidaying with a friend, or exploring the Alaskan rain forest, or enjoying a curry. Moral goodness is just one aspect of the good things in life and, if you live as if the moral aspect is the only aspect that matters, then you are likely to be very impoverished in terms of the non-moral goods in your life. And that means missing out on a lot.



Wolf imagines the Loving Saint as perfectly happy to live a life in which non-moral goods play no part. The ultra-ascetic moral life –no friendships, no hobbies, no distractions from the ethical– doesn't come at a cost for the Loving Saint in terms of contentment. But Wolf wonders how this can be. Does the Loving Saint not see everything that he is missing out on and, if so, how can this not affect his happiness? Perhaps, Wolf suggests, the Loving Saint is almost missing a piece of perceptual equipment: an ability to see that there is more to life than morality. Perhaps this explains why the Loving Saint can stay happy. By contrast, Wolf does not suppose that the Rational Saint fails to see that there is a huge area of life that she is missing out on. Wolf imagines the Rational Saint persisting in her barren life through a sense of duty alone. But why go so far as to live a life entirely and exclusively devoted to moral causes? Wolf suggests answers that makes the Rational Saint look not so rational after all: perhaps self-loathing and/or a pathological fear of damnation.

Wolf's two versions of moral sainthood are modelled on the two most influential moral philosophies of modern Western philosophy: utilitarianism (which inspires Wolf's Loving Saint) and Kantianism (which inspires the Rational Saint). What would your life be like, Wolf asks, if you lived these moral worldviews to the max? Wolf suggests that neither worldview, if lived comprehensively, delivers a very appealing life: each, as we have seen, produces a vision of the good life that consists so thoroughly in devotion to the needs of others that there is no time for personal enjoyment of the many non-moral good things in life –no time, in fact, for a life of one's own. You would spend your whole existence, to echo some words of Bernard Williams, as a servant of the morality system. It is a significant feature of both utilitarianism and Kantianism that neither value personal happiness very highly, if at all. Utilitarianism is a philosophy of 'the greatest happiness of the greatest number' and so, if the needs of the many require you to make enormous personal sacrifices, including sacrificing your happiness, then so be it. Wolf rightly imagines the perfect utilitarian, the Loving Saint, as a happy person: and indeed, that would be ideal. But no one should become a utilitarian for reasons of their own personal happiness or wellbeing: that isn't the point of utilitarian morality. Your individual happiness, considered in the context of billions of conscious lives, is just a drop in the ocean. If doing the right thing for the general good – e.g. selling your main assets and devoting the proceeds to charitable action – would make you unhappy, then that's a shame, but your unhappiness doesn't stop the right thing from being the right thing. Kantian



morality is even less concerned with personal happiness. Kantianism, derived from and named after the 18th-century philosopher Immanuel Kant, is a philosophy that emphasizes our rational responsibility to other rational beings (hence Wolf's '*Rational Saint*' label). The reason to do the right thing is because it is your duty to others, not because it will make you happy. If other rational beings need our aid – if they are starving or oppressed, for example – then we owe it to them, just as they would owe it to us if the positions were reversed. Kant did think that being moral made you worthy of happiness but that was all he would allow. One suspects that, had he lived to hear it, Kant would have liked the remark attributed to the 20th-century Austrian philosopher Ludwig Wittgenstein: I don't know why we are here, but I'm pretty sure that it is not in order to enjoy ourselves. If modern moral theories, followed as ideals, produce unappealing visions of life, then you might think that something is wrong with the theories themselves. Perhaps what is needed is a more well-rounded conception of the good life. In fact, you might believe it a sign that things have gone badly wrong with regard to modern morality that the expression '*the good life*' has become ambiguous. The expression is ambiguous because you must ask: do you mean by '*the good life*' the *morally good life* or the *most desirable life*? The former perhaps conjures up images of tending to the poor, and the latter images of tending to a glass of Champagne. The morally good life has become identified with a life of selfless altruism and the most desirable life with a life of self-focused pleasure-seeking. The good life has therefore become split in two opposing directions, and the resulting huge schism seems a cause for concern.

These reflections, among others, might send one in the direction of Ancient Greek virtue ethics in search of views that predate the schism. Many of the most famous philosophers of the period, Aristotle most notably, held views of ethics that encouraged neither selfishness nor selflessness: the best kind of life would be concerned with others, and involve pleasurable engagement with others' lives, but it would not require impartial dedication to the needs of strangers. Ethics is more concerned with the question of how to be a good friend than it is the question of how to save the world. And, as with good friendships, ethics is both good for you and good for other people. At the heart of Aristotle's ethics is the ultimate win-win. The best ethical life simply is the most desirable life, and the fulfilment of our social nature consists in living in mutual happiness with others. Ancient views such as Aristotle's therefore render the schism between morality and personal happiness



inconceivable. Wolf, in depicting moral sainthood in unappealing terms, could easily be misinterpreted as encouraging a return to views such as Aristotle's. But a careful reading of *'Moral Saints'* makes clear that Wolf has no such intention. The fact that modern morality has evolved to include extensive responsibilities towards strangers is not something that Wolf wishes to undo. She is quite content to leave the concept of modern morality as it is: strongly altruistic, impartial and global in its reach. It's quite right that morality concerns the lives of strangers thousands of miles away and that, as far as morality is concerned, the value of a stranger's life is equal to that of one of your near and dear. Wolf sees that, given the terrible state of the world, this leaves so much moral work to be done that it could entirely consume one's life. One could become, or aim to become, a moral saint. But this is not a reason, for Wolf, to reject modern morality. What she does think it shows is that a line must be drawn between what is morally required of you and that which is morally praiseworthy but not morally required (what philosophers sometimes term the *supererogatory*). Morality doesn't oblige you to become a moral saint. Morality doesn't require you to have no other interests besides morality. You have a life. Having a life doesn't mean that you don't take morality seriously or that you have given up on trying to be a decent person. It's a trap to think that choosing not to be a saint automatically means that you should be a sinner. And this has a moral point: rejecting the idea that you should aim to score 10/10 for morality is no excuse for a low score either. In *'Moral Saints'*, Wolf offers a critique of moral sainthood that is also, once properly understood, a defense of morality. She has developed a compelling case for rejecting a way of life guided solely by moral demands, but this does not mean that she wants to throw the moral baby out with the saintly bathwater.

One ongoing theme in Wolf's philosophy is that it isn't the wisest idea to look to moral theories in order to find comprehensive ideals of how to live. Moral concepts mark out very important areas of life but don't tell us everything about life or how to live it. It's therefore not a criticism of a moral theory that life wouldn't be very appealing if we transformed the theory in question into our sole answer to life's questions. That would be to misunderstand the role of a moral theory. Wolf, in putting moral theory in its place, wants to liberate moral philosophy from some of its excessive moralism. We can be inspired in how to live by all sorts of sources: a lover we met online, a neighbor, a character in a TV series, a line of poetry. Wolf is particularly interested in leaving room for individual interests and passions to shape one's life and thinks



that meaning in life is unlikely to come from morality as such. In part, this is because meaning often comes from commitment to your loved ones, and on numerous occasions your commitment to family and friends will come ahead of your commitment to doing what would be morally ideal. Take an example from a recent psychological study by researchers at Oxford and Yale: if you are committed to your grandson, then you might give him money to fix his car ahead of helping a charity dedicated to combating malaria, even if doing the latter would do more good. The fact that you are not morally perfect doesn't make you a bad person. You can be '*perfectly wonderful*', as Wolf says, '*without being perfectly moral*'.

