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THE POWER OF ALGORITHMS:

part 7

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PREFACE

Настоящее учебное пособие включает актуальные тексты (2018-2019гг.) учебно-познавательной тематики для студентов механико-математического факультета (направления 02.03.01 «Математика и компьютерные науки», 01.03.02 «Прикладная математика и информатика», 38.03.05 «Бизнес-информатика»). Целью данного пособия является формирование навыка чтения и перевода научно-популярных текстов, а также развитие устной речи студентов (умение выразигь свою точку зрения, дать оценку обсуждаемой проблеме).

Пособие состоит из 5 разделов, рассматривающих значение информационных технологий в современном мире. Каждый из них содержит аутентичные материалы (источники: *Aeon, Quanata Magazine, Vox, The New Yorker, The Atlantic, Bloomberg*) и упражнения к ним.

Раздел “Supplementary reading“ служит материалом для расширения словарного запаса и дальнейшего закрепления навыков работы с текстами по специальности. Пособие может успешно использоваться как для аудиторных занятий, так и для внеаудиторной практики.

1. No boss? No thanks

Exercise I.

Say what Russian words help to guess the meaning of the following words: boss, managers, management, gurus, serious, leaders, tendencies, firms, operations, service

Exercise II.

Make sure you know the following words and word combinations.

pooh-pooh, self-commitment, assigned, outlier, bland, managerial, heyday, unanticipated, collaborative, to designate, to reside

No boss? No thanks

Far from making them obsolete, the flatter business organisations of today need managers more than ever but in new ways

Management thinking is notoriously faddish. One week, the gurus, star CEOs, pundits and professors are talking about downsizing as the solution to corporate bureaucracy and inefficiency. The next week, the bandwagon has moved on to knowledge-management. Then to empowerment. And so on – sometimes in cycles, such that old ideas are revived, dressed up and resold to a gullible audience. Serious thinkers might pooh-pooh all this as guru talk, driven by media hype and 'thought leaders' hawking their latest books. But fads matter. Often they capture real tendencies and point towards meaningful solutions. Total quality management (TQM), for example, was the hot fad of the early 1990s, but it contained real value. It was popular because many manufacturing firms had overemphasised scale and cost-reduction at the expense of product

quality. TQM suggested that maintaining a higher and more consistent level of quality across all company operations was better for long-term performance. Companies and consumers benefited as waste was reduced, and product and service quality increased. Other management fads are more questionable. For instance, critics have argued that the downsizing craze of the 1990s hollowed US corporations and made them less innovative. One of today's biggest fads is the 'bossless company'. According to proponents of this idea, management is passé. The American management guru Gary Hamel declared: 'First, let's fire all the managers. Think of the countless hours that team leaders, department heads, and vice presidents devote to supervising the work of others.' Hamel suggests that all management is waste and, implicitly, that all that managers do is 'supervise' – both highly dubious claims. But proponents of the bossless company have other arguments. It seems obvious, they argue, that the 20th-century factory or office with its army of worker-drones is being replaced by flatter organisations, peer-to-peer networks, worker empowerment and other forms of worker-led democracy. Advanced technologies promise real-time access to coworkers anywhere and to all information relevant to the task at hand. Coordination can be handled by employees through lateral consultation with coworkers, and firms can cooperate through electronic means. Why, then, do we need managers?

Such arguments and claims, in turn, lead to predictions that one day all companies will be flat, not pyramidal. As the popular management writer Tim Kastelle put it: 'It's time to start reimagining management. Making everyone a chief is a good place to start.' Managerial authority and hierarchy are outdated, ineffective ways of managing and organising,

we are told. Just as the top-down, rigid and stuffy Encyclopaedia Britannica was displaced by the bottom-up and flexible Wikipedia, traditionally organised companies are being displaced by the 'wikified' firms of the knowledge-based economy with flat structures, peer assessment, self-organising teams and employee ownership. This narrative is not entirely novel. In the 1970s, Bill Gore, the CEO of the US company behind Gore-Tex fabrics, pushed the notion of the 'lattice organisation', featuring 'direct transactions, self-commitment, natural leadership, and no assigned or assumed authority'. In the 1980s, Ricardo Semler, the young CEO of the São Paolo-based Semco Partners, made big noises when he rejected the autocratic leadership style of his predecessor (his father) and adopted a radical form of industrial democracy. And in the early 1990s, the Danish businessman Lars Kolind became famous for the flat, empowered and flexible 'spaghetti organisation' he introduced to the hearing-aid company in Copenhagen. These experiments garnered strong media attention, and were pushed by US business gurus, but were generally seen as outliers and oddities. Not anymore. The bossless-company narrative shows up with a very high and increasing frequency in the business press, popular management writing and so on. Consultants push practices that concentrate decision making in self-managing teams as replacements for top-down design, hierarchy and managerial authority. In other words, the new narrative on firm organisation is not irrelevant academic discussion or fluffy consultant talk with no serious implications for business. On the contrary, these are ideas that truly matter – and they are already reshaping business.

This movement is gaining steam for a couple of reasons. It is very much part of the 21st-century culture in its emphasis on personal development, resilience and fulfilment through empowering employees, and decentralised and democratic decision processes. There is also a strong moralistic and political undertone to the narrative; in Private Government, the philosopher Elizabeth Anderson argues that firms are effectively totalitarian states, enjoying rights and privileges that would be unconstitutional for ordinary states to impose on their citizens. The historian Caitlin Rosenthal has argued that the factory system, hierarchy and managerial authority are partly derived from the slave system. What can be more morally defensible than getting rid of the remnants of slavery? Unfortunately, the bossless-company narrative is dead wrong. It misunderstands the nature of management, which isn't going away, and it is based on questionable evidence. Given these fundamental defects, this narrative is potentially harmful to managers, students and policymakers. To see why, let's look at what the new narrative is rebelling against – the 'conventional narrative'. This is the picture of the typical 'modern' company with its owners, executives, middle managers and employees – the most salient of what the 2009 Nobel laureate Oliver Williamson called the 'economic institutions of capitalism'. In a complex, modern, industrial economy, nearly all production takes place inside business firms, and much of what we call the 'market' is firms competing or cooperating with each other. In the mid-20th century, bestsellers portrayed the large enterprise as a highly efficient – but also bland and dehumanising – machine. In academic literature, landmark studies of managerial hierarchy

showed how the large enterprise had displaced its smaller predecessors through superior efficiency and productivity. Businesses grow by bringing transactions and activities inside the firm. The managerial function organised in a formal hierarchy is central to the understanding of what firms are and what they do, and for the functioning of the economy. Firms can also reduce the number of transactions they control, for example, by outsourcing – huge trends in business over the past three decades. However, even if smaller, they remain firms. This traditionally organised firm was seen, until recently, as an important source of dynamism, wealth-creation and growth. Even critics could not imagine an industrial economy without large companies. Adam Smith's 18th-century division of labour idea was gradually brought from the market into the modern industrial enterprise. This narrative has been foundational for most thinking about management. It has informed the way that economists, sociologists, historians and other scholars think about firms, hierarchies and managers. It still unites the thinking of academics, consultants and managers, and it still underpins most subjects taught in business schools. And there is a good reason for that: the old narrative is still largely correct.

Here is what we think is wrong with the fashionable bossless company story: despite big changes in technology and demographics, and increasing globalisation, the basic idea of a firm, the nature of ownership and responsibility, and how people coordinate tasks are the same as always. Firms are designed to produce valuable goods and services by combining resources, including labour, into valuable goods and services. Decisions have to be made about what to produce and how to produce it. Workers need information, tools and equipment, and motivation. And

some individuals or groups need to bear the final responsibility, and be held accountable for the firm's actions. All of this is as true today, in our knowledge-based, empowered, startup economy, as it was during the heyday of the large industrial corporation of the 20th century. You don't need a boss to tell you what to do throughout the day or how to interact with other people. But you do need an entrepreneur to launch a venture, an owner or owners to take responsibility for the overall aims of the project, and managers to establish and enforce the rules of the game. That's what modern management is all about – designing the system in which knowledge-based workers can thrive. Despite the bossless-company critique – and the more general hype about the 'new economy', the role of knowledge workers, the centrality of networks and platforms, and the like – the old narrative is essentially correct. As the economists have explained, firms exist to facilitate and coordinate production in ways that are not possible in transactions between firms. We have argued that this account needs to pay more attention to uncertainty, and that it is the firms' owners, not their managers, who should play the decisive entrepreneurial role. But the resulting synthesis is broadly in harmony with the conventional narrative.

There are three specific problems with the bossless-company critique. First, it doesn't offer systematic evidence for radical decentralisation across firms in general, but rather a few cherry-picked examples. In many cases, these firms already had in place a technology that makes decentralisation easy. Look at Apple, for example. Its late CEO Steve Jobs made key decisions in a way that can only be described as dictatorial. Under Jobs, 'only one executive "owned" a profit-and-loss-

statement, and that was the chief financial officer'. In other words, Jobs himself was in charge of everything else. Charismatic figures such as Elon Musk fill the headlines in the business press, though they are often better known for their visionary leadership than their managerial effectiveness. Also, companies that have survived major shocks to their markets or technology have often benefited from having strong leaders with almost authoritarian leadership styles; think of Disney, Apple, Xerox and IBM. There is a lesson to be learned: centralising the authority to make decisions is usually a more effective way to adapt to unanticipated change than more consensus-driven approaches. Second, while technological miracles such as the internet, cheap and reliable wireless communication, Moore's law and information markets have induced sweeping changes in manufacturing, retail, transportation and communication, the laws of economics are still the laws of economics. And human nature hasn't changed. The basic problem of management and business – how to assemble, organise and motivate groups of people and resources to produce goods and services that consumers want – is still the same. As should be clear by now, we think that the bossless-company narrative has been badly oversold by its proponents. Yes, there are conditions under which nearly bossless companies can exist and thrive. However, they are and will remain exceptions. Therefore, the basic message of the classic 20th-century thinkers on the nature and function of the business firm remains valid today: coordination by designated managers usually works better than any other known method, including the bottom-up, spontaneous coordination among peers stressed in the bossless company literature. A

question worth asking, however, is whether authority today is the same as authority in the past. The kernel of truth in the new narrative is that for many everyday business activities, employees no longer need a boss to direct them on tasks or to monitor their progress. Such involvement can actually be demotivating, particularly for highly qualified specialists. This means that managers need to move away from specifying precise methods and processes. Instead, they should specify goals and the overall principles they want employees to apply. It is when technology and activity systems are highly interdependent that a more hands-on approach is needed. In dynamic environments, decisions become highly time-sensitive, and 'democratic' decision making is inefficient when each decision affects another. Often the knowledge about who should do what to coordinate responses to changes in the environment resides within the management team – who therefore should make the decision. In short, today's business landscape features exciting developments in information technology and collaboration that have led to new forms of organisation, production and distribution. Far from making management obsolete, however, these changes make good management more important than ever.

Adapted from Aeon

Exercise III.

Fill in the gaps.

1) As a result, they tend to be dismissive of the fashionable and _____.

2) She has made education and women's _____ the focus of her domestic agenda.

3) Critics have long accused him of falseness, of merely acting out _____ roles.

4) The highest estimate he saw was $560 billion, but he considers that an _____.

5) The displays here have a sense of rightness to them rather than an air of _____.

6) Some people have had positive experiences that contribute to greater _____.

7) We get so caught up in the hype of having this we forget the most _____ thing.

8) She also hopes to _____ the relationship between government and businesses.

9) Having been traumatized by _____ loss, it is difficult not to expect it.

10) Since I really didn't know much about it myself, I didn't try to _____ it.

Exercise IV.

Make up sentences of your own with the following word combinations:

to climb/jump/get on the bandwagon, peer to peer network, to make big noises, profit and loss statement, to garner, to hawk, to facilitate, to oversell.

Exercise V.

Match the words to the definitions in the column on the right:

obsolete	the ability of a substance or object to spring back into shape; elasticity

faddish	the act of conferring legality or sanction or formal warrant
guru	an engagement or obligation that restricts freedom of action
corporate	pointing outward
downsizing	a strange or peculiar person, thing, or trait
empowerment	of or relating to a corporation, esp. a large company or group
commitment	make (something) smaller
oddity	(in Hinduism and Buddhism) A spiritual teacher, esp. one who imparts initiation
resilience	intensely fashionable for a short time
salient	no longer produced or used; out of date

Exercise VI.

Identify the part of speech the words belong to: management, solution, bureaucracy, inefficiency, empowerment, gullible, audience, serious, meaningful, total

Exercise VII.

Match the words to make word combinations:

guru	thinkers
knowledge	audience
flatter	leaders

media	solutions
information	quality
thought	talk
meaningful	organization
serious	hype
gullible	market
product	management

Exercise VIII.

Summarize the article “No boss? No thanks”.

2. How the Brain Links Gestures, Perception and Meaning

Exercise I.

Say what Russian words help to guess the meaning of the following words: gestures, tendency, communication, nuances, taboo, index, abstract, metaphorical, phenomenon

Exercise II.

Make sure you know the following words and word combinations.

seamless, ad nauseam, odor, contentious, to glean, staunch, to corroborate, to stammer, to mediate, to hone

How the Brain Links Gestures, Perception and Meaning

Neuroscience has found that gestures are not merely important as tools of expression but as guides of cognition and perception.

Remember the last time someone flipped you the bird? Whether or not that single finger was accompanied by spoken obscenities, you knew exactly what it meant. The conversion from movement into meaning is both seamless and direct, because we are endowed with the capacity to speak without talking and comprehend without hearing. We can direct attention by pointing, enhance narrative by miming and convey entire responses with a simple combination of fingers. The tendency to supplement communication with motion is universal, though the nuances of delivery vary slightly. In Ghana, left-handed pointing can be taboo, while in Greece or Turkey forming a ring with your index finger and thumb to indicate everything is A-OK could get you in trouble. Despite their variety, gestures can be loosely defined as movements used to reiterate or emphasize a message — whether that message is explicitly

spoken or not. A gesture is a movement that “represents action,” but it can also convey abstract or metaphorical information. It is a tool we carry from a very young age, if not from birth; even children who are congenitally blind naturally gesture to some speech. Everybody does it. And yet, few of us have stopped to give much thought to gesturing as a phenomenon — the neurobiology of it, its development, and its role in helping us understand others’ actions. As researchers delve further into our neural wiring, it’s becoming increasingly clear that gestures guide our perceptions just as perceptions guide our actions. Susan Goldin-Meadow is considered a titan in the gesture field — although, as she says, when she first became interested in gestures during the 1970s, “there wasn’t a field at all.” A handful of others had worked on gestures but almost entirely as an offshoot of nonverbal-behavior research. She has since built her career studying the role of gesture in learning and language creation, including the gesture system that deaf children create when they are not exposed to sign language. (Sign language is distinct from gesturing because it constitutes a fully developed linguistic system.) At the University of Chicago, where she is a professor, she runs one of the most prominent labs investigating gesture production and perception. “It’s a wonderful window into unspoken thoughts, and unspoken thoughts are often some of the most interesting,” she said, with plenty of gestures of her own. Many researchers who trained with Goldin-Meadow are now pursuing similar questions outside the University of Chicago. Miriam Novack completed her doctorate under Goldin-Meadow in 2016, and now she examines how gesture develops over the course of a lifetime. No other species points,

Novack explained, not even chimpanzees or apes, according to most reports, unless they are raised by people. Human babies, in contrast, often point before they can speak, and our ability to generate and understand symbolic motions continues to evolve in tandem with language. Gesture is also a valuable tool in the classroom, where it can help young children generalize verbs to new contexts or solve math equations. “But,” she said, “it’s not necessarily clear when kids begin to understand that our hand movements are communicative — that they’re part of the message.” When children can’t find the words to express themselves, they let their hands do the talking. Novack, who has studied infants as young as 18 months, has seen how the capacity to derive meaning from movement increases with age. Adults do it so naturally, it’s easy to forget that mapping meaning onto hand shape and trajectory is no small feat.

Gestures may be simple actions, but they don’t function in isolation. Research shows that gesture not only augments language, but also aids in its acquisition. In fact, the two may share some of the same neural systems. Acquiring gesture experience over the course of a lifetime may also help us intuit meaning from others’ motions. But whether individual cells or entire neural networks mediate our ability to decipher others’ actions is still up for debate. Noam Chomsky, a towering figure in linguistics and cognitive science, has long maintained that language and sensorimotor systems are distinct entities — modules that need not work together in gestural communication, even if they are both means of conveying and interpreting symbolic thought. Because researchers don’t yet fully understand how language is organized within the brain or which neural circuits derive meaning from gesture, the question is unsettled. But many

scientists, like Anthony Dick, an associate professor at Florida International University, theorize that the two functions rely on some of the same brain structures. Using functional magnetic resonance imaging (fMRI) scans of brain activity, Dick and colleagues have demonstrated that the interpretation of “co-speech” gestures consistently recruits language processing centers. The specific areas involved and the degree of activation vary with age, which suggests that the young brain is still honing its gesture-speech integration skills and refining connections between regions. In Dick’s words, “Gesture essentially is one spire in a broader language system,” one that integrates both semantic processing regions and sensorimotor areas. But to what extent is the perception of language itself a sensorimotor experience, a way of learning about the world that depends on both sensory impressions and movements Manuela Macedonia had only recently finished her master’s degree in linguistics when she noticed a recurring pattern among the students to whom she was teaching Italian: No matter how many times they repeated the same words, they still couldn’t stammer out a coherent sentence. Printing phrases ad nauseam didn’t do much to help, either. “They became very good listeners,” she said, “but they were not able to speak.” She was teaching by the book: She had students listen, write, practice and repeat, just as Chomsky would advocate, yet it wasn’t enough. Something was missing. Today, as a senior scientist at the Institute of Information Engineering and a researcher at the Max Planck Institute for Human Cognitive and Brain Sciences in Leipzig, Macedonia is getting closer to a hypothesis that sounds a lot like Dick’s: that language is anything but modular. When

children are learning their first language, Macedonia argues, they absorb information with their entire bodies. A word like “onion,” for example, is tightly linked to all five senses: Onions have a bulbous shape, papery skin that rustles, a bitter tang and a tear-inducing odor when sliced. Even abstract concepts like “delight” have multisensory components, such as smiles, laughter and jumping for joy. To some extent, cognition is “embodied” — the brain’s activity can be modified by the body’s actions and experiences, and vice versa. It’s no wonder, then, that foreign words don’t stick if students are only listening, writing, practicing and repeating, because those verbal experiences are stripped of their sensory associations. Macedonia has found that learners who reinforce new words by performing semantically related gestures engage their motor regions and improve recall. Doing so wires the brain for retention, because words are labels for clusters of experiences acquired over a lifetime. Multisensory learning allows words like “onion” to live in more than one place in the brain — they become distributed across entire networks. If one node decays due to neglect, another active node can restore it because they’re all connected. “Every node knows what the other nodes know,” Macedonia said. The power of gestures to enrich speech may represent only one way in which gesture is integrated with sensory experiences. A growing body of work suggests that, just as language and gesture are intimately entwined, so too are motor production and perception. Specifically, the neural systems underlying gesture observation and understanding are influenced by our past experiences of generating those same movements, according to Elizabeth Wakefield. Wakefield studies the way everyday

actions aid learning and influence cognition. But before she could examine these questions in depth, she needed to understand how gesture processing develops. As a graduate student working with the neuroscientist Karin James at Indiana University in 2013, she performed an fMRI study that was one of the first to examine gesture perception in both children and adults. When the participants watched videos of an actress who gestured as she spoke, their visual and language processing regions weren't the only areas firing. Brain areas associated with motor experiences were active as well, even though the participants lay still in the scanner. Adults showed more activity in these regions than children did, however, and Wakefield thinks that is because the adults had more experience with making similar motions (children tend to gesture less when they talk). "We, to my knowledge, were the first people looking at gesture processing across development," Wakefield said. "That small body of literature on how gesture is processed developmentally has important implications for how we might think about gesture shaping learning." Wakefield's study is not the only evidence that gesture perception and purposeful action both stand on the same neural foundation. Countless experiments have demonstrated a similar motor "mirroring" phenomenon for actions associated with ballet, basketball, playing the guitar, tying knots and even reading music. In each case, when skilled individuals observed their craft being performed by others, their sensorimotor areas were more active than the corresponding areas in participants with less expertise.

Lorna Quandt, who studies these phenomena among the deaf and hard of hearing, takes a fine-grained approach. She breaks gestures down into their sensorimotor components, using electroencephalography (EEG)

to show that memories of making certain actions change how we predict and perceive others' gestures. In one study, she and her colleagues recorded the EEG patterns of adult participants while they handled objects of varying colors and weights, and then while they watched a man in a video interact with the same items. Even when the man simply mimed actions around the objects or pointed to them without making contact, the participants' brains reacted as though they were manipulating the articles themselves. Moreover, their neural activity reflected their own experience: The EEG patterns showed that their recollections of whether the objects were heavy or light predictably influenced their perception of what the man was doing. "When I see you performing a gesture, I'm not just processing what I'm seeing you doing; I'm processing what I think you're going to do next," Quandt said. "And that's a really powerful lens through which to view action perception." My brain anticipates your sensorimotor experiences, if only by milliseconds. Exactly how much motor experience is required? According to Quandt's experiments, for the straightforward task of becoming more expert at color-weight associations, just one tactile trial is enough, although reading written information is not. According to Dick, the notion that brain motor areas are active even when humans are immobile but observing others' movements (a phenomenon known as "observation-execution matching") is generally well-established. What remains controversial is the degree to which these same regions extract meaning from others' actions. Still more contentious is what mechanism would serve as the basis for heightened understanding through

sensorimotor activation. Is it coordinated activity across multiple brain regions, or could it all boil down to the activity of individual cells?

More than a century ago, the psychologist Walter Pillsbury wrote: “There is nothing in the mind that has not been explained in terms of movement.” This concept has its modern incarnation in the mirror neuron theory, which posits that the ability to glean meaning from gesture and speech can be explained by the activation of single cells in key brain regions. It’s becoming increasingly clear, however, that the available evidence regarding the role of mirror neurons in everyday behaviors may have been oversold and overinterpreted. The mirror neuron theory got its start in the 1990s, when a group of researchers studying monkeys found that specific neurons responded when the animals made certain goal-directed movements like grasping. The scientists were surprised to note that the same cells also fired when the monkeys passively observed an experimenter making similar motions. It seemed like a clear case of observation-execution matching but at the single-cell level. The researchers came up with a few possible explanations: Perhaps these “mirror neurons” were simply communicating information about the action to help the monkey select an appropriate motor response. For instance, if I thrust my hand toward you to initiate a handshake, your natural reaction is probably to mirror me and do the same. Alternatively, these single cells could form the basis for “action understanding,” the way we interpret meaning in someone else’s movements. That possibility might allow monkeys to match their own actions to what they observed with relatively little mental computation. This idea ultimately usurped the other because it was such a beautifully simple way to explain how we intuit meaning from

others' movements. As the years passed, evidence poured in for a similar mechanism in humans, and mirror neurons became implicated in a long list of phenomena, including empathy, imitation, altruism and autism spectrum disorder, among others. And after reports of mirroring activity in related brain regions during gesture observation and speech perception, mirror neurons became associated with language and gesture, too. Gregory Hickok, a professor of cognitive and language sciences at the University of California, and a staunch mirror neuron critic, maintains that, decades ago, the founders of mirror neuron theory threw their weight behind the wrong explanation. In his view, mirror neurons deserve to be thoroughly investigated, but the pinpoint focus on their roles in speech and action understanding has hindered research progress. Observation-execution matching is more likely to be involved in motor planning than in understanding, he argues. Even those who continue to champion the theory of action understanding have begun to pump the brakes, according to Valeria Gazzola, who leads the Social Brain Laboratory at the Netherlands Institute for Neuroscience. Although she is an advocate of the mirror neuron theory, Gazzola acknowledged that there's no consensus about what it actually means to "understand" an action: "While mirror neurons serve as an important component of cognition, whether they explain the whole story, I would say that's probably not true." Initially, most evidence for mirroring in humans was derived from studies that probed the activity of millions of neurons simultaneously. Researchers have since begun to experiment with techniques like fMRI adaptation, which they can use to analyze subpopulations of cells in specific cortical regions. But they only

rarely have the opportunity to take direct measurements from individual cells in the human brain, which would provide the most direct proof of mirror neuron activity. Moreover, people who cannot move or speak because of motor disabilities like severe forms of cerebral palsy can in most cases still perceive speech and gestures. They don't need fully functioning motor systems (and mirror neurons) to perform tasks that require action understanding.