You might find meaning in life from a specific moral cause –working to prevent homelessness for example– but that's different from trying to find meaning by doing whatever is morally ideal on every occasion. Indeed, the individual character of your life is given by its concrete combination of relationships, passions and interests. Wolf, against the current of much popular philosophical thought, holds the view that meaning in life depends on spending your life absorbed in activities that are *objectively good*. '*Meaning in life arises,*' as Wolf says in a brilliant slogan, '*when subjective attraction meets objective attractiveness ...*' But the objective goods that typically provide meaning are, according to Wolf, the non-moral goods that a moral saint's life would be so sorely lacking in: loving relationships (including friendships), engagement with the natural world, love of fine art or great sport, and so on. These non-moral goods will in practice be *instantiated* (as philosophers say) in an actual life: in my case, a loving relationship is, for example, a 20-year friendship with Chris; an engagement with the natural world is a nightly walk through Wicken Fen in Cambridgeshire; a love of fine art is a love of Frida Kahlo's paintings; a love of great sport is a Saturday afternoon following the football. We each have our own subjective attractions to the good things in life. '*Time,*' as the poet Nick Laird wrote, '*is how you spend your love.*'

Nature lovers aren't typically concerned about Nature in the abstract but rather about specific goings-on that they are directly involved with: how will the puffins cope at Bempton Cliffs now that the sand eels have been overfished, and so on. You might, however, start out with a love of the puffins and end up joining a moral cause to save them: perhaps a local environmental movement. And this could be taken as evidence that Wolf's strong distinction between the moral and the non-moral is, in

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practice, blurry. Love can take you from a non-moral interest to a moral commitment, and it might be hard to specify where that line is crossed. You might, for example, work as a benefits officer and come to like a particular resident of your district. Concern for her grows into concern over the policies that are changing her life and her family's life for the worse. You could come to be rather saint-like in your dedication to getting the policies changed. But, if you have absorbed Wolf's lessons, you will not throw away your whole life for the sake of the cause. You will continue to make time for friends, for lazy summer nights watching the bees hum in the lavender, and you won't lose that brilliantly sarcastic sense of humor. You won't become, in other words, a moral saint.



Einstein's Solution to Productivity



Credit: Reuters/*Lucy Nicholson*

In 1902, a young, depressed, and solemn 21-year-old Albert Einstein was on the verge of giving up on his dream of becoming a physicist. Six years prior, Einstein had enrolled in a Mathematics and Physics teaching diploma at the Swiss Federal Polytechnic in Zurich, Switzerland, where he frequently skipped classes and spent his spare time wooing girls, whilst playing his violin at ladies' luncheons and cocktail parties.

Because of his devil-may-care attitude, Einstein's professors cast him aside as a lazy student destined for a mediocre career in physics. And after graduating, Einstein couldn't get a job -in fact, he was passed over for a role as a lab assistant, and even contemplated selling insurance. After two frustrating years of job hunting, Einstein moved to Bern to work as a clerk in the Swiss patent office. Working six days a week as a patent clerk, Einstein could barely find any time to develop his scientific ideas and would eventually give up on a career in physics.

Or would he?

In March 1905, Einstein submitted a paper that challenged the general consensus that light was a wave, and instead proposed that it was a particle. Two months later,



in May 1905, Einstein submitted a second paper. This time he challenged widely held beliefs that atoms didn't exist and provided proofs of their existence.

But Einstein wasn't done yet.

In June 1905, Einstein submitted a third paper—the granddaddy of them all. Einstein proposed the idea that time and space were the same and formalized his thoughts as the special theory of relativity. Then, in September 1905, Einstein published a fourth paper as a follow-up to the previous one. He suggested that mass and energy were equivalent and derived the most famous equation in the history of mankind: $E=MC^2$. In the years to come, these four papers -produced during “*Einstein's Miracle Year*” -would radically transform the way humans understand the world.

And by the end of his career, Einstein would publish over 300 scientific papers, receive a Nobel Prize in Physics, and firmly establish himself as one of the greatest physicists of all time.

So, here's a puzzling question: How is it possible that this failed scientist and unknown 26-year-old clerk destined for a mediocre life could suddenly produce four groundbreaking papers within the span of a year, that would change the course of history? And what's the most important lesson on productivity and success that we can learn from Einstein?

The cult of extreme productivity

“If you're lonely when you're alone, you're in bad company.” - Jean-Paul Sartre

We live in a world that rewards busyness and the idea of “*getting things done*”: an addictive rat race to cross off as many things from your to-do list, as fast as possible. Because of this viral hype, we bury ourselves in busyness and attempt to achieve much more than we're capable of. Each day, we create unrealistic expectations to respond to every single email in our inbox, spend quality time with our family and friends, exercise, read a book, sleep by 10 pm, and so on. But these superhuman attempts to get so much done, and the constant bombardment of new productivity tips, hacks, and gadgets, leads to procrastination, stress, burnout, and disappointment. Worst of all, the cult of extreme productivity has robbed us off the ability of enjoying our own company.



A study conducted at the University of Virginia discovered that participants would rather subject themselves to electric shocks than be left alone with their thoughts. Likewise, in our everyday lives, we distract ourselves with social media, emails, and new goals and ideas, to avoid being alone with our thoughts. The cult of extreme productivity has sold us the lie that boredom should be avoided at all costs, and doing nothing at all is an unproductive strategy for lazy people. Yet, it is during moments of solitude that we can discover ingenious solutions to familiar problems and gain clarity to make better decisions.

A time to do nothing but be alone

In his book, *Einstein: His Life and Universe*, biographer and historian Walter Isaacson shares Einstein's thoughts on the need for solitude: *"I am truly a 'lone traveler' and have never belonged to my country, my home, my friends, or even my immediate family, with my whole heart; in the face of all these ties, I have never lost a sense of distance and a need for solitude."*

From his youth, Einstein had a habit of spending a lot of time away from his friends, family, and work, to do nothing but think. He would regularly go for long walks, wander off to quiet cabins in the mountains, play his violin, or sail the seas with his wooden boat to find serenity. It was during these moments of solitude that Einstein would discover ingenious solutions to difficult problems: *"He would often play his violin in his kitchen late at night, improvising melodies while he pondered complicated problems. Then, suddenly in the middle of playing, he would announce excitedly, I've got it!"*

Ironically, Einstein often lamented about the distractions of communication devices his discoveries later created. In a letter to his friend, he wrote, *"How conducive to thinking and working the long sea voyage is -a paradisaical state without correspondence, visits, meetings, and other inventions of the devil!"* If Einstein were alive today, he'd be labeled a loner in need of more social time. But without his solitude, he'd never have achieved an extraordinary level of success in his lifetime.

Coincidentally, throughout history, there's a theme of great thinkers -leaders, scientists, entrepreneurs, writers, religious figures, artists- who regularly sought



solitude to rejuvenate and refine their thoughts: Leonardo da Vinci, Martin Luther King, Nietzsche, Jesus Christ, Nikola Tesla, and Ernest Hemingway, to name a few. Likewise, practicing solitude would help to improve our productivity, creativity, and decision-making in everyday life.

For example, I take daily walks in our quiet *garden*, travel without headphones, and spend a few days in on our deck, surrounded by flowers and redwoods. And I can say without a shadow of doubt, that my breakthrough ideas and clarity on crucial life decisions, have shown up during these moments of solitude. Simply block out a few minutes each day to be alone and do nothing at all. By doing so, you'll tap into your inner genius and uncover the most effective ways to take action.