Because claims about individual cells remain so difficult to corroborate empirically, most investigators today choose their words carefully. Monkeys may have "mirror neurons," but humans have "mirroring systems," "neural mirroring" or an "action-observation network." (According to Hickok, even the monkey research has shifted more toward a focus on mirroring effects in networks and systems.) Researchers may not be able to pinpoint the exact cells that help us to communicate and learn with our bodies, but the overlap between multisensory systems is undeniable. Gesture allows us to express ourselves, and it also shapes the way we understand and interpret others. To quote one of Quandt's papers: "The actions of others are perceived through the lens of the self." So, the next time someone gives you the one-finger salute, take a moment to appreciate what it takes to receive that message loud and clear. If nothing else, it might lessen the sting a bit.

Adapted from Quanata Magazine

Exercise III.

Fill in the gaps.

1) Positive mood has also been proven to show negative effects on _____ as well.

2) The _____ flow of information means one investigation often triggers another.

3) The difference might look like a _____ but in reality it is pretty fundamental.

4) Virtual mirror technology also means those 3D wall screens _____ your reality.

5) I've started to develop this extraordinary admiration for people who _____.

6) As we have noted _____, the FBI specializes in fabricating terror attacks.

7) uclear power has been politically _____ in the United States for decades.

8) Review student _____ rates and implement plan to reduce student withdrawals.

9) You can also _____ useful information from newsletters written by future leaders.

10) Moreover, biochemical and molecular biological data _____ these findings.

Exercise IV.

Make up sentences of your own with the following word combinations:

to flip smb the bird, no small feat, to throw one's weight behind a person/plan/campaign, to endow, to reiterate, to delve, to augment, to intuit, to get somebody in trouble, explicitly spoken

Exercise V.

Match the words to the definitions in the column on the right:

obscenity	a strong taste, flavor, or smell

cognition	make a soft, muffled crackling sound like that caused by the movement of dry leaves or paper
nuance	the continued possession, use, or control of something
offshoot	wind or twist together; interweave
coherent	be an expression of or give a tangible or visible form to (an idea, quality, or feeling)
rustle	united as or forming a whole
to embody	a side shoot or branch on a plant
retention	a subtle difference in or shade of meaning, expression, or sound
to entwine	the mental action or process of acquiring knowledge and understanding through thought, experience, and the senses
tang	an offensive or indecent word or phrase

Exercise VI.

Identify the part of speech the words belong to. corroborate, empirically, investigators, carefully, exact, communicate, multisensory, undeniable, appreciate

Exercise VII.

Match the words to make word combinations:

unspoken	motions
neural	babies

one-finger	shape
hand	cells
symbolic	salute
human	circuit
deaf	information
nonverbal-behavior	thoughts
metaphorical	children
individual	research

Exercise VIII.

Summarize the article “How the Brain Links Gestures, Perception and Meaning”.

3. Should animals, plants, and robots have the same rights as you?

Exercise I.

Say what Russian words help to guess the meaning of the following words: absurd, sensations, factor, legal, chimpanzees, natural, ecosystems, legal, status, silicon

Exercise II.

Make sure you know the following words and word combinations.

outlying, slavery, to be abolished, to get the vote, to get rights, to be unjustly imprisoned, the right not to be experimented on, to dismiss that notion as absurd, entity, to deserve rights

Should animals, plants, and robots have the same rights as you?

How humanity's idea of who deserves moral concern has grown — and will keep growing.

Everyone reading this sentence likely (hopefully!) agrees that women deserve the same rights as men. But just a couple of centuries ago, that idea would've been dismissed as absurd. The same is true for the belief that black people should have the same rights as white people. Commonly accepted now; unthinkable a couple of centuries ago. There's a concept from philosophy that describes this evolution — it's called humanity's expanding moral circle. The circle is the imaginary boundary we draw around those we consider worthy of moral consideration. Over the centuries, it's expanded to include many people who were previously left out of it. As they were brought into the circle, those people won rights.

Slavery was abolished. Women got the vote. The moral circle is a fundamental concept among philosophers, psychologists, activists, and others who think seriously about what motivates people to do good. Now new social movements use it to make the case for granting rights to more and more entities. Animals. Nature. Robots. Should they all get rights similar to the ones you enjoy? For example, you have the right not to be unjustly imprisoned (liberty) and the right not to be experimented on (bodily integrity). Maybe animals should too. If you're tempted to dismiss that notion as absurd, ask yourself: How do you decide whether an entity deserves rights?

Many people think that sentience, the ability to feel sensations like pain and pleasure, is the deciding factor. If that's the case, what degree of sentience is required to make the cut? Maybe you think we should secure legal rights for chimpanzees and elephants but not for, say, shrimp. Some people argue we should include anything that's alive or that supports living things. Maybe you think we should secure rights for natural ecosystems. Lake Erie won legal personhood status in February, and recent years have seen rights granted to rivers and forests in New Zealand, India, and Colombia. And then there are some who argue that even machines can be granted rights. What about a robot we may invent in the future that seems just as sentient as chimpanzees and elephants, despite being made of silicon? The idea of expanding humanity's moral circle raises knotty questions. What happens when different beings have competing needs? How do we decide whose rights take precedence? These are questions that activists for the rights of animals, nature, and robots all grapple with as they use the idea of the moral circle to mount their arguments. They say

there's no reason to assume that once we've included all human beings, the circle has expanded as far as it should. They invite us to envision a possible future in which we've stretched our moral universe still further:"The circle of altruism has broadened from the family and tribe to the nation and race, and we are beginning to recognize that our obligations extend to all human beings. The process should not stop there"- to stop at human beings would be arbitrary: "the only justifiable stopping place for the expansion of altruism is the point at which all whose welfare can be affected by our actions are included within the circle of altruism. Reason enables us to take the point of view of the universe." Although rationality might help nudge us toward a more universal perspective, it alone can't get us all the way there. There are other psychological, sociological, and economic forces at work. Psychologists have shown that we tend to feel more capable of extending moral concern to others if we're not competing with them for scarce resources and if our own needs are already taken care of. Abraham Maslow famously illustrated this basic concept with his image of a pyramid representing our hierarchy of needs. It's pretty hard to worry about the lofty goals at the top of the pyramid if we're busy worrying about our own bodily safety, which is at the base. Mapping this insight onto the moral circle, a team of Australian psychologists noted: "One possibility is that moral expansiveness is evident in cases for which people's basic needs have been met, allowing them to turn their attention and resources to more distant entities." Scholars have tried to show through particular historical examples how the development of new technologies can create the conditions for more people to gain rights. In

some cases, that's because the inventions take care of some of our more basic needs. Emanuela Cardia at the University of Montreal found that household inventions — the washing machine, the refrigerator, the electric stove — were a major engine of liberation for women. Once the washing machine was invented and made widely accessible, for instance, women were freed up to do other things, like join the workforce. Similarly, other inventions have catalyzed the expansion of the moral circle. For instance, the printing press was crucial to humanity's ethical development because it helped spread humanitarian ideas. This isn't to say we should adopt a technologically deterministic view. Tech innovation isn't necessarily the primary factor allowing the moral circle to expand (and in fact, it can often cause a lot of harm). But it's one of several factors that can make a larger moral circle more likely.

Another factor, of course, is the presence of activists who are willing to work hard to push the boundaries of the circle. So in trying to figure out how advocates can boost their chances of successfully expanding the circle, it makes sense to investigate what contributed to the success or failure of past movements. One group chose the British anti-slavery movement as a case study and used it to identify successful tactics and best practices that can be applied to a very different context: today's movement against animal farming. Jacy Reese, the co-founder of the Sentience Institute and author of The End of Animal Farming, told me the study yielded a number of interesting insights. For one, he said, "Anti-slavery advocates were having the exact same debates that we're having in the animal rights movement." Meanwhile, psychologists are conducting empirical research to understand what motivates people to expand the

moral circle. They've found that a lot depends on how the issue is phrased. The Australian psychologist Simon Laham found that if you ask people which entities they'd include in their circle, they produce a smaller circle than if you ask them which entities they'd exclude. "Clearly," Laham writes, "if one wants to foster expansiveness of moral regard, one should focus not on why an entity should be afforded moral treatment, but why an entity should not be." Recently an international team of psychologists found that if you ask people to compare animals with humans, that yields a larger circle than if you ask them to compare humans with animals. Again, even though the exercise is basically the same, the way you package it matters. Here's another important lesson, gleaned from multiple psychology studies: We humans are much more likely to extend concern to entities we perceive to be like us. When we view animals as having cognitive and emotional capacities similar to humans', we tend to include them in our moral circle, while animals that aren't so easily anthropomorphized get left out. For advocates, this could suggest that anthropomorphizing animals is a highly worthwhile strategy — when you can pull it off. Psychologists asked participants to place various human and nonhuman entities within defined boundaries that indicate how much moral concern they deserve. People have a tendency to put their family and friends at the center of their moral circle, with other human groups afforded lower levels of priority. The experiment shows that many people think sentience is a crucial factor in deciding how much moral concern an entity deserves. Humans are favored over chimps, chimps are favored over chickens, chickens are favored over plants. Plants are an interesting

marginal case. In recent years, some have argued that plants have some degree of sentience. They seek out certain outcomes (like sunlight) and avoid others, they send out biochemical distress signals to other plants, and they "seem to lose consciousness" when sedated in scientific experiments. But the idea that plants are sentient is hotly contested— a status reflected by their outlying position in the moral expansiveness scale. Many respondents told me they don't see plants as sentient, although they said they'd change their views if convincing new evidence were to emerge. We need more scientific knowledge before we can resolve the questions about how much we should care about plants.

One marginal case not tested for in the moral expansiveness scale is artificial intelligence. For some people, the question of whether future robots will belong in our circle is straightforward. "The rights of robots is still just a case of how you apply the boundary of sentience. If AI is sentient, then it's definitely included. If not, then it's not." How we're going to discover whether a robot is sentient is still open for debate, but to many it's obvious that whenever the answer turns out to be yes, inclusion in the moral circle must follow. It's worth noting that any choice of litmus test for inclusion in the circle is, to some degree, culturally determined. Instead of working to empirically determine which entities are and aren't sentient, you might sidestep that whole question and believe instead that anything that's alive or that supports life is worthy of moral consideration. How wide will humanity's moral circle be in 100 years? It's entirely possible that we'll have expanded it in some respects and narrowed it in others. I can imagine us having laws against eating sentient animals, even as we continue to repress certain classes of people. When we look at

human history, we see not linear progress but a messy squiggle. It is defined by who's in power, as is the very definition of what counts as progress. Not having simple answers may make us uncomfortable, but I tend to think it's a productive discomfort.

Adapted from Vox

Exercise III.

Fill in the gaps.

1) Another _____ is making sure the younger generation knows the Nepali language.

2) It seems ethical to assume _____, and extend rights rather than limit them.

3) Will there be _____ intellectual property issues surrounding these techniques?

4) Many states have tried to cut prison spending as they _____ with budget gaps.

5) Health-care reform does not need to be accomplished on some _____ timetable.

6) Supermarkets design their stores to _____ us towards items that might tempt us.

7) Business education does have the long-standing use of the _____ in teaching.

8) The real _____ test will be to see if greater engagement translates into action.

9) Even a dozen back-up sites might not be enough to _____ a smart cyber-attack.

10) If I draw a _____ on a piece of paper and present it as art, then it is so.

Exercise IV.

Make up sentences of your own with the following word combinations:
to pull off, commonly accepted, to get rights, take precedence, to mount arguments, take the point of view, take care of, basic needs, to cause a lot of harm

Exercise V.

Match the words to the definitions in the column on the right:

knotty	prod (someone) gently, typically with one's elbow, in order to draw their attention to something
squiggle	state of elementary or undifferentiated consciousness
sidestep	relate to; be about
litmus	full of knots
to contest	engage in a close fight or struggle without weapons; wrestle
to nudge	based on random choice or personal whim, rather than any reason or system
arbitrary	an event in which people compete for supremacy in a sport, activity, or particular quality
to grapple	a dye obtained from certain lichens that is red under acid conditions and blue under alkaline conditions

sentience	a short line that curls and loops in an irregular way
concern	a step taken sideways, typically to avoid someone or something

Exercise VI.

Identify the part of speech the words belong to. marginal, moral, expansiveness, obvious, inclusion, empirically, determine, consideration, progress, discomfort

Exercise VII.

Match the words to make word combinations:

granting	beings
legal	ecosystems
natural	study
case	rights
natural	boundary
human	rights
fundamental	ecosystems
imaginary	concept
moral	view
deterministic	circle

Exercise VIII.

Summarize the article "Should animals, plants, and robots have the same rights as you?"