Embrace solitude

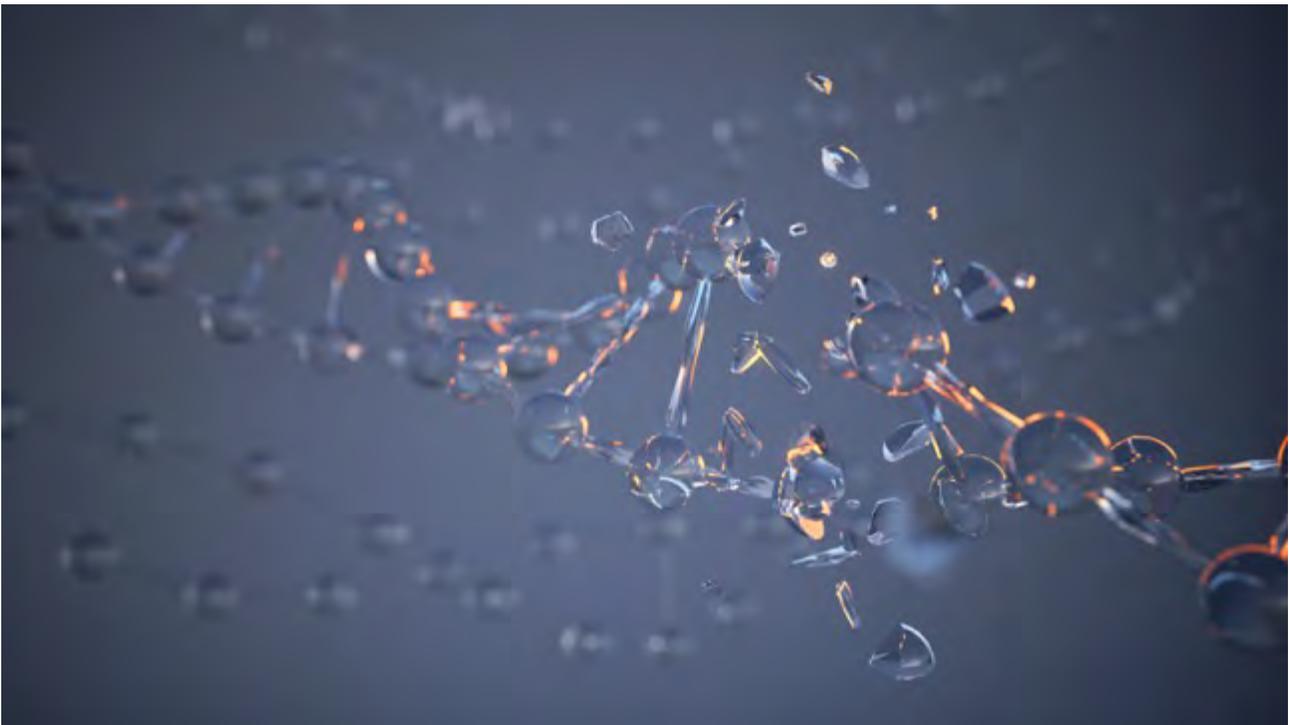
"Writing, at its best, is a lonely life." Ernest Hemingway

In our pursuit of "*getting more things done*," we've lost sight of the true meaning of productivity. Productivity isn't about getting more things done, rather it's about getting the **right** things done, while doing less. The best way to figure out the right things to focus on and the best ways to tackle them is to spend more time alone with your thoughts and embrace solitude. And just like Einstein, you'll achieve much more and unleash your potential.



Fragile DNA Enables New Adaptations to Evolve Quickly

If highly repetitive gene-regulating sequences in DNA are easily lost, then that may explain why some adaptations evolve quickly and repeatedly.



Stretches of DNA that are rich in certain repeated sequences are “fragile” and can be lost easily, introducing mutations. They can be harmful, but they might also be the key to why some adaptations evolve repeatedly – Credit: **Olena Shmahalo**/Quanta Magazin

Evolutionary biologists have puzzled over why nature, with vast genetic resources at its disposal, sometimes seems stuck in a rut. Against the odds, separate species and populations independently evolve the same solutions to life’s challenges, and the same genes are recruited to mutate and enable certain adaptations again and again. Now researchers at Stanford University think they have found part of the answer, at least for the fish called three-spine sticklebacks (*Gasterosteus aculeatus*). According

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to a recent study described in *Science*, the stickleback's DNA has fragile “hot spots” that are predisposed to break and mutate more often, with an accompanying loss of traits. The result is that these fish rapidly evolve the same adaptation — the loss of a pair of fins on their pelvis — repeatedly. The discovery serves as a reminder that when looking at how mutations help with “survival of the fittest,” it’s also important to consider why those mutations occurred — “*arrival of the fittest*,” according to David Kingsley, the evolutionary geneticist whose lab conducted the study. This work is “*raising the specter that not all sites in the genome are equal. Some places are going to be more prone to mutation, and those may be meaningful for the repeated adaptation of populations*,” said Sean B. Carroll, professor of biology at the University of Maryland and the director of science education at the Howard Hughes Medical Institute, who was not involved in the study. “*I think that’s fascinating.*”

About 10,000 years ago, the end of the last ice age created many new freshwater lakes and streams, as retreating glaciers filled depressions in the land with meltwater and some shifting waterways lost what had been their direct connections to the ocean. For some marine three-spine sticklebacks that lived off the coast but migrated inland to breed, this change in the landscape had huge consequences because they became trapped in the new lakes.



In marine populations, the three-spine stickleback (*Gasterosteus aculeatus*) has a pair of pelvic fins on its underside. Evolution has repeatedly favored the loss of those fins in sticklebacks that adapted to life in freshwater lakes and streams – Credit: blickwinkel/Teigler



As these freshwater populations evolved in their new habitats, they frequently developed the same adaptations in parallel, one of which was the loss of their pelvic fin. No one is certain why evolution repeatedly favored that change, but it's possible that the loss of the pelvic fins reduced the burden of building bone in freshwater environments where calcium and phosphate are limited. It may also have made it easier for the freshwater sticklebacks to evade some local predators.

For evolutionary geneticists who study the fish, like those in Kingsley's laboratory, an obvious question was whether the parallel losses of the pelvic fin resulted from the same genetic changes or from different ones.



As a graduate student at Stanford University, the geneticist **Kathleen Xie** became curious about why the repeated evolutionary loss of the pelvic fin in freshwater sticklebacks always involved the same gene - Credit: **Rod Searcey** Photography

There are many ways to “break” the development of a trait, just as there are many ways to break a complex piece of machinery, so there's no a priori reason to think that the mutations would always occur in the same part of the genome. But work in the Kingsley laboratory from 2010 and 2012 showed that the same genetic mechanisms were involved over and over again. The fish always seemed to lose a specific DNA regulatory region called the *Pel* enhancer, which drives the expression of a protein involved in pelvic fin development. “*So, there was a surprising predictability to the genetic pathways that the fish were using as they adapted to a given set of environmental conditions,*” Kingsley said. Kathleen Xie, who is now a research fellow at the Dana-Farber Cancer Institute in Boston, became curious about what molecular mechanism was making that evolutionary change so reproducible, and she made that question the focus of her doctoral thesis work in Kingsley's laboratory.

One possible explanation was that the marine sticklebacks had already carried a rare mutation for the loss of the pelvic fin, one that arose in their ancestors. Once in fresh water, the stickleback populations could “*reach into a bag of previously invented*



tricks,” Kingsley said, and put that existing mutation to a new use. But that’s not what was happening: In each population, brand-new mutations were occurring in the *Pel* enhancer, Kingsley said. And in every case, the mutation involved the loss of hundreds to thousands of DNA base pairs.

When Xie, Kingsley and their lab colleagues looked more closely at the original marine form of the sticklebacks’ *Pel* enhancer, they found that it was unusually fragile: It broke 25 to 50 times more frequently than DNA sequences typically do. It also contained exceptionally long strings of alternating guanine and tyrosine DNA bases (GT repeats). The classic DNA structure is a right-handed double helix called B-DNA, but DNA can assume other structures, too. A string of GT repeats, however, can locally alter the structure to something more unusual, such as left-handed (or Z) DNA, which is prone to errors and breakage because cells have difficulty replicating it accurately. The fragility of the *Pel* sequence depends on the length of its string of GT repeats as well as the position of those repeats relative to where on the DNA the replication process begins. *“This is very interesting because any of those properties would be easy to change over the course of evolution,”* Kingsley noted. If you altered the length of the GTs, changed the orientation of the GTs, or changed whether they’re replicated on the upper or the lower strand of DNA, all those features can alter the fragility of the sequence and therefore the rate of mutation, he explained. Fragile DNA is normally bad for cells because it is associated with cancer and gene disruption. But in this case, for the fragility of the *Pel* enhancer to have survived, the strange sequences might also have provided some advantages.

It’s easy to fall into the mistake of thinking that the main advantage was that fragility made the *Pel* gene highly evolvable so that it could enable an important adaptation if needed. But natural selection doesn’t place bets on traits that might be adaptive someday. Instead, Xie and Kingsley’s preferred hypothesis is that gene expression, not mutability, was the key: If the GT repeats stimulate gene expression in marine sticklebacks, then evolution may have originally favored them for helping those fish produce long, robust pelvic fins. Adding and subtracting repeats would then have been an easy way to fine-tune the expression of the genes involved in pelvic fin development. Once the same letters are repeated by chance a few times, Kingsley explained, *“the local repeat has a natural tendency to grow and shrink because of alignment errors that can occur between DNA strands during recombination or DNA*



replication.” The fortuitous side effect was that the long sequence of GT repeats was also fragile and mutable. “*The very tunability of the expression also makes them prone to ‘snapping the knob off’ the control panel completely,*” Kingsley said, which could lead to a major change in body structure when the fishes’ environment changed drastically.

A mutation from the breakage of fragile DNA is different from the mutations caused by randomly arising single-nucleotide changes. When a fragile region breaks, it changes hundreds or thousands of base pairs – eliminating substantial chunks of regulatory sequences in one fell swoop. That allows for the rapid evolution of big, novel traits, not just the fine-tuning of existing features in the organism’s phenotype, or physical characteristics. “*So, I think they have a higher phenotypic effect than simply making a single base pair change,*” Kingsley said.



According to the evolutionary geneticist **David Kingsley**, the new findings in sticklebacks underscore the importance of understanding why particular mutations arise frequently, not just what they do — the “arrival of the fittest” as well as the “survival of the fittest.” – Credit:

Cynthia Kingsley

In this way, a bigger DNA lesion may produce a bigger change in the phenotype, which is then subject to stronger positive or negative selection, he added. According to population genetics, a large mutation with a strong phenotypic effect has a higher chance of becoming fixed in a population, Kingsley said. In contrast, single base-pair mutations would be more likely to be lost randomly through a process of genetic drift. “*You have to think about both the ‘arrival of the fittest’ and ‘the survival of the fittest,’*” Kingsley said. “*Nonrandom biochemical properties are influencing the spectrum of mutations offered up to evolution,*” and that can lead to the reuse of the same genetic mechanisms when an environment selects for a particular trait.

Kingsley’s team has found at least 100 other locations in the marine sticklebacks’ genome that have abundant GT repeats, and they suspect those

regions have similar fragility because they are often absent from the fishes’ freshwater descendants. The researchers are now investigating which traits are



linked to those sequences. When the marine fish were adapting to fresh water, the loss of fragile DNA regions might have made traits other than the pelvic fin disappear — but Kingsley thinks it's at least plausible that some of those DNA losses also triggered the emergence of entirely novel features in the freshwater species.

Michi Tobler, an evolutionary biologist at Kansas State University who studies parallel adaptations among fishes that live in highly toxic hydrogen sulfide springs in Mexico, is more skeptical of that possibility. If an organism needs a new trait to adapt to a novel environment, he said, *"I'm not sure how that would happen through this increased likelihood of deletions in the genome that they're documenting."* But he agreed that the model Xie and Kingsley have suggested could be fruitful. *"What the study has given us is a really new and exciting avenue to look at this problem of mutational input and how it shapes evolution,"* he said. *"We have something to look for now."* Carroll made a similar point: *"The interesting thing here is that if this mechanism operates at other loci [positions in the genome], we're really going to want to understand the origins of these sequences and the forces that influence their gain, loss and retention in populations,"* he said. *"I think people are going to pay attention because they'll look around and say, 'Hey, is anything like this going on in something I'm studying?'"*

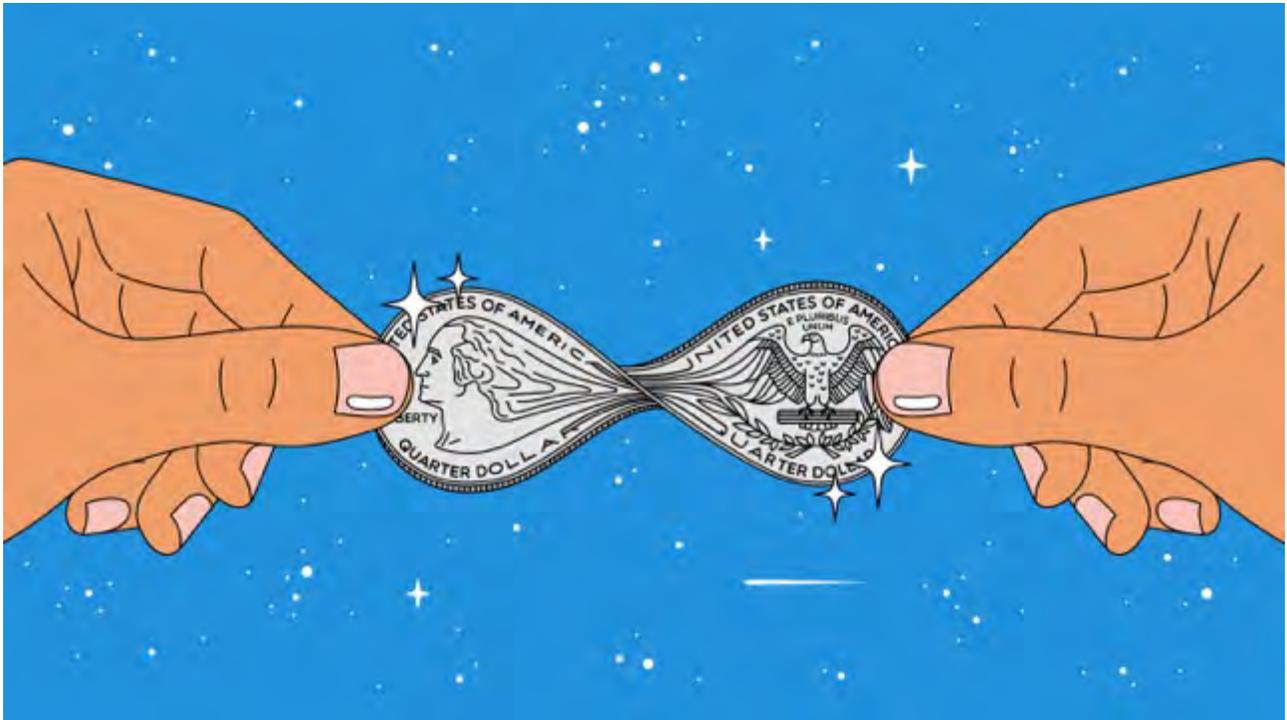
It's currently unclear how much evolution and adaptation are affected by mutation mechanisms like DNA fragility that produce unusual structural changes in the genome. Researchers have tended to focus on single nucleotide changes, Kingsley said, because simple nucleotide changes are easy to score in genome analyses. Mechanisms that generate large mutations at elevated rates may be understudied. But these large-effect mutations may play a more important role than has generally been acknowledged, Kingsley argues, especially in species with relatively small populations and long generation times, like humans. In a 2010 study, he and his colleagues showed that in the evolution of humans since our ancestors split from those of chimpanzees more than 5 million years ago, about half of the molecular changes that natural selection favored were the result of mechanisms that produced frequent mutations. *"And that's just the cases we already know about,"* he wrote in an email. The new findings have sensitized Kingsley and his colleagues to the fact that, as in these fish, the genetic changes driving a species' rapid evolution may not spread throughout a population purely because of their beneficial effects; they may also



have special properties that make them occur more frequently. *“That lesson,”* he wrote, *“can only help in the search for the causal basis of other interesting traits, whether in sticklebacks, or humans or other species.”*

Quantum Paradox: Where Our Reality Goes Wrong

A thought experiment has shaken up the world of quantum foundations, forcing physicists to clarify how various quantum interpretations (such as many-worlds and the Copenhagen interpretation) abandon seemingly sensible assumptions about reality.



If a coin toss cannot be both heads and tails, physicists must jettison simple assumptions about the nature of reality. Credit: Allison Filice for Quanta Magazine



Anil Ananthaswamy – Credit Quanta Magazine

That quantum mechanics is a successful theory is not in dispute. It makes astonishingly accurate predictions about the nature of the world at microscopic scales. What has been in dispute for nearly a century is just what it's telling us about what exists, what is real. There are myriad interpretations that offer their own take on the question, each requiring us to buy into certain as-yet-unverified claims - hence assumptions - about the nature of reality.