4. Moral technology

Exercise I.

Say what Russian words help to guess the meaning of the following words: medical, potential, photograph, ethics, seriously, forms, adaptation, extremely, control, press

Exercise II.

Make sure you know the following words and word combinations.

to nudge, to trawl, prematurely, consent, to aspire, impetus, backbone, apparatus, transcend, to envisage

Moral technology

Self-driving cars don't drink and medical AIs are never overtired. Given our obvious flaws, what can humans still do best?

Artificial intelligence (AI) might have the potential to change how we approach tasks, and what we value. If we are using AI to do our thinking for us, employing AI might atrophy our thinking skills. The AI we have at the moment is narrow AI – it can perform only selected, specific tasks. And even when an AI can perform as well as, or better than, humans at certain tasks, it does not necessarily achieve these results in the same way that humans do. One thing that AI is very good at is sifting through masses of data at great speed. Using machine learning, an AI that's been trained with thousands of images can develop the capacity to

recognise a photograph of a cat (an important achievement, given the predominance of pictures of cats on the internet). But humans do this very differently. A small child can often recognise a cat after just one example.Because AI might ‘think’ differently to how humans think, and because of the general tendency to get swept up in its allure, its use could well change how we approach tasks and make decisions. The impact of technology on shaping our values is well-established. At a recent roundtable discussion on the ethics of AI, the group I was in spent most of our time discussing the well-known example of the washing machine, which did not simply ‘take over’ the laundry, but which has had a major impact on attitudes to cleanliness and housework, and on the manufacture of clothing. Because AI is designed to contribute not merely to the laundry, but to how we think and make decisions over an indeterminate number of tasks, we need to consider seriously how it might change our own thought and behaviour. It’s important to remember that AI can take many forms, and be applied in many different ways, so none of this is to argue that using AI will be ‘good’ or ‘bad’. In some cases, AI might nudge us to improve our approach. But in others, it could reduce our approach to important issues. It might even skew how we think about values.

We can get used to technology very swiftly. Change-blindness and fast adaptation to technology can mean we’re not fully aware of such cultural and value shifts. For example, attitudes to privacy have changed considerably along with the vast technological shifts in how we communicate and how data is shared and processed. One of the very things driving progress in AI is indeed the vast amounts of data now available, much of it about us, collected as we go about our daily lives. Many people

are extremely wary of the organisations that have control of our data, while nonetheless continuing to post large amounts of very personal information that even a few years ago would have been considered private. Research shows that people's concerns about data privacy are inconsistent from one situation to the next. This is not to say that technology 'alone' has done this, since there are always other social changes operating at the same time. And perhaps we are especially blind to the effects of some technology because it does so much to shape how we see the world. The challenge of AI is that it might operate in ways we aren't fully aware of. It helps to mould how we communicate with each other, how we think, how we find the world. This is not completely new: writing technology, the printing press and the telephone have already altered how we perceive and interact with our world, and even changed our brains. But AI might be even more powerful. Algorithms embedded into the technology through which we access so much information could be shaping what information we receive, how we receive it, even how we react to it. And AI might be shaping our behaviour, not as an unintended consequence of its use, but by design. Technology, often aided by AI, is exploiting human psychology to shape how we behave. Phones and social media platforms are designed by drawing upon psychological research about how to produce addictive responses to their use.

So let's explore a few examples of the use or potential use of AI, focusing on how machines and humans use and analyse data. First, let's be clear that there can be great advantages in using AI over human decision making. The fast sharing and robust data-analysis that AI performs can be extremely advantageous. For example, the information engineer Paul

Newman of the Oxford Mobile Robotics Group points out that learning from accidents in vehicles driven by humans is a slow and complex process. Other humans can't learn directly from each individual case, and even the human involved might learn little or nothing. But whenever an autonomous car has an accident, all the data can immediately be shared among all other autonomous vehicles, and used to reduce the chances of a future accident. This aspect of AI – the ability to share information like a hive mind and to analyse data rapidly and rigorously – might then constitute a real improvement in how we solve problems. Sharing pooled data is something AI is extremely good at. Analysing data quickly is another. In fact, it's access to vast pools of data, together with the ability to analyse this data at speed, that's helping to drive the current boom in AI. Although autonomous vehicles can also make errors, this example demonstrates the human faults that AI can overcome. There are all sorts of ways in which humans fail to take in or analyse the data needed to make good decisions and to act on them. An autonomous vehicle will never be ashamed to admit fault, never be too vain to wear driving glasses, never insist on driving when tired, never refuse to go on an advanced driver course. Overcoming bias is one way of improving human decision making – especially where issues of value are concerned. Some of these biases and irrationalities involve the rejection of, or failure to process, relevant information. So this model of using AI to pool data seems to be an advantage we can apply to decision making. But such a conclusion might be hasty. Not all our problems can be solved by a purely data-led approach. It is pretty clear that avoiding car accidents is good. It's a safety

issue where what we're doing is mostly applying technological fixes, and it's pretty easy to measure success. The vehicle either crashes or it doesn't, and deaths and injuries can be determined. But for problems that are less purely technical, it's not so clear that a data-driven, 'hive mind' approach is always good. Take medicine, for example, one of the most promising areas of AI. Medicine is both a science, and an art: it combines science and technology with the pursuit of values: the value of health, the value of good patient relations, the value of person-centred care. In medicine, we are not just looking for a technological fix. The use of AI in diagnosis is very promising, for example, in assisting with the interpretation of medical images by trawling through vast amounts of data. The evidence seems to be that AI can detect differences between images that the human eye doesn't notice. But it can also make blatant errors that a human would never make. So, currently, combining AI with human skills seems the best option for improving diagnosis. So far, this is excellent news. But a piece in The New England Journal of Medicine raises serious questions about using AI in diagnosis and treatment decisions. Think about medicine as a science. If AI forms the 'repository for the collective medical mind', we'd have to be extremely careful before using it in a way that moves towards uniformity of professional thinking, which might foreclose independent thought and individual clinical experience. If we could be utterly confident that AI was only improving accuracy, then greater uniformity of medical thinking would be good. But there's a danger that AI might prematurely shut off options or lead us down particular treatment routes. Moreover, the authors warn that such machine learning might even be used to nudge

treatment towards hitting targets or achieving profits for vested interests, rather than what's best for patients. The data might drive the medicine, rather than the other way around. Think about medicine as an art. It involves relating to patients as real individuals living their own lives. Although AI might help us better achieve the goal of health, treatments with a lower chance of success might be the better option for some patients, all things considered. A data-driven approach alone cannot tell us this. And we need to be cautious we're not carried away by the power of technology. For we already know that free and informed consent is extremely hard to achieve in practice, and that the medical establishment influences patients' consent. But with the added gravitas of technology, and of blanket professional agreement, the danger is that wedding the existing power of the medical profession to the added power of AI, 'Computer says take the drugs' might become a reality. The relationship between physician and patient is at the heart of medicine, and of our understanding of medical ethics. But the use of AI could subtly, even radically, alter this. Precisely how we implement the morally laudable aim of using AI to improve patient care needs careful consideration.

AI's ability to manipulate and process vast amounts of data might push us into giving undue or sole prominence to data-driven approaches to identifying and solving problems. This might lead to uniformity of thinking, even in cases where there are reasons to aspire to variety of thought and approach. It might also eclipse other factors and, in doing so, distort not just our thinking, but our values.How a decision is made, and by whom; how an action is performed, and by whom – these are critical issues in many circumstances. It's especially the case where values are

concerned. Take the use of juries. We all know that juries are flawed: they sometimes get the wrong answer. Algorithms are already helping US courts come to some decisions regarding sentencing. There are fears that this can help entrench existing biases against certain groups. But imagine that we have reached the point at which feeding all the available evidence into a computer has led to more accurate verdicts than those reached by juries. In such a case, the computer would be able to pool and analyse all data with speed and (in this imagined example) accuracy and efficiency. Compare how actual juries work, where individuals might have made differing notes about the case, recall different things and, even after hours of deliberations, still have different views of the evidence. The power of AI to gather and analyse data might go a long way to address these shortcomings. But this example readily demonstrates that we care about more than simply getting things right. Even if, by using a machine, we get a more accurate answer, there can still be some reason to value the distinctive contribution of having humans serving on juries. The bias that humans can display, the tendency to be swayed by emotion, is of course a potential weakness in reaching a verdict. But it has also been the impetus for changes in the law. No matter how good at assessing evidence a machine might be, we're a long way off developing machines with a finely tuned sense of justice, an eye for the underdog, and the moral backbone to defy the apparatus of the legal system. Perhaps, in the future, AI might assist judges and juries to come to decisions – but this is rather different to envisaging that AI might replace humans in legal decision making. We

need to consider this carefully, in full awareness of the many implications for justice and democracy.

One great attraction of using AI is simply the sheer speed at which it can analyse data. Efficiency is a virtue, but this virtue depends upon the ends to which it is being used. It's also by no means the only virtue. If a machine can accomplish something quickly and efficiently, we might be more tempted to use it than is really merited. And the speed with which it accomplishes tasks might make us overlook problems in how it achieves its ends. We might then end up placing too great a value on such efficiently generated results. The virtues of AI include its particular ability to share data to reach a universal view of things; its capacity to help exclude human bias; the speed and efficiency with which it operates. It can transcend human capacity in all these things. But these virtues must all be measured up against our other values. Without doing so, we might be entranced by the power of AI into allowing it to take the lead in determining how we think about some of our most important values and activities.

Adapted from Aeon

Exercise III.

Fill in the gaps.

1) There's a deep psychological _____ to a relaxed, unstructured work environment.

2) This seems to be the least _____ of the applications but still worth a mention.

3) Companies are scouring the globe for new technologies and _____locations.

4) If it is taught well you will learn how to think both _____ and creatively.

5) To begin with, promoting a personal agenda is a _____ misuse of your position.

6) In practical terms, a _____ might just be in one company, or widely shared.

7) It is a _____ ideal and looks set to make him a very successful businessman.

8) The people that make up organizations such as those are the _____ of America.

9) Historical figures _____ contemporary political issues and unite Americans.

10) It is those without imagination who can not _____ a world that is different.

Exercise IV.

Make up sentences of your own with the following word combinations: hive-mind, to foreclose, do best, to do one's thinking for somebody, to recognise a photograph of, to get swept up in its allure, make decisions, take many forms,to get used to, to be fully aware of

Exercise V.

Match the words to the definitions in the column on the right:

to mould	involving or creating favorable circumstances that increase the chances of success or effectiveness; beneficial

atrophy	a place, building, or receptacle where things are or may be stored
allure	(of bad behavior) Done openly and unashamedly
to skew	having or showing an excessively high opinion of one's appearance, abilities, or worth
robust	waste away, typically due to the degeneration of cells, or become vestigial during evolution
vain	suddenly change direction or position
advantageous	form in clay, wax, etc; "model a head with clay"
blatant	able to withstand or overcome adverse conditions
repository	powerfully attract or charm; tempt

Exercise VI.

Identify the part of speech the words belong to: laudable, power values, activities, attraction, analyse, efficiency, efficiently, include, ability

Exercise VII.

Match the words to make word combinations:

human	information
printing	psychology
constitute	cars
personal	interest
daily	machine
vested	lives

washing	pool
roundtable	skills
thinking	discussion
self-driving	press

Exercise VIII .

Summarize the article “Moral technology” .

SUPPLEMENTARY READING

How e-commerce is transforming rural China

JD.com is expanding its consumer base with drone delivery and local recruits who can exploit villages' tight-knit social networks to drum up business.

Xia Canjun was born in 1979, the youngest of seven siblings, in Cenmang, a village of a hundred or so households nestled at the foot of the Wuling Mountains, in the far west of Hunan Province. Xia's mother was illiterate, and his father barely finished first grade. The family made a living as corn farmers, and had been in Cenmang for more generations than anyone could remember. The region was poor, irrigation was inadequate—the family often went hungry—and there were few roads. Trips to the county seat, Xinhuang, ten miles away, were made twice a year, on a rickety three-wheeled cart, and until the age of ten Xia didn't leave the village at all. But he was never particularly unhappy. "When you are a frog at the bottom of the well, the world is both big and small," he likes to say, referring to a famous fable by Zhuangzi, the Aesop of ancient China, in which a frog, certain that nowhere can be as good as the environment he knows, is astonished when a turtle tells him about the sea. As a child, Xia said, he was "a happy frog," content to play in the dirt roads between the mud houses of the village.

In 1990, in sixth grade, Xia saw a map of the world for the first time. Of course, Cenmang wasn't on it. Neither was Xinhuang, the city that loomed so large in his imagination. "The world was this great beyond, and we were this dot that I couldn't even find on a map," he told me. The same year, the Xias bought their first TV, a black-and-white set so small that it could have fit inside the family wok. Market reforms were transforming China, but in Cenmang changes arrived slowly. It was several years before another appliance, a washing machine, entered the household.

Still, rather than becoming a manual laborer, like his parents and siblings, Xia was able to go to technical college, and afterward he got a job at a local company that produced powdered milk. He married a girl from a nearby village and had a son. In 2009, he bought his first smartphone. Not many of his friends knew much about the Internet in those days, but Xia's eyes were opened: "Everything that was going on in China could be squeezed onto that screen." When the powdered-milk company downsized, he decided that it was time to look farther afield. He moved to Shenzhen, a sprawling coastal city, and found a job as a courier, becoming one of China's quarter of a billion migrant workers.

Life in the big city was at once overwhelming and colorless. Work consumed most of his days, and people were aloof, with none of the warmth he'd known back home. Whereas Xia had some connection to nearly everyone in Xinhuang and its surrounding villages, Shenzhen was an anonymous jumble, in which he felt like "a tiny, undifferentiated dot." Then, eighteen months in, an unexpected opportunity arose. Xia had been making deliveries for JD.com, the second-biggest e-commerce

company in China, and he heard that the business was expanding into rural Hunan. A regional station manager would be needed in Xinhuang.

JD.com, or Jingdong, as the company is known in Chinese, is the third-largest tech company in the world in terms of revenue, behind only Amazon and Google's parent company, Alphabet, Inc. In the Western press, JD is often referred to as the Chinese Amazon, but unlike Amazon, which has all but saturated the American e-commerce market and therefore has to expand by moving into new sectors, such as entertainment, JD still has ample room to extend its customer base—thanks to places like Cenmang and Xinhuang. Although China has the most Internet users of any country and the largest e-commerce market in the world—more than twice the size of America's—there are still hundreds of millions of Chinese whose lives have yet to migrate online. Analysts predict that China's online retail market will double in size in the next two years, and that the growth will come disproportionately from third- and fourth-tier cities and from the country's vast rural hinterland. At a time when the Chinese government has instituted monumental infrastructure programs to develop these regions, companies like JD are providing a market-driven counterpart, which is likely to do for China what the Sears, Roebuck catalogue did for America in the early twentieth century.

Today, Xia oversees deliveries to more than two hundred villages around the Wuling Mountains, including his birthplace. But, in line with JD's growth strategy, an equally important aspect of Xia's job is to be a promoter for the company, getting the word out about its services. His income depends in part on the number of orders that come from his region. Across China, JD has made a policy of recruiting local representatives who can exploit the thick social ties of traditional communities to drum up business. Xia himself is not unaware of the irony: after venturing out to the great beyond, he discovered that the world was coming to Cenmang.

The JD depot in downtown Xinhuang is on a side street, wedged between a curtain shop and a small convenience store. When I arrived, early one Sunday morning in November, Xia was rolling up the building's metal grille with one hand and holding a steamed pork bun in the other. Xia is solidly built, with a heavy, square face made ruddy by years of outdoor work. He wore the standard uniform of a JD deliveryman: a red-and-gray windbreaker with a matching red polo shirt underneath. He liked the uniform, he told me, because customers immediately knew why he was on their doorstep. In much of China, the livery has become as recognizable as that of U.P.S. workers in the U.S.

Three younger men soon arrived, also in uniform, and Xia called a meeting to run through arrangements for what was sure to be their busiest twenty-four hours of the year: November 11th, when people all over China celebrate Singles' Day, taking advantage of deep discounts to lavish gifts on themselves. Since 2009, the e-commerce behemoth Alibaba, drawing inspiration from Black Friday and Valentine's Day, has made the holiday an annual nationwide shopping spree.

"Brothers!" Xia bellowed, looking down at a crumpled sheet of notes. The men stood up straight, with their hands behind their backs. "If June 18th"—the

anniversary of JD's founding, now promoted as a shopping binge to rival Singles' Day—"was our midterms, then November 11th is the final exam! We must not lose face for JD!"

The men listened expressionlessly while Xia spoke, and, when he had finished, gave soldierly assent. All three were born and bred in the villages surrounding Xinhuang. When I asked why they had decided to work for JD, each of them replied with some version of "E-commerce is the future!" A vapid slogan, perhaps, but one that nonetheless reflected their awareness of a changing landscape that would define the course of their professional lives. Working for JD gave them a level of security that starting a small business, say, never could. You wouldn't wake up to find that a multibillion-dollar company had suddenly been shuttered, one of the men said. I asked if any of them were tempted to try their luck in a big city someday, as Xia had done. "What for?" another replied. JD was going to expand, he told me, and the implication was clear: soon they could all be managing underlings of their own.

Later, I asked Xia about his recruitment process, and he gave me an odd look. "I already knew who I wanted," he said. The men were friends, or friends of friends, who'd submitted no paperwork. Résumés and references were for strangers, and nobody was a stranger in Xinhuang. Xia's work as a promoter for JD followed the same principle. Advertisements had little effect in Xinhuang. People believed you because they knew you, Xia told me. That's how a deliveryman earns trust.

A mother and her skinny teen-age daughter wandered in to fetch an order of the daughter's favorite pan-fried instant noodles. The daughter liked to snack on them as she studied, and the local grocers didn't offer the unusual flavors she preferred. Soon afterward, a shy fourteen-year-old came in to pick up a pair of Adidas sneakers. At ninety dollars, they were cheaper than in the stores. I asked Xia if he earned most of his salary from the wallets of teen-agers. "They are the ones who teach their parents how everything works," he said. "And the parents then teach the grandparents."

After an hour or so, Xia and I set out to make deliveries to nearby townships and villages, driving along curving, mountainous dirt tracks marked with potholes. Rice paddies and soybean fields glided by, and construction sites with wobbly-looking bamboo sticks for scaffolding. We got stuck behind a truckload of squealing pigs whose rickety pen threatened to spill them onto our windshield. An elderly couple walked by, pulling a cart piled with timber, on which a small child was precariously perched. At regular intervals along the way, billboards exhorted people to "overthrow poverty!" and told those who "got rich first" to "help those who will later become rich." The tone of old Communist maxims was effortlessly adapting itself to a vision of social change powered by market capitalism.

Frequently, we would lurch to a stop on the shoulder of the road so that Xia could make a call or answer one from a customer. JD requires deliverymen to phone ahead and check that a recipient is at home. There's no point in scheduling a set delivery time, he explained: "Compared with cities, there isn't as much a sense of structure." People phoned to ask him to drop a package off at the local market or post office or medical clinic.

At one point, he stopped to ask directions from an acquaintance who was squatting outside her home in plastic slippers, washing cabbage leaves with a hose. She pointed to a narrow path that turned out to snake on for two more miles of hairpin turns, revealing vistas of farmland dotted with thatch-roofed houses, and gray-green mountains in the distance. Old women bent over large trays of dried chili peppers. Children played on the open road.

"Wa! You actually came all the way out here," a woman in her mid-twenties, balancing a toddler on her hip, said when we eventually arrived. She opened the package and gently stroked the purchase that had occasioned our odyssey: a five-dollar pink baby towel. Over the years, Xia has found that baby goods—clothes, formula, diapers—make up a considerable proportion of his deliveries. "I ordered my son's diapers on JD, too," he told me. "Everyone wants the best for their kids. For a long time, there wasn't any choice. Now there is."

After several more deliveries—a pair of pants, a cell-phone case, bedsheets—we headed back to Xinhuang. Xia returned to the depot to pick up more packages, and I wandered into the old town—tiny, serpentine alleys with sagging wooden Qing-dynasty houses that didn't look much different from the way they might have two centuries ago. No one bothered to close their doors in the daytime, and inside I saw elders playing mah-jongg in unlit parlors next to altars for deceased relatives, often watched over by faded portraits of Chairman Mao.

At the entrance to one alley, middle-aged men chain-smoked and played cards at round tables outside a restaurant. Everyone looked up as I entered, and I thought for a moment that I must be trespassing. I asked the proprietor, an aproned woman in her forties, if there was a menu, and she nodded, moving to the back of the room, past baskets of unwashed leafy vegetables. She yanked open a refrigerator door to display plastic containers of pig intestines, ears, and other offal. A pig's head rolled slightly on the bottom shelf. After a somewhat confusing exchange, I was made to understand that this—the bloodied porcine array before me—was the menu. Whatever I picked she was happy to toss into the wok. (There was only one sauce.) Twenty minutes later, a steaming casserole appeared, for which, I later learned, I was scandalously overcharged. But that made sense: it was likely that everyone who had ever entered the restaurant was a local who knew the owners and knew exactly what would be served and how much it would cost. A menu assumes the availability of choices and the existence of strangers. Both were concepts that Xinhuang was only just beginning to embrace.

The headquarters of JD, in a business park in the southern suburbs of Beijing, is a colorful warehouse of trendy, playful futurism—with common areas resembling beehives or bamboo glades; tables and benches hanging from the ceiling on chains; tents; podlike chairs; and gigantic sets of chess and Go. Outside, in the parking lot, the company tests its fleet of self-driving cars. On my way into the main building, I caught sight of a glass box the size of an airport newsstand: a cashless, self-service convenience store. Employees walked in empty-handed and walked out with snacks, their purchases logged by face-recognition technology. The transaction was entirely

elided, in keeping with a favorite pronouncement of retail gurus: “When checkout is working really well, it will feel like stealing.”

JD’s founder and C.E.O., Liu Qiangdong, has his office on the eighteenth floor. In contrast with the postmodern riot elsewhere, everything in his suite is blindingly white, the walls bare except for a single gargantuan calligraphy painting that spells out the saying “Tranquillity yields transcendence.”

Liu is forty-four, with a round, fleshy face and a practiced, confident demeanor befitting the eighteenth-richest man in China. (The current estimate of his wealth hovers just below ten billion dollars.) His fame has grown in step with his wealth; on subways and sidewalks, he gazes out from posters with energizing patriotic slogans. Recently, China’s social-media scene has been rife with speculation about Liu’s increasingly toned and trim physique, and whether it was an attempt to keep up with his wife, Zhang Zetian, who is twenty years his junior. (An Internet celebrity, Zhang is universally known as Milk Tea Sister, for the photograph of her posing with a bubble tea that launched her stardom.) The couple have a daughter, and Zhang, who is the country’s youngest female billionaire, tirelessly promotes a portfolio of luxury brands carried by JD. Fashion is among the company’s fastest-growing areas, and when Liu extended his hand I glimpsed a watch by Audemars Piguet, which recently partnered with JD to launch its first online boutique.

In interviews, Liu is eager to emphasize the humbleness of his origins. Born near Suqian, a fourth-tier city in Jiangsu Province, he grew up in a village not much more developed than those where Xia makes his deliveries. His parents worked as merchants, plying their trade up and down the Yangtze River, selling coal to the south and produce to the north. Because they were away on business much of the time, Liu was often in the care of his maternal grandmother—“the epitome of a rural village woman,” he said. He likes to tell the story of leaving his home town for Beijing, after his stellar performance on a national exam earned him a place at the prestigious Renmin University. His family did not have enough money for his trip to the capital, so the rest of the village chipped in, and those who didn’t have cash donated eggs to sustain him on the long train ride. During his first week in the capital, Liu recalls, he ate only eggs.

Liu started his first business—a restaurant—while still in college, with his wages from a part-time job. It went bankrupt within eight months. When he tells the story, it comes out as a parable about the need for integrity: dishonest employees sneaked money from the till and inflated their expense claims with faked receipts. His second business was the foundation of all his success: in 1998, he opened a stall, Jingdong Century Trading, at a Beijing consumer-electronics market. Liu stresses that he took a different tack from that of his competitors, whose solution to the problem of how to turn a profit while competing on price was usually to sell substandard goods. He made it an article of faith that no product would ever be counterfeit and no price tag would ever be negotiable—a novel concept in China, where haggling is the norm.