Now, a new thought experiment is confronting these assumptions head-on and shaking the foundations of quantum physics. The experiment is decidedly strange. For example, it requires making measurements that can erase any memory of an event that was just observed. While this isn't possible with humans, quantum computers could be used to carry out this weird experiment and potentially discriminate between the different interpretations of quantum physics.

"Every now and then you get a paper which gets everybody thinking and discussing, and this is one of those cases," said Matthew Leifer, a quantum physicist at Chapman University in Orange, California. *"[This] is a thought experiment which is going to be added to the canon of weird things we think about in quantum foundations."* The experiment, designed by Daniela Frauchiger and Renato Renner, of the Swiss Federal Institute of Technology Zürich, involves a set of assumptions that on the face of it



seem entirely reasonable. But the experiment leads to contradictions, suggesting that at least one of the assumptions is wrong. The choice of which assumption to give up has implications for our understanding of the quantum world and points to the possibility that quantum mechanics is not a universal theory, and so cannot be applied to complex systems such as humans.

Quantum physicists are notoriously divided when it comes to the correct interpretation of the equations that are used to describe quantum goings-on. But in the new thought experiment, no view of the quantum world comes through unscathed. Each one falls afoul of one or another assumption. Could something entirely new await us in our search for an uncontroversial description of reality?



Credit: Quanta Magazine

Quantum theory works extremely well at the scale of photons, electrons, atoms, molecules, even macromolecules. But is it applicable to systems that are much, much larger than macromolecules? *“We have not experimentally established the fact that quantum mechanics applies on larger scales, and larger means even something the size of a virus or a little cell,”* Renner said. *“In particular, we don’t know whether it extends to objects the size of humans and even lesser, [whether] it extends to objects the size of black holes.”*

Despite this lack of empirical evidence, physicists think that quantum mechanics can be used to describe systems at all scales -meaning it’s universal. To test this assertion, Frauchiger and Renner came up with their thought experiment, which is an extension of something the physicist Eugene Wigner first dreamed up in the 1960s. The new experiment shows that, in a quantum world, two people can end up

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disagreeing about a seemingly irrefutable result, such as the outcome of a coin toss, suggesting something is amiss with the assumptions we make about quantum reality. In standard quantum mechanics, a quantum system such as a subatomic particle is represented by a mathematical abstraction called the wave function. Physicists calculate how the particle's wave function evolves with time.



Eugene Wigner, a Hungarian-American theoretical physicist, was one of the key minds behind the development of quantum theory. He was awarded the Nobel Prize in Physics in 1963. – Credit: Oak Ridge National Laboratory, U.S. Dept. of Energy

But the wave function does not give us the exact value for any of the particle's properties, such as its position. If we want to know where the particle is, the wave function's value at any point in space and time only lets us calculate the probability of finding the particle at that point, should we choose to look. Before we look, the wave function is spread out, and it accords different probabilities for the particle being in different places. The particle is said to be in a quantum superposition of being in many places at once. More generally, a quantum system can be in a superposition of states, where "state" can refer to other properties, such as the spin of a particle. Much of the Frauchiger-Renner thought experiment involves manipulating complex quantum objects -maybe even humans- that end up in superpositions of states.



The experiment has four agents: Alice, Alice's friend, Bob, and Bob's friend. Alice's friend is inside a lab making measurements on a quantum system, and Alice is outside, monitoring both the lab and her friend. Bob's friend is similarly inside another lab, and Bob is observing his friend and the lab, treating them both as one system. Inside the first lab, Alice's friend makes a measurement on what is effectively a coin toss designed to come up heads one-third of the time and tails two-thirds of the time. If the toss comes up heads, Alice's friend prepares a particle with spin pointing down, but if the toss comes up tails, she prepares the particle in a superposition of equal parts spin UP and spin DOWN. Alice's friend sends the particle to Bob's friend, who measures the spin of the particle. Based on the result, Bob's friend can now make an assertion about what Alice's friend saw in her coin toss. If he finds the particle spin to be UP, for example, he knows the coin came up tails.

How the Thought Experiment Works



Credit: *Lucy Reading-Ikkanda*/Quanta Magazine

The experiment continues. Alice measures the state of her friend and her lab, treating all of it as one quantum system, and uses quantum theory to make predictions. Bob



does the same with his friend and lab. Here comes the first assumption: An agent can analyze another system, even a complex one including other agents, using quantum mechanics. In other words, quantum theory is universal, and everything in the universe, including entire laboratories (and the scientists inside them), follows the rules of quantum mechanics. This assumption allows Alice to treat her friend and the lab as one system and make a special type of measurement, which puts the entire lab, including its contents, into a superposition of states. This is not a simple measurement, and herein lies the thought experiment's weirdness.

The process is best understood by considering a single photon that's in a superposition of being polarized horizontally and vertically. Say you measure the polarization and find it to be vertically polarized. Now, if you keep checking to see if the photon is vertically polarized, you will always find that it is. But if you measure the vertically polarized photon to see if it is polarized in a different direction, say at a 45-degree angle to the vertical, you'll find that there's a 50 percent chance that it is, and a 50 percent chance that it isn't. Now if you go back to measure what you thought was a vertically polarized photon, you'll find there's a chance that it's no longer vertically polarized at all -rather, it's become horizontally polarized. The 45-degree measurement has put the photon back into a superposition of being polarized horizontally and vertically. This is all very fine for a single particle, and such measurements have been amply verified in actual experiments. But in the thought experiment, Frauchiger and Renner want to do something similar with complex systems.

As this stage in the experiment, Alice's friend has already seen the coin coming up either heads or tails. But Alice's complex measurement puts the lab, friend included, into a superposition of having seen heads *and* tails. Given this weird state, it's just as well that the experiment does not demand anything further of Alice's friend.



Renato Renner, a physicist at the Swiss Federal Institute of Technology Zurich, devised the paradox along with Daniela Frauchiger, who left academia shortly thereafter.

Credit: ETH Zurich/**Giulia Marthaler**

Alice, however, is not done. Based on her complex measurement, which can come out as either YES or NO, she can infer the result of the measurement made by Bob's friend. Say Alice got YES for an answer. She can deduce using quantum mechanics that Bob's friend must have found the particle's spin to be UP, and therefore that Alice's friend got tails in her coin toss. This assertion by Alice necessitates another assumption about her use of quantum theory. Not only does she reason about what she knows, but she reasons about how Bob's friend used quantum theory to arrive at his conclusion about the result of the coin toss. Alice makes that conclusion her own. This assumption of consistency argues that the predictions made by different agents using quantum theory are not contradictory. Meanwhile, Bob can make a similarly complex measurement on his friend and his lab, placing them in a quantum superposition. The answer can again be YES or NO. If Bob gets YES, the measurement is designed to let him conclude that Alice's friend must have seen heads in her coin toss.

It's clear that Alice and Bob can make measurements and compare their assertions about the result of the coin toss. But this involves another assumption: If an agent's measurement says that the coin toss came up heads, then the opposite fact -that the coin toss came up tails- cannot be simultaneously true. The setup is now ripe for a contradiction. When Alice gets a YES for her measurement, she infers that the coin toss came up tails, and when Bob gets a YES for his measurement, he infers the coin toss came up heads. Most of the time, Alice and Bob will get opposite answers. But



Frauchiger and Renner showed that in 1/12 of the cases both Alice and Bob will get a YES in the same run of the experiment, causing them to disagree about whether Alice's friend got a heads or a tails. *"So, both of them are talking about the past event, and they are both sure what it was, but their statements are exactly opposite,"* Renner said. *"And that's the contradiction. That shows something must be wrong."*

This led Frauchiger and Renner to claim that one of the three assumptions that underpin the thought experiment must be incorrect.



Credit: Quanta Magazine

"The science stops there. We just know one of the three is wrong, and we cannot really give a good argument [as to] which one is violated," Renner said. *"This is now a matter of interpretation and taste."*

Fortunately, there are a wealth of interpretations of quantum mechanics, and almost all of them have to do with what happens to the wave function upon measurement. Take a particle's position. Before measurement, we can only talk in terms of the probabilities of, say, finding the particle somewhere. Upon measurement, the particle assumes a definite location. In the Copenhagen interpretation, measurement causes the wave function to collapse, and we cannot talk of properties, such as a particle's position, before collapse. Some physicists view the Copenhagen interpretation as an argument that properties are not real until measured.

This form of *"anti-realism"* was anathema to Einstein, as it is to some quantum physicists today. And so is the notion of a measurement causing the collapse of the wave function, particularly because the Copenhagen interpretation is unclear about



Quantum Contradictions

The Frauchiger-Renner thought experiment forces physicists to abandon one of three seemingly commonsense assumptions. Each of these assumptions corresponds to a leading interpretation of quantum mechanics.

ASSUMPTION:

Quantum Theory Is Universal

Everything in the universe, from small particles to large laboratories, follows the rules of quantum mechanics.



VIOLATED BY:

Theories that assert that **larger quantum systems will spontaneously collapse** into a classical state abandon this assumption.

ASSUMPTION:

Quantum Theory Is Consistent

The predictions made by different agents using quantum theory are not contradictory.



VIOLATED BY:

Theories such as QBism assert that the results of measurements **depend on the perspective of each individual observer.**

ASSUMPTION:

Opposite Facts Cannot Both Be True

If one statement is true, then its opposite cannot also be true.



VIOLATED BY:

In the many-worlds interpretation of quantum theory, **all possible outcomes of a measurement happen**; each is realized in its own universe.

exactly what constitutes a measurement. Alternative interpretations or theories

Credit: **Lucy Reading-Ikkanda**/Quanta Magazine



mainly try to either advance a realist view -that quantum systems have properties independent of observers and measurements- or avoid a measurement-induced collapse, or both. For example, the many-worlds interpretation takes the evolution of the wave function at face value and denies that it ever collapses. If a quantum coin toss can be either heads or tails, then in the many-worlds scenario, both outcomes happen, each in a different world. Given this, the assumption that there is only one outcome for a measurement, and that if the coin toss is heads, it cannot simultaneously be tails, becomes untenable. In many-worlds, the result of the coin toss is both heads and tails, and thus the fact that Alice and Bob can sometimes get opposite answers is not a contradiction.

"I have to admit that if you had asked me two years ago, I'd have said [our experiment] just shows that many-worlds is actually a good interpretation and you should give up the requirement that measurements have only a single outcome," Renner said.

This is also the view of the theoretical physicist David Deutsch of the University of Oxford, who became aware of the Frauchiger-Renner paper when it first appeared on arxiv.org. In that version of the paper, the authors favored the many-worlds scenario. (The latest version of the paper, which was peer reviewed and published in *Nature Communications* in September, takes a more agnostic stance.) Deutsch thinks the thought experiment will continue to support many-worlds. *"My take is likely to be that it kills wave-function-collapse or single-universe versions of quantum theory, but they were already stone dead,"* he said. *"I'm not sure what purpose it serves to attack them again with bigger weapons."* Renner, however, has changed his mind. He thinks the assumption most likely to be invalid is the idea that quantum mechanics is universally applicable.

This assumption is violated, for example, by so-called spontaneous collapse theories that argue -as the name suggests- for a spontaneous and random collapse of the wave function, but one that is independent of measurement. These models ensure that small quantum systems, such as particles, can remain in a superposition of states almost forever, but as systems get more massive, it gets more and more likely that they will spontaneously collapse to a classical state. Measurements merely discover the state of the collapsed system. In spontaneous collapse theories, quantum mechanics can no longer to be applied to systems larger than some threshold mass. And while these models have yet to be empirically verified, they haven't been ruled



out either. Nicolas Gisin of the University of Geneva favors spontaneous collapse theories as a way to resolve the contradiction in the Frauchiger-Renner experiment. *“My way out of their conundrum is clearly by saying, ‘No, at some point the superposition principle no longer holds,’”* he said.

“We have not experimentally established the fact that quantum mechanics applies on larger scales, and larger means even something the size of a virus or a little cell.” (Renato Renner).

If you want to hold on to the assumption that quantum theory is universally applicable, and that measurements have only a single outcome, then you’ve got to let go of the remaining assumption, that of consistency: The predictions made by different agents using quantum theory will not be contradictory. Using a slightly altered version of the Frauchiger-Renner experiment, Leifer has shown that this final assumption, or a variant thereof, must go if Copenhagen-style theories hold true. In Leifer’s analysis, these theories share certain attributes, in that they are universally applicable, anti-realistic (meaning that quantum systems don’t have well-defined properties, such as position, before measurement) and complete (meaning that there is no hidden reality that the theory is failing to capture). Given these attributes, his work implies that there is no single outcome of a given measurement that’s objectively true for all observers. So, if a detector clicked for Alice’s friend inside the lab, then it’s an objective fact for her, but not so for Alice, who is outside the lab modeling the entire lab using quantum theory. The results of measurements depend on the perspective of the observer. *“If you want to maintain the Copenhagen type of view, it seems the best move is towards this perspectival version,”* Leifer said. He points out that certain interpretations, such as quantum Bayesianism, or QBism, have already adopted the stance that measurement outcomes are subjective to an observer.

Renner thinks that giving up this assumption entirely would destroy a theory’s ability to be effective as a means for agents to know about each other’s state of knowledge; such a theory could be dismissed as solipsistic. So, any theory that moves toward facts being subjective must re-establish some means of communicating knowledge that satisfies two opposing constraints. First, it should be weak enough that it doesn’t provoke the paradox seen in the Frauchiger-Renner experiment. Yet it must also be strong enough to avoid charges of solipsism. No one has yet formulated



such a theory to everyone's satisfaction. The Frauchiger-Renner experiment generates contradictions among a set of three seemingly sensible assumptions. The effort to explicate how various interpretations of quantum theory violate the assumptions has been "*an extremely useful exercise*," said Rob Spekkens of the Perimeter Institute for Theoretical Physics in Waterloo, Canada.

"This thought experiment is a great lens through which to examine the differences of opinions between different camps on the interpretation of quantum theory," Spekkens said. *"I don't think it's really eliminated options that people were endorsing prior to the work, but it has clarified precisely what the different interpretational camps need to believe to avoid this contradiction. It has served to clarify people's position on some of these issues."*

Given that theoreticians cannot tell the interpretations apart, experimentalists are thinking about how to implement the thought experiment, in the hope of further illuminating the problem. But it will be a formidable task, because the experiment makes some weird demands. For example, when Alice makes a special measurement on her friend and her lab, it puts everything, the friend's brain included, into a superposition of states.

Mathematically, this complicated measurement is the same as first reversing the time evolution of the system -such that the memory of the agent is erased and the quantum system (such as the particle the agent has measured) is brought back to its original state- and then performing a simpler measurement on just the particle, said Howard Wiseman of Griffith University in Brisbane, Australia. The measurement may be simple, but as Gisin points out rather diplomatically, "*Reversing an agent, including the brain and the memory of that agent, is the delicate part.*" Nonetheless, Gisin is not averse to thinking that maybe, one day, the experiment could be done using complex quantum computers as the agents inside the labs (acting as Alice's friend and Bob's friend). In principle, the time evolution of a quantum computer can be reversed. One possibility is that such an experiment will replicate the predictions of standard quantum mechanics even as quantum computers get more and more complex. But it may not. "*Another alternative is that at some point while we develop these quantum computers, we hit the boundary of the superposition principle and [find] that actually quantum mechanics is not universal,*" Gisin said.