The business prospered, swelling in five years to a chain of electronics stores across Beijing, and it earned him his first million. But the emergence of JD as an online brand was a fluke. In 2003, the sars pandemic struck, and Beijingers hunkered down in their homes. Liu had to temporarily close his stores, and, casting around for a way to continue selling, he began to offer his products on online bulletin boards. In a marketplace where everyone was a fraud until proven otherwise, the anonymity of the Internet only magnified the sense of suspicion, and no one responded to Liu's posts. But then an old customer, whom Liu had never met, posted on a board, vouching for the authenticity of the goods, and orders began to come in. Within a couple of years, the online sales had reached a level that enabled him to close all his brick-and-mortar stores. In Liu's telling, JD's birth is bound up with a lesson about the importance of trust in business.

"Chinese people don't easily believe the good will of strangers," Liu told me. "Why do you think Chinese fight tooth and nail to get on the bus and subway?" He shook his head and laughed. "It doesn't matter that it's less efficient or unnecessary. It's a complete reflex for them, because it's what they've been taught since they were young."

Though the origin story might strike some as self-serving, Liu's diagnosis of "a fundamental lack of trust in Chinese society" does relate to qualities that make JD distinctive. Rather than competing on price, in a marketplace steeped in counterfeit goods and shoddy service, JD has focussed on developing a reputation for dependability. It maintains a much publicized "no-fakes" guarantee, and works hard, if not quite infallibly, to keep its site free of them. "One transaction can't earn trust," Liu told me. "But over time people come to rely on you."

Establishing this reputation has required JD to adopt a strategy radically different from that of its greatest rival, Alibaba, which is essentially the eBay of China—a platform connecting customers to a vast network of third-party sellers. Although there are an increasing number of third-party sellers on JD's site, the core of its business, like Amazon's, involves managing the entire supply chain. It buys from manufacturers, stocks inventory in warehouses, and invests billions of dollars in development, including a kind of in-house FedEx, called JD Logistics. There are now nearly eighty-five thousand delivery personnel like Xia, and several thousand depots, from large hubs to tiny outlets like the one in Xinhuang. "The couriers are the faces of JD," Liu said. "They come to your home. You have to trust them." The success of this network, combined with the notorious unreliability of the Chinese postal service, means that JD Logistics is now itself a product—a service that other e-commerce players pay to use.

Viewed in a certain light, JD can be seen as a privately financed national infrastructure project. "JD has brought the entire nation closer together and made it more close-knit," Liu told me proudly. Although the company's infrastructure investments make plenty of business sense—its stock, which is traded on the Nasdaq exchange, reached an all-time high at the start of this year—it is not incidental that the vision underlying them is completely in harmony with that of the government. In

recent years, China has built roads and high-speed rail links to bind the country's least accessible regions more closely to the big cities that are the engine of its economic growth. And the tech sector has emerged as a centerpiece of the country's global ambitions.

For the country's leading tycoons, keeping in the government's good graces is a well-established habit. During our conversation, Liu repeatedly spoke of company strategy in terms of deeper ambitions for the country as a whole, framing economic advancement as a civic virtue. A thirty-year economic miracle was not enough in itself, he said; one also had to "lead society in the right direction and bring in positive energy." "Positive energy" is a phrase much used by President Xi Jinping, and my conversation with Liu took place less than two weeks after the Chinese Communist Party's Nineteenth National Congress, which had signalled a tightening of Xi's grip on the country. It has become evident that, compared with his predecessors Hu Jintao and Jiang Zemin, Xi demands more direct and explicit fealty from corporate titans. Recently, he stipulated that all publicly listed companies must establish a Party branch in the workplace.

Ryan Manuel, a political scientist at the University of Hong Kong, told me that, until recently, there was a cautious symbiosis between the government and Chinese tech giants, an outgrowth of forms of Internet supervision dating back to the early nineties, when the Web first came to China. But Xi, Manuel said, is now "putting the onus of censorship on the companies themselves, and dealing with them the way he managed his anti-corruption campaign." The message is clear: as long as executives follow the Party line and police their ownorganizations, companies will be given permission to thrive, and championed as evidence of China's soft power. But if there are transgressions the Party will target company leaders, even people as famous as Liu or Alibaba's founder, Jack Ma—or Wu Xiaohui, the billionaire C.E.O. of Anbang, one of the largest insurers in the country, who, in May, was sentenced to eighteen years in prison after being convicted of fraud and embezzlement. Manuel said that, in such cases, the charges are frequently opaque—"corruption," "ideological failings"—but the fates of the company and of its top executives are sealed.

As a result, the recent public utterances of business leaders have displayed a new caution, coupled with an extravagant eagerness to demonstrate loyalty to the Party. A couple of weeks after I met Liu, he was named the head of a poor village south of Beijing, and he quickly unveiled a five-year plan to increase its wealth tenfold. Last year, he made a remarkable announcement on TV. "Our country can realize the dream of Communism in our generation," he said. "All companies will belong to the state."

On a brisk autumn morning a few days before my visit to JD's headquarters, I stood in the courtyard of a former glassworks in Zhangwei, a village in Jiangsu Province, expectantly waiting for diapers, shampoo, and other sundries to fall from the sky. A drone, which was ferrying the goods, was due to arrive at any minute. A few villagers—mostly grannies and toddlers—milled about, careful not to stray too

close to a circular green-felt landing pad. Beyond the sloping red-tile roofs of the surrounding houses, I could see silk squashes drooping from vines slung between utility poles. I was waiting with Li Dapeng, the principal scientist at JD-X, an in-house research lab that oversees JD's drone development. JD uses seven types of drones, some for long-distance deliveries and others to carry heavier packages over short distances. The one we were expecting carries around thirty pounds up to a dozen miles from its base, at a top speed of forty-five miles an hour. Zhangwei is on the outskirts of Liu Qiangdong's native city, Suqian, which is also a hub of JD activity. Zhangwei was one of the first villages to be serviced by drone, starting in early 2017, and now gets an average of four deliveries a day.

Li pointed to a whirring speck in the sky. As it drew closer, the first thing I could make out was a red box under the belly of the drone. A minute later, I saw three spinning propellers, which seemed improbably small for the size of their load, like the wings of a bumblebee. The children pointed their fingers upward, faces lifted, and cheered for the "toy plane." But no one else seemed terribly excited. A young man with gelled hair, who arrived as the drone was descending, said that, for a few weeks, these landings had drawn big crowds, but that people soon had got used to them: "Things change so fast around here, there's no time to be surprised about anything."

The young man, who introduced himself as Zhang Xiaoyan, turned out to be the village JD promoter and deliveryman. As he stood near the drone, which hovered a few inches from the ground, it automatically released its cargo box and zipped off into the sky. Zhang cut open the box and began organizing the seven packages that were inside according to their destinations.

Li and I went with him as he made his rounds, setting off past an abandoned outhouse and a tumbledown barn with hay bursting through its doors. Like Xia, Zhang had been born in the region he now served and had graduated from a local technical college, before heading for a larger city—in his case, Suzhou, where he did grunt work in factories and restaurants. And, like Xia, he'd jumped at the chance to return home with a stable JD job. As a local, he had an intimate knowledge of Zhangwei's social demographics. To him, it didn't seem strange that people should still be digging wells for water even as they set up Wi-Fi in their homes. Only the very richest inhabitants, perhaps fifty people, owned cars. Almost everyone had a TV, but no more than half the villagers had a refrigerator, because people mostly ate vegetables that they grew themselves and chickens that they kept running around in their yards until the moment they were needed for the pot. A tiny minority had computers. Everyone had a cell phone.

In China, what is sometimes called "the shift to mobile" never happened—hasn't needed to happen—because the country's wealth is too recent for people to have been swept up in the PC revolution, the way Americans were. Instead, they went straight to phones, an example of a phenomenon known as leapfrogging, in which non-participation in an older technology spurs early adoption of whatever innovation comes next. Jack Ma, of Alibaba, has argued that the entire e-commerce sector in

China exemplifies this pattern: people happily shop online because there haven't been Walmarts everywhere. In the U.S., "e-commerce is a dessert," he said. "In China, it's become the main course."

The bulk of Zhang's orders had been placed online with phones. Mostly people bought electronics, household goods, and snacks. But recently a big shipment of king crabs had arrived. I wondered whether the villagers had been skeptical about the freshness of the crabs, and Zhang explained that JD had given an explicit guarantee. "I opened up the box right then and there so everyone could see," he said, miming the motion of lifting the cardboard flaps. "If the crabs did not move, the buyers would get their money back." To everyone's delight, the crabs were even bigger and livelier than the ones at the fish market.

After Zhang had finished making his deliveries, he took us to the village's lone convenience store. "Big Auntie!" he said, greeting the owner, a woman in her early fifties with bouffant hair. Nodding and smiling, she welcomed us in, and talked about the waning fortunes of her shop, which she'd run for decades. People were ordering online more, but that was only one of many causes. "All the young people have left, and the old people never buy much," she said. A government program to encourage resettlement in denser urban areas had offered people housing in Suqian, prompting a minor exodus. Her own children had left some time ago, and Big Auntie expressed uncertainty about the future. She gestured toward a construction site that I couldn't quite make out in the distance, and said that developers had come in to assess the possibility of turning farmland into apple and peach orchards, "where city folks can come and pick fruits and have a picnic."

After leaving the store, Li and I got in a car and headed for the drone control center in Suqian. On the way, our driver pointed to a pair of cylindrical glass buildings, with clusters of young people hurrying in and out. "JD's main call center," Li said, and told me that it handled trouble-shooting calls for the entire country. Liu built it in 2009, providing jobs for more than nine thousand people in his home town. Throughout Suqian, Liu is spoken of in tones that suggest a mythic hero or a minor deity. If it weren't for Old Liu, people say, who would have heard of us in this drab, no-name city?

At the drone center, Li led me to a control room, where a screen covering an entire wall showed the routes of all the drones and pinpointed their current locations with blinking lights. Next door was a glass-enclosed space that looked like a gaming café—rows of computers with dozens of young men squinting intently at the screens. It turned out to be a training center for drone pilots. The screens displayed animations of quadcopters that looked vaguely drunk as they wove through the sky toward landing pads.

JD's drone classes last three months, and each student pays ten thousand yuan (around two thousand dollars)—"a small price," an instructor in the room made sure to inform me, considering how much they stood to earn. I asked him if they were guaranteed a job, and he shook his head and said, rather grandly, "We keep only the very best students." But there was no shortage of other opportunities for the rest. In

China, drones are rapidly invading just about every industry where they can plausibly be deployed. They are used to spray crops, to monitor pollution levels and disaster zones, to create fireworks displays and produce photojournalism, and even to catch schoolkids cheating on the standardized tests that, in the Chinese education system, assume life-or-death significance.

I chatted with some of the students, few of whom were native to Suqian. One, from Shanxi Province, had recently served in the Army; another had been selling life insurance; and another, from Inner Mongolia, had worked in interior design. Not many had been to college, and some hadn't even graduated from high school, but the instructor said that you didn't need any technical or scientific knowledge to fly a drone, just as you didn't need to know about fabric or design to be a clerk in a clothing store. Like Xia's deliverymen, the trainees evinced confidence about the opportunities that technology would confer on relatively unskilled workers like themselves. Drones, one declared, provided a job that "pointed toward the future."

A man let me try flying the virtual drone on his terminal. I couldn't keep it in the air for more than a few seconds before it nose-dived to the ground.

"You're pressing too hard on the gas," someone said in exasperation, after my third suicidal plunge.

"This is harder than driving a car," I said, attempting to deflect embarrassment with humor. But no one laughed, and it emerged that none of these drone-pilot trainees had ever been behind the wheel of a car.

In the late nineteen-eighties and early nineties, in Chongqing, where I was born and lived until the age of eight, I knew only two types of retail arrangement: small-time venders who spread their wares out on sidewalks or in carts hitched to the backs of bicycles; and state-owned brick-and-mortar stores, where everything sat on shelves or lay under glass counters, guarded by legions of clerks. In the Army-hospital compound where I lived—my mother was a doctor—there was exactly one convenience store, for twenty thousand residents. It was known as the fuwushe, or service agency, and in many ways it resembled Big Auntie's shop in Zhangwei. It sold everything from soap and toilet paper to pickled plums and foreign-brand Cheerios. If you got a soft drink, it came in a spindly glass bottle, and even after you paid for it you couldn't take it with you; you had to drink it on the premises, and a clerk watched to make sure you returned the bottle to a plastic crate.

Customers were never permitted to touch any item, even a pack of gum, until the clerk had retrieved it for them. If you asked for something and then decided not to purchase it, you got a dirty look, and, if the clerk thought you were shopping around for the best price, you were shown the door. The fuwushemanager was a powerful figure, someone you wanted to ingratiate yourself with in the hope of having the chance to buy rare items. My mother assiduously cultivated his good will so that she could buy imported cigarettes and brand-name alcohol as holiday presents for her father. The idea that the staff of a shop might try to ingratiate themselves with the customers occurred to no one. The government owned everything, so what would be the incentive?