Leifer, for his part, is holding out for something new. "*I think the correct*

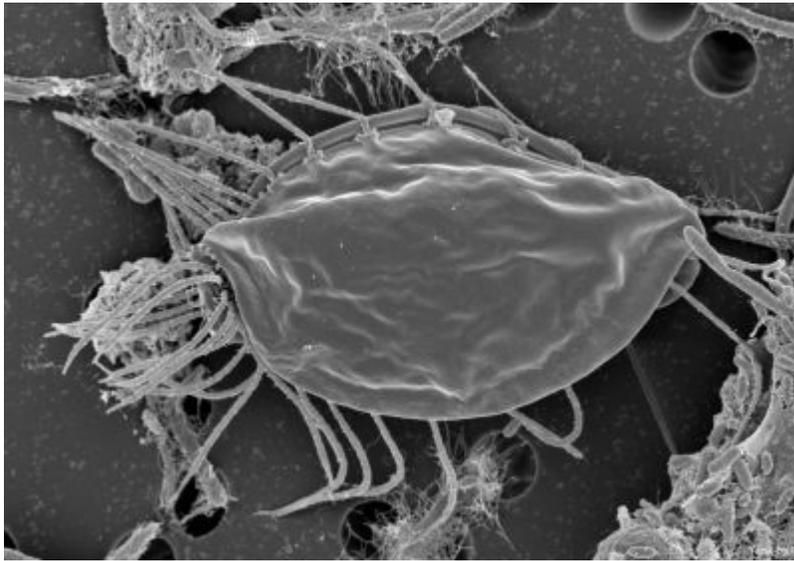


interpretation of quantum mechanics is none of the above,” he said. He likens the current situation with quantum mechanics to the time before Einstein came up with his special theory of relativity. Experimentalists had found no sign of the “luminiferous ether” - the medium through which light waves were thought to propagate in a Newtonian universe. Einstein argued that there is no ether. Instead he showed that space and time are malleable. “Pre-Einstein I couldn’t have told you that it was the structure of space and time that was going to change,” Leifer said. Quantum mechanics is in a similar situation now, he thinks. “It’s likely that we are making some implicit assumption about the way the world has to be that just isn’t true,” he said. “Once we change that, once we modify that assumption, everything would suddenly fall into place. That’s kind of the hope. Anybody who is skeptical of all interpretations of quantum mechanics must be thinking something like this. Can I tell you what’s a plausible candidate for such an assumption? Well, if I could, I would just be working on that theory.”



A Newfound Kingdom and the Tree of Life

Neither animal, plant, fungus nor familiar protozoan, a strange microbe that sits in its own “*supra-kingdom*” of life foretells incredible biodiversity yet to be discovered by new sequencing technologies.



A micrograph of *Hemimastix kukwesjijk*, the newly described hemimastigote named after a “*hairy, rapacious ogre*” from the traditions of the Mi’kmaq First Nation of Nova Scotia, where the specimen was collected. - Credit: **Yana Eglit**

The tree of life just got another major branch. Researchers recently found a certain rare and mysterious microbe called a hemimastigote in a clump of Nova Scotian soil. Their subsequent analysis of its DNA revealed that it was neither animal, plant, fungus nor any recognized type of protozoan - that it in fact fell far outside any of the known large categories for classifying complex forms of life (eukaryotes). Instead, this flagella-waving oddball stands as the first member of its own “*supra-kingdom*” group, which probably peeled away from the other big branches of life at least a billion years ago. “*It’s the sort of result you hope to see once in a career,*” said Alastair Simpson, a microbiologist at Dalhousie University who led the study.

Impressive as this finding about hemimastigotes is on its own, what matters more is that it’s just the latest (and most profound) of a quietly and steadily growing number



of major taxonomic additions. Researchers keep uncovering not just new species or classes but entirely new kingdoms of life -raising questions about how they have stayed hidden for so long and how close we are to finding them all.

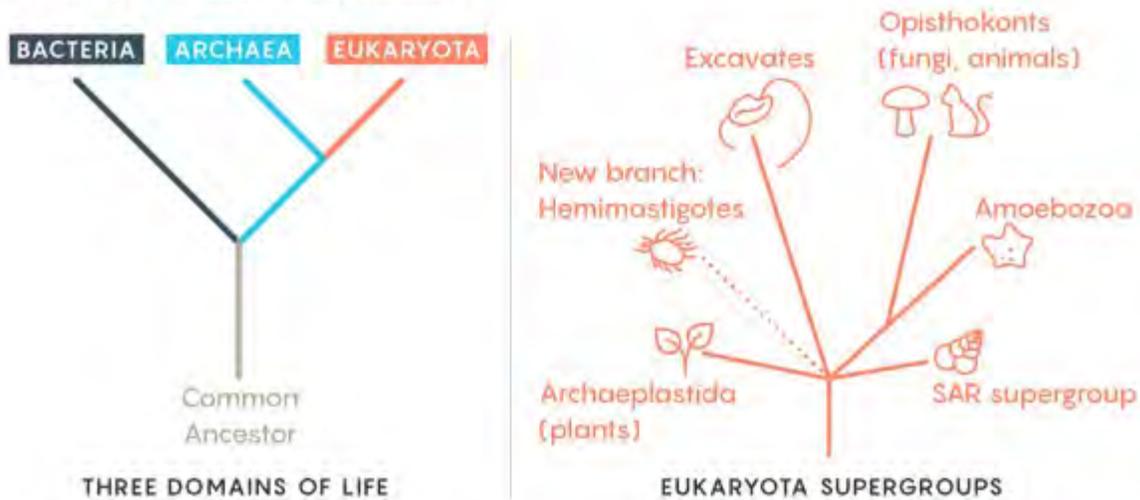
Yana Eglit is a Dalhousie graduate student dedicated to discovering novel lineages of the single-cell eukaryotes called protists. While hiking in Nova Scotia on a cold spring day in 2016, she fell back from her friends to scrape a few grams of dirt into a plastic tube. (Such impromptu soil sampling, she said, is “*a professional hazard.*”) Back in the lab, Eglit soaked her sample in water, and over the next month she periodically peeked at it through a microscope for signs of unusual life. Late one evening, something odd in the sample caught her eye. An elongated cell radiating whiplike flagella was “*awkwardly swimming, as though it didn’t realize it had all these flagella that could help it move,*” Eglit said. Under a more powerful scope, she saw it fit the description of a hemimastigote, a rare kind of protist that was notoriously hard to cultivate. The next morning, the lab was abuzz with excitement over the opportunity to describe and sequence the specimen. “*We dropped everything,*” she recalled.

Hemimastigotes represent one of a handful of Rumsfeldian “*known unknown*” protist lineages -moderately well-described groups whose positions on the tree of life are not precisely known because they are difficult to culture in a lab and sequence. Protistologists have used peculiarities of hemimastigotes’ structure to infer their close relatives, but their guesses were “*shotgunned’ all over the phylogeny,*” Simpson said. Without molecular data, lineages like hemimastigotes remain orphans of unknown ancestry. But a new method called single-cell transcriptomics has revolutionized such studies. It enables researchers to sequence large numbers of genes from just one cell. Gordon Lax, another graduate student in the Simpson lab and an expert on this method, explained that for hard-to-study organisms like hemimastigotes, single-cell transcriptomics can produce genetic data of a quality previously reserved for more abundant cells, making deeper genomic comparisons finally possible. The team sequenced more than 300 genes, and Laura Eme, now a postdoctoral researcher at Uppsala University, modeled how those genes evolved to infer a classification for hemimastigotes. “*We were fully expecting them to fall within one of the existing supergroups,*” she explained. Lab members were instead stunned to find that hemimastigotes fit nowhere on the tree. They represented their own distinct lineage apart from the other half-dozen super groups.



An Old, Unnoticed Branch on the Tree of Life

The place of hemimastigotes within Eukaryota (the domain of eukaryotes, or life with complex cells) has always been contested. But a new DNA analysis revealed that hemimastigotes represent a novel supergroup that split off from all the known ones more than a billion years ago. Because some supergroups do not have well-established names, this tree shows one major lineage they include.



Credit: **Lucy Reading-Ikkanda**/Quanta Magazine

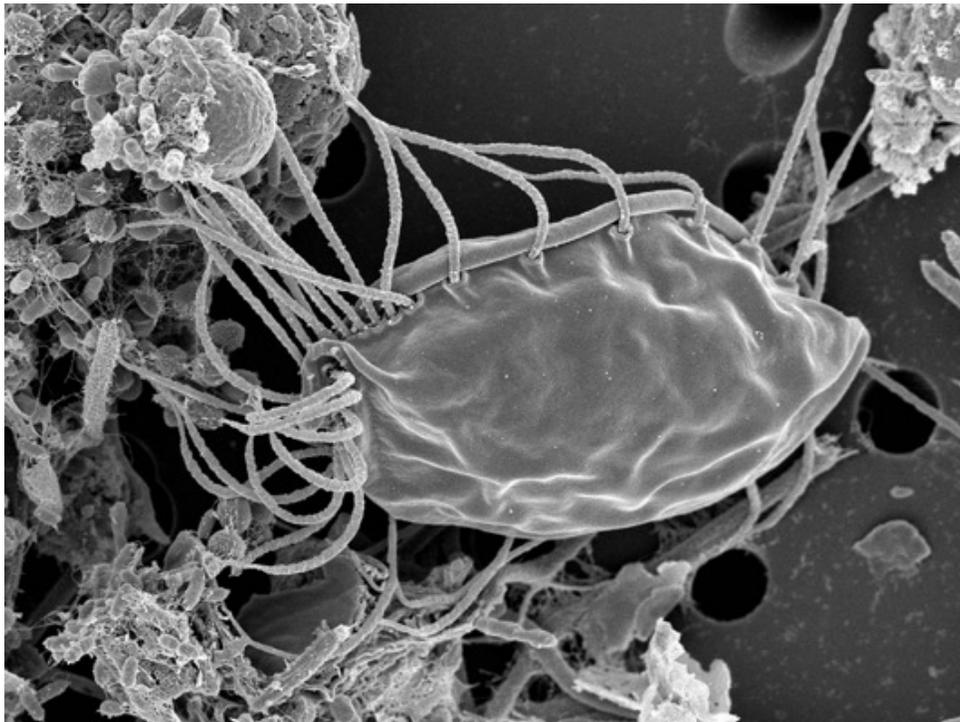
To understand how evolutionarily distinct the hemimastigote lineage is, imagine the eukaryotic tree splayed out before you on the ground as a narrowing set of paths, which begin with places for all living groups of eukaryotes near your toes and converge far in the distance at our common ancestor. Starting at our mammalian tip, walk down the path and back into history, past the fork where our lineage diverged from reptiles and birds, past the turnoffs for fishes, for starfish and for insects, and then farther still, beyond the split that separates us from fungi. If you turn around and look back, all the diverse organisms you passed fall within just one of the six eukaryote supergroups. Hemimastigotes are still up ahead, in a supergroup of their own, on a path that nothing else occupies.

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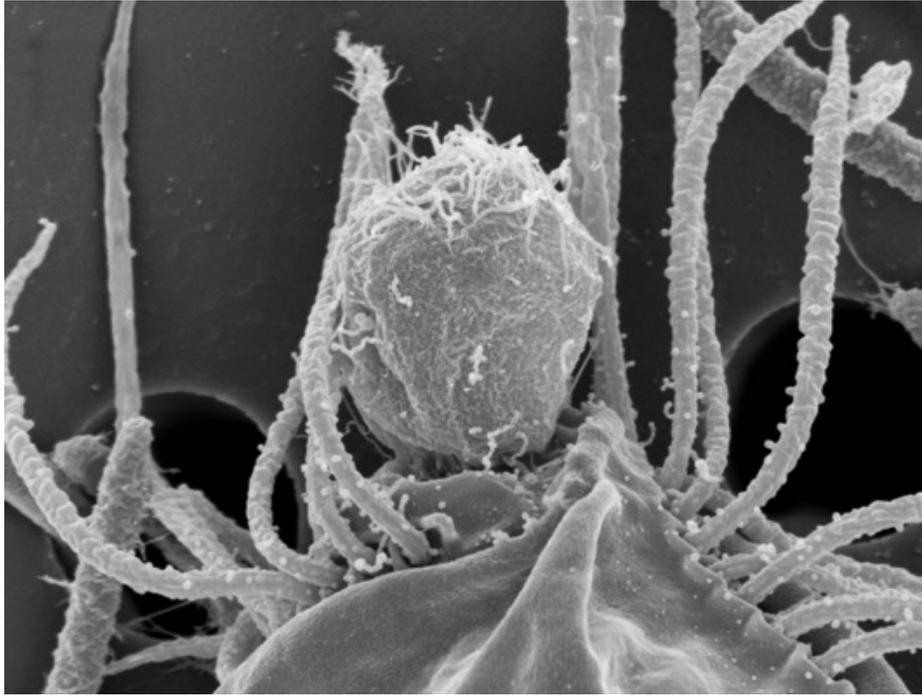


Fabien Burki, a biologist at Uppsala University in Sweden who wasn't involved in this study, was happy to see this result, but not entirely surprised. *"It's a bit like searching for life on other planets,"* he said. *"When we finally find it, I don't think we will be very surprised, but it will be a huge discovery."* Burki, Simpson, Eglit and many others also think we have much more of the tree of life to uncover, largely because of how quickly it's changing. *"The tree of life is being reshaped by new data. It is really quite different than even what it was 15 or 20 years ago,"* Burki said. *"We're seeing a tree with many more branches than we thought."*

Finding a lineage as distinct as hemimastigotes is still relatively rare. But if you go down a level or two on the hierarchy, to the mere kingdom level -the one that encompasses, say, all animals- you find that new major lineages are popping up about once a year. *"That rate isn't slowing down,"* said Simpson. *"If anything, it might be speeding up."*



A view of the full body of a hemimastigote, the only known representative of a newly identified supergroup of organisms. The following series of images shows how a hemimastigote attacks and eats prey. Credit: **Yana Eglit**



Hemimastix kukwesjijk sucks the cytoplasm out of its victim. – Credit: **Yana Eglit**

The availability of more capable sequencing technology such as single-cell transcriptomics is part of what's driving this trend in eukaryotes, especially for known unknown groups. It empowers researchers to glean usable DNA from single specimens. But Eme cautions that these methods still require the keen eye of skilled protistologists, like Eglit, “*so that we can actually target what we want to look at.*”

Another kind of sequencing, called metagenomics, could accelerate discovery even further. Researchers can now venture into the field, grab a sample of dirt from the trail or a biofilm from a deep-sea vent, and sequence everything in the sample. The catch is that it's usually just a snippet of one gene. For bacteria and archaea - organisms in the two other domains of life distinct from eukaryotes- that's usually enough to work with, and metagenomics has been behind recent huge discoveries such as the *Asgard archaea*, an enormous phylum of archaea totally unknown to science until about three years ago. But for eukaryotes, which tend to have larger and more complicated genomes, metagenomics is a troublesomely broad way to sample. It reveals many types of organisms that live in an environment, “*but unless you have a larger known reference sequence, it's very difficult to put these different things into*



an evolutionary framework,” Burki said. That’s why, according to Simpson, most of the recent, really deep eukaryotic lineages have been discovered the “*old fashioned*” way, through identifying a weird protist in the lab and targeting it for sequencing. “*But the two methods are complementary and inform one another,”* Simpson said. For example, it’s now clear that hemimastigotes popped up in previously published metagenomic databases. Yet “*we just had no way of recognizing them until we had longer hemimastigote sequences to compare them to,”* he said. Metagenomics can point to potential hot spots of unknown diversity, and deeper sequencing can make metagenomic data more meaningful.

The future is bright for researchers cataloging diversity, in both ordinary and extraordinary environments. While metagenomic tools allow us to explore extreme environments -like the sediment near hydrothermal vents where the Asgard archaea were found- researchers can also find new lineages in their backyards. “*This whole new supra-kingdom lineage was discovered by a graduate student out on a hike who happened to collect some dirt,”* Burki said. “*Imagine if we could scan every environment on Earth.”*

As scientists continue to fill out the tree, the algorithms used to add branches will only get more efficient, according to Eme. This will help researchers resolve deeper, more ancient splits in the history of life. “*Our understanding of how life unfolded is still very much incomplete,”* said Burki. Questions like why eukaryotes emerged or how photosynthesis evolved remain unanswered because “*we don’t have a tree that is stable enough to pinpoint where these key events happened,”* he said. Beyond answering such fundamental questions, the simple joy of discovery motivates researchers like Burki and Eglit. “*The microbial world is a wide-open frontier,”* said Eglit. “*It’s thrilling to explore what’s out there.”*



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