I never questioned the system—none of us did. We couldn't have fathomed an alternative. And, because we knew nothing else, there was no vantage from which to consider what the system implied about our society, or what assumptions about human nature were folded into these everyday transactions. For instance, there was always a lurking sense that any commercial establishment that permitted customers to touch the merchandise would be all but looted. There was a social implication, too, in the very name "service agency." It suggested a place that you visited out of necessity. The notion that shopping could be a leisure activity, something you actually enjoyed or even explored your identity through, would have been absurd.

Thinking of shopping in this way would also have been bourgeois individualism, of course. And yet there was nothing inherently Communist about the setup. A century earlier, in the capitalist West, people were requesting items at the counters of groceries and dry-goods stores in much the same way as we did at the fuwushe. Indeed, when, in 1916, Clarence Saunders opened the first self-service grocery store, the Piggly Wiggly, in Memphis, Tennessee, stocking a thousand products—four times as many as the average store—for customers to pick out themselves, the idea was mocked for its sheer outlandishness.

It's easy for me to imagine how ridiculous the Piggly Wiggly would have seemed back then, because I can still remember the first visit my mom and I made to a Stop & Shop in New Haven, Connecticut, soon after we moved to the U.S., in 1992. I interpreted the unguarded aisles of open shelves as a sign that everything was free. I'd never heard the word "supermarket" before, and it seemed likely that "super" indicated a market where no money was necessary. My mother was awed that store employees, instead of trailing our every move as they did in China, seemed indifferent to our presence. How had shoplifting not bankrupted the establishment? What sort of society would allow such a risk? She could never have guessed that, within three decades, in China, there would be highly paid retail executives working out ways to make shopping more like theft.

No one warns you that immigrating to a more-developed country can feel like time travel—even though, insofar as we moved partly in the hope of a better standard of living, modernity was exactly what we were after. Yet, shortly before leaving China, I had experienced time travel in the other direction, when my parents sent me to live with my father's relatives, in rural Shanxi, for three months. If Chongqing in 1991 was, in retail terms, stuck in 1916, Shanxi was perhaps still in 1830. I didn't know before I arrived that I wouldn't see meat for three months; that the idea of easy access to a store, even a modest fuwushe, would be risible; or that hunger could feel like a demon clawing at your stomach. The only place to buy anything was at a weekly bazaar held in a village some distance away. When my cousins and I were hungry, which was always, we stole drying dates from a neighbor's yard and climbed persimmon trees.

My father's birthplace wasn't just poor. It was to a large extent pre-economic. People foraged, farmed, mended, bartered, exchanged favors. This gave the place a particular feel—foreign to me at first—which my aunt called "interwovenness." The

whole village behaved as one, because you needed the strength of the whole village simply to survive. “Everyone in the village is related to one another, once you go back enough generations,” my aunt said, with satisfaction. “We are one family.” That web of relationships became your identity.

What does it mean when this kind of social network becomes something that a villager like Xia is paid to monetize? Capitalism, of course, has been steadily eroding that traditional sense of identity in China since the early eighties, but for a long time change did not reach the countryside, whose brutal poverty made it immune to the tide of obsessive consumerism sweeping through the cities. E-commerce, though, with its ability to penetrate deeper and faster into the hinterland, brings with it a new sense of personal identity—one less tethered to the group and, arguably, freer, but also more vulnerable to social atomization. A generation back, when everyone in my father’s village was mired in the same kind of deprivation, the name of the village was his most significant marker of identity. But Zhang told me that, in the places where he delivered, people were increasingly forming subgroups determined by their possessions. The car owners fraternized with other car owners; the computer owners with other computer owners; and those who had little of anything were now a society unto themselves.

In New Haven, my mother and I revised our mode of thinking slowly, tenuously, and those changes informed our evolving sense of self. Malls and supermarkets—where we encountered, and later purchased, our first bread-maker, an apparatus as absurd as it was wondrous—became places for teaching ourselves a new, aspirational identity: what to buy and where. Yet, for a country of 1.4 billion people, time travel is very different. You don’t so much assimilate into the dominant culture as create an entirely new one.

In the world of Chinese retail, the area where you most strongly feel the absence of older forms of identity, and the frenetic impulse to reinvent oneself, is the luxury-goods market. The Chinese are the most prolific consumers of luxury items globally, accounting for thirty-two per cent of sales last year. And, because habits of consumption are less ingrained—no one’s granny shopped at Bergdorf’s—people have been notably willing to buy, say, twenty-thousand-dollar watches with a mere tap on a phone. Unsurprisingly, retailers have poured into the sector, and Jeffrey Towson, a business professor at Peking University, suggested to me that JD may be particularly well positioned for the current moment, because of its reputation for dependability and its no-fakes guarantee.

At JD’s headquarters, after my meeting with Liu, I had tea with Belinda Chen, the director of fashion merchandising. Born in Beijing, Chen, who speaks accentless English, attended Berkeley and Wharton, but then turned down a job at Amazon to come back home, believing that China’s tech scene offered more opportunity than Silicon Valley. (This is a common view: JD’s chief technology officer, a former Yahoo employee, assured me that the American tech industry is “on a downward slope.”)

Chen explained that JD's burgeoning focus on luxury was a consequence not only of the rise of a moneyed middle class but also of the middle class's relative youth. Buyers of big-ticket items are five to ten years younger than their Western counterparts. "Most of them experience, and learn about, luxury brands over the phone," she said. "So digital becomes increasingly important."

But selling luxury goods online presents challenges, as Liu had explained: "When you are selling products for thousands of dollars, you aren't only selling the product, you are selling an experience. We have to make sure that consumers are getting a premium experience—otherwise, what's the point of bringing luxury online?" Perhaps JD's most striking solution is its so-called white-glove service: in certain cities, buyers of fancy items can have their purchase chauffeured to them by a smartly dressed driver sporting white gloves. It has proved popular, partly because people like to show off for their friends. "The Chinese are increasingly status-conscious in an already very status-conscious society," Chen said.

In Beijing, I accompanied a white-glove courier, a twenty-seven-year-old named Shang Kai, on his rounds. He'd been a regular JD deliveryman in the city for five years when he heard that the company was recruiting workers for the new service. He fit all the requirements for the job: male, under thirty-five, able to drive, five feet ten or above, with a good physique and "proper facial features." He talked it over with his wife, and they agreed that this was the kind of opportunity they'd moved to the capital for.

Shang makes his deliveries in a small electric car painted with bursts of JD red. He wears a made-to-measure business suit and a tie. As we set off on his first delivery, a package sat between us: judging by its weight, he guessed it to be a digital camera. He'd noticed that, when he started his job, some customers insisted on opening their package right away to check for problems, but increasingly people seemed to trust the JD brand. Shang took pride in being part of that brand—part of the luxury package that the customer was paying for. Not long ago, a young man who'd ordered an iPhone X for his girlfriend was so impressed by Shang's appearance that he rushed back to his apartment and grabbed his camera to take a picture of Shang next to his delivery car, box in hand.

This was something that had never happened to Shang before, being admired, and he had the odd, exhilarating feeling that he had "miraculously ascended to the white-collar class." Before this job, Shang had never worn a suit and tie, and, back when he trudged around town in his red uniform, no one even said "please" or "thank you." Now young women flirted with him, striking up conversations when he brought them their packages. A waiter in a restaurant he frequented, who used to bark at him impatiently, now bowed and said, "Sir, please follow me." On one delivery, I saw two older women watch intently as he pulled on his white gloves, a step he saves till last, so as not to dirty them. A few days before, he had delivered solid gold bars, worth tens of thousands of dollars, to an investment bank that was apparently giving them out as bonuses. Shang felt as if he were discovering a new stratum of life. "I had gold bars in my hands!" he marvelled. He'd never been inside an investment bank

before—hadn't even really known what one was. "To be honest, I still don't really know," he admitted. "But now I can say I've been in one, you know?"

Shang was from a family of peanut farmers in rural Henan, and found village life slow and constricting. Men married at eighteen and became fathers at twenty. "You can see the end of your life at its beginning," he said. As soon as he finished high school, he left to join the Army. One of his teachers had given him a valuable piece of advice: "The future belongs to those who know English, computers, and their way around a vehicle." Shang knew that his English was hopeless and his computer skills average at best. That left driving, without which his new career would have been out of reach.

On the sidewalk, Shang's phone rang. Someone who had been planning to pay in cash had suddenly realized that he didn't have enough on hand. Shang arranged to make the delivery another time. This wasn't unusual with younger customers, he said, adding that almost everyone he delivered to was under forty.

The next destination on the list was an office building that gleamed like black obsidian. In the lobby was a marble security counter and turnstiles for badge-wearing employees. Shang gazed up at the soaring ceilings. Then he straightened his back, brushed something invisible from his lapel, and told the security guard that he was a JD employee making a delivery. The man gave him a once-over, called up to the recipient, and waved us toward the elevators. It wasn't until we arrived on the fifth floor that I realized we were in a law firm. Men and women carrying briefcases or hugging stacks of paper hurried to and fro. We waited by the elevators for a considerable time, while they stepped around us. I asked Shang if he ever counted up how much of his day was spent waiting, and he shrugged to indicate that he didn't mind it much. Although he typically worked twelve to thirteen hours a day, six days a week, he liked how relaxed his schedule was; driving around in a sporty, temperature-controlled car was much more congenial than Army life, which was in turn less arduous than working in the fields all day. Still, he and his wife now had a one-year-old son, and he wanted to teach the boy about the value of time—a commodity that, he'd noticed, the most important people had the least of.

As we spoke, a thirtyish lawyer in a pencil skirt approached us with a timid smile. It was the third time she had come out to the elevator bank. "Hello, Ma'am," Shang said, with a decorous nod. "I'm the messenger from JD." The woman smiled with embarrassment and explained that she'd been looking for someone in the usual red uniform. "I thought you were either a client or a colleague here that I didn't recognize," she said. As we rode the elevator back down, there was a quiet satisfaction in Shang's manner: being mistaken for a lawyer was another exotic adventure to add to the list. The white-glove service, designed to satisfy the aspirations of the wealthy, had an equally aspirational aspect for him.

Recently, Shang made an expensive purchase of his own: an iPhone 7 for his wife. It cost a month's salary, but he was pleased. The next time his wife and his son made the thirteen-hour train ride back to Henan, she'd likely be in possession of the only iPhone 7 the villagers had ever seen. Shang himself could get back only once or

twice a year, but video chats on his smartphone made it seem as if his parents weren't so far away. He and his wife wanted to have one more baby, and the plan was to raise the children in the city. "Going back to the village now," he said, his voice softening as he looked for the words, "it's like an ocean trying to flow back into a stream." As we got back in the car, I asked if he was sure he'd never want to live in Henan again, and there was a pause as he checked the coördinates of the next delivery. "In forty years, maybe," Shang said, tucking his gloves into his breast pocket. "I'll be a grandpa, or maybe a great-grandpa. But I guess it would still be the place I came from, the place I have called home."
Adapted from The New Yorker

Google X and the Science of Radical Creativity
How the secretive Silicon Valley lab is trying to resurrect the lost art of invention
I. The Question

A snake-robot designer, a balloon scientist, a liquid-crystals technologist, an extradimensional physicist, a psychology geek, an electronic-materials wrangler, and a journalist walk into a room. The journalist turns to the assembled crowd and asks: Should we build houses on the ocean?

The setting is X, the so-called moonshot factory at Alphabet, the parent company of Google. And the scene is not the beginning of some elaborate joke. The people in this room have a particular talent: They dream up far-out answers to crucial problems. The dearth of housing in crowded and productive coastal cities is a crucial problem. Oceanic residences are, well, far-out. At the group's invitation, I was proposing my own moonshot idea, despite deep fear that the group would mock it.

Like a think-tank panel with the instincts of an improv troupe, the group sprang into an interrogative frenzy. "What are the specific economic benefits of increasing housing supply?" the liquid-crystals guy asked. "Isn't the real problem that transportation infrastructure is so expensive?" the balloon scientist said. "How sure are we that living in densely built cities makes us happier?" the extradimensional physicist wondered. Over the course of an hour, the conversation turned to the ergonomics of Tokyo's high-speed trains and then to Americans' cultural preference for suburbs. Members of the team discussed commonsense solutions to urban density, such as more money for transit, and eccentric ideas, such as acoustic technology to make apartments soundproof and self-driving housing units that could park on top of one another in a city center. At one point, teleportation enjoyed a brief hearing.

X is perhaps the only enterprise on the planet where regular investigation into the absurd is not just permitted but encouraged, and even required. X has quietly looked into space elevators and cold fusion. It has tried, and abandoned, projects to design hoverboards with magnetic levitation and to make affordable fuel from seawater. It has tried—and succeeded, in varying measures—to build self-driving cars, make drones that deliver aerodynamic packages, and design contact lenses that measure glucose levels in a diabetic person's tears.

These ideas might sound too random to contain a unifying principle. But they do. Each X idea adheres to a simple three-part formula. First, it must address a huge problem; second, it must propose a radical solution; third, it must employ a relatively feasible technology. In other words, any idea can be a moonshot—unless it's frivolous, small-bore, or impossible.

The purpose of X is not to solve Google's problems; thousands of people are already doing that. Nor is its mission philanthropic. Instead X exists, ultimately, to create world-changing companies that could eventually become the next Google. The enterprise considers more than 100 ideas each year, in areas ranging from clean energy to artificial intelligence. But only a tiny percentage become "projects," with full-time staff working on them. It's too soon to know whether many (or any) of these shots will reach the moon: X was formed in 2010, and its projects take years; critics note a shortage of revenue to date. But several projects—most notably Waymo, its self-driving-car company, recently valued at $70 billion by one Wall Street firm—look like they may.

X is extremely secretive. The company won't share its budget or staff numbers with investors, and it's typically off-limits to journalists as well. But this summer, the organization let me spend several days talking with more than a dozen of its scientists, engineers, and thinkers. I asked to propose my own absurd idea in order to better understand the creative philosophy that undergirds its approach. That is how I wound up in a room debating a physicist and a roboticist about apartments floating off the coast of San Francisco.

I'd expected the team at X to sketch some floating houses on a whiteboard, or discuss ways to connect an ocean suburb to a city center, or just inform me that the idea was terrible. I was wrong. The table never once mentioned the words floating or ocean. My pitch merely inspired an inquiry into the purpose of housing and the shortfalls of U.S. infrastructure. It was my first lesson in radical creativity. Moonshots don't begin with brainstorming clever answers. They start with the hard work of finding the right questions.

Creativity is an old practice but a new science. It was only in 1950 that J. P. Guilford, a renowned psychologist at the University of Southern California, introduced the discipline of creativity research in a major speech to the American Psychological Association. "I discuss the subject of creativity with considerable hesitation," he began, "for it represents an area in which psychologists generally, whether they be angels or not, have feared to tread." It was an auspicious time to investigate the subject of human ingenuity, particularly on the West Coast. In the next decade, the apricot farmland south of San Francisco took its first big steps toward becoming Silicon Valley.

Yet in the past 60 years, something strange has happened. As the academic study of creativity has bloomed, several key indicators of the country's creative power have turned downward, some steeply. Entrepreneurship may have grown as a status symbol, but America's start-up rate has been falling for decades. The label innovation may have spread like ragweed to cover every minuscule tweak of a soda

can or a toothpaste flavor, but the rate of productivity growth has been mostly declining since the 1970s. Even Silicon Valley itself, an economic powerhouse, has come under fierce criticism for devoting its considerable talents to trivial problems, like making juice or hailing a freelancer to pick up your laundry.

Breakthrough technology results from two distinct activities that generally require different environments—invention and innovation. Invention is typically the work of scientists and researchers in laboratories, like the transistor, developed at Bell Laboratories in the 1940s. Innovation is an invention put to commercial use, like the transistor radio, sold by Texas Instruments in the 1950s. Seldom do the two activities occur successfully under the same roof. They tend to thrive in opposite conditions; while competition and consumer choice encourage innovation, invention has historically prospered in labs that are insulated from the pressure to generate profit.

The United States' worst deficit today is not of incremental innovation but of breakthrough invention. Research-and-development spending has declined by two-thirds as a share of the federal budget since the 1960s. The great corporate research labs of the mid-20th century, such as Bell Labs and Xerox Palo Alto Research Center (parc), have shrunk and reined in their ambitions. America's withdrawal from moonshots started with the decline in federal investment in basic science. Allowing well-funded and diverse teams to try to solve big problems is what gave us the nuclear age, the transistor, the computer, and the internet. Today, the U.S. is neglecting to plant the seeds of this kind of ambitious research, while complaining about the harvest.

No one at X would claim that it is on the verge of unleashing the next platform technology, like electricity or the internet—an invention that could lift an entire economy. Nor is the company's specialty the kind of basic science that typically thrives at research universities. But what X is attempting is nonetheless audacious. It is investing in both invention and innovation. Its founders hope to demystify and routinize the entire process of making a technological breakthrough—to nurture each moonshot, from question to idea to discovery to product—and, in so doing, to write an operator's manual for radical creativity.

II. The Inkling

Inside x's palo alto headquarters, artifacts of projects and prototypes hang on the walls, as they might in a museum—an exhibition of alternative futures. A self-driving car is parked in the lobby. Drones shaped like Jedi starfighters are suspended from the rafters. Inside a three-story atrium, a large screen renders visitors as autonomous vehicles would see them—pointillist ghosts moving through a rainbow-colored grid. It looks like Seurat tried to paint an Atari game.

Just beyond the drones, I find Astro Teller. He is the leader of X, whose job title, captain of moonshots, is of a piece with his piratical, if perhaps self-conscious, charisma. He has a long black ponytail and silver goatee, and is wearing a long-sleeved T-shirt, dark jeans, and large black Rollerblades. Fresh off an afternoon skate?, I ask. "Actually, I wear these around the office about 98 percent of the time,"

he says. I glance at an X publicist to see whether he's serious. Her expression says: Of course he is.

Teller, 47, descends from a formidable line of thinkers. His grandfathers were Edward Teller, the father of the hydrogen bomb, and Gérard Debreu, a mathematician who won a Nobel Prize in Economics. With a doctorate in artificial intelligence from Carnegie Mellon, Teller is an entrepreneur, a two-time novelist, and the author of a nonfiction book, Sacred Cows, on marriage and divorce—co-written with his second wife. His nickname, Astro, though painfully on the nose for the leader of a moonshot factory, was bestowed upon him in high school, by friends who said his flattop haircut resembled Astroturf. (His given name is Eric.)

In 2010, Teller joined a nascent division within Google that would use the company's ample profits to explore bold new ideas, which Teller called "moonshots." The name X was chosen as a purposeful placeholder—as in,We'll solve for that later. The one clear directive was what X would not do. While almost every corporate research lab tries to improve the core product of the mother ship, X was conceived as a sort of anti–corporate research lab; its job was to solve big challenges anywhere except in Google's core business.

When Teller took the helm of X (which is now a company, like Google, within Alphabet), he devised the three-part formula for an ideal moonshot project: an important question, a radical solution, and a feasible path to get there. The proposals could come from anywhere, including X employees, Google executives, and outside academics. But grand notions are cheap and abundant—especially in Silicon Valley, where world-saving claims are a debased currency—and actual breakthroughs are rare. So the first thing Teller needed to build was a way to kill all but the most promising ideas. He assembled a team of diverse experts, a kind of Justice League of nerds, to process hundreds of proposals quickly and promote only those with the right balance of audacity and achievability. He called it the Rapid Evaluation team.

In the landscape of ideas, Rapid Eval members aren't vertical drillers but rather oil scouts, skillful in surveying the terrain for signs of pay dirt. You might say it's Rapid Eval's job to apply a kind of future-perfect analysis to every potential project: If this idea succeeds, what will have been the challenges? If it fails, what will have been the reasons?

The art of predicting which ideas will become hits is a popular subject of study among organizational psychologists. In academic jargon, it is sometimes known as "creative forecasting." But what sorts of teams are best at forecasting the most-successful creations? Justin Berg, a professor at the Stanford Graduate School of Business, set out to answer this question in a 2016 study focused on, of all things, circus performances.

Berg found that there are two kinds of circus professionals: creators who imagine new acts, and managers who evaluate them. He collected more than 150 circus-performance videos and asked more than 300 circus creators and managers to watch them and predict the performers' success with an audience. Then he compared their reactions with those of more than 13,000 ordinary viewers.

Creators, Berg found, were too enamored of their own concepts. But managers were too dismissive of truly novel acts. The most effective evaluation team, Berg concluded, was a group of creators. “A solitary creator might fall in love with weird stuff that isn’t broadly popular,” he told me, “but a panel of judges will reject anything too new. The ideal mix is a panel of creators who are also judges, like the teams at X.” The best evaluators are like player-coaches—they create, then manage, and then return to creating. “They’re hybrids,” Berg said.

Rich devaul is a hybrid. He is the leader of the Rapid Eval team but he has also, like many members, devoted himself to major projects at X. He has looked into the feasibility of space elevators that could transport cargo to satellites without a rocket ship and modeled airships that might transport goods and people in parts of the world without efficient roads, all without ever touching the ground. “At one point, I got really interested in cold fusion,” he said. “Because why not?”

One of DeVaul’s most consuming obsessions has been to connect the roughly 4 billion people around the world who don’t have access to high-speed internet. He considers the internet the steam engine or electrical grid of the 21st century—the platform technology for a long wave of economic development. DeVaul first proposed building a cheap, solar-powered tablet computer. But the Rapid Eval team suggested that he was aiming at the wrong target. The world’s biggest need wasn’t hardware but access. Cables and towers were too expensive to build in mountains and jungles, and earthbound towers don’t send signals widely enough to make sense for poor, sparsely populated areas. The cost of satellites made those, too, prohibitive for poor areas. DeVaul needed something inexpensive that could live in the airspace between existing towers and satellites. His answer: balloons. Really big balloons.

The idea struck more than a few people as ridiculous. “I thought I was going to be able to prove it impossible really quickly,” said Cliff L. Biffle, a computer scientist and Rapid Eval manager who has been at X for six years. “But I totally failed. It was really annoying.” Here was an idea, the team concluded, that could actually work: a network of balloons, equipped with computers powered by solar energy, floating 13 miles above the Earth, distributing internet to the world. The cause was huge; the solution was radical; the technology was feasible. They gave it a name: Project Loon.

At first, Loon team members thought the hardest problem would be sustaining an internet connection between the ground and a balloon. DeVaul and Biffle bought several helium balloons, attached little Wi-Fi devices to them, and let them go at Dinosaur Point, in the Central Valley. As the balloons sluiced through the jet stream, DeVaul and his colleagues chased them down in a Subaru Forester rigged with directional antennae to catch the signal. They drove like madmen along the San Luis Reservoir as the balloons soared into the stratosphere. To their astonishment, the internet connection held. DeVaul was ecstatic, his steampunk vision of broadband-by-balloon seemingly within grasp. “I thought, The rest is just ballooning!” he said. “That’s not rocket science.”

He was right, in a way. Ballooning of the sort his team imagined isn’t rocket science. It’s harder.

Let's start with the balloons. Each one, flattened, is the size of a tennis court, made of stitched-together pieces of polyethylene. At the bottom of the balloon hangs a small, lightweight computer with the same technology you would find at the top of a cell tower, with transceivers to beam internet signals and get information from ground stations. The computer system is powered by solar panels. The balloon is designed to float 70,000 feet above the Earth for months in one stretch. The next time you are at cruising altitude in an airplane, imagine seeing a balloon as far above you as the Earth is far below. The balloons have to survive in what is essentially an alien environment. At night, the temperature plunges to 80 degrees below zero Celsius, colder than your average evening on Mars. By day, the sun could fry a typical computer, and the air is too thin for a fan to cool the motherboard. So Loon engineers store the computer system in a specially constructed box—the original was a Styrofoam beer cooler—coated with reflective white paint. The computer system, guided by an earthbound data center, can give the balloon directions ("Go northeast to Lima!"), but the stratosphere is not an orderly street grid in which traffic flows in predictable directions. It takes its name from the many strata, or layers, of air temperatures and wind currents. It's difficult to predict which way the stratosphere's winds will blow. To navigate above a particular town—say, Lima—the balloon cannot just pick any altitude and cruise. It must dive and ascend thousands of feet, sampling the gusts of various altitudes, until it finds one that is pointing in just the right direction. So Loon uses a team of balloons to provide constant coverage to a larger area. As one floats off, another moves in to take its place.

Four years after Loon's first real test, in New Zealand, the project is in talks with telecommunications companies around the world, especially where cell towers are hard to build, like the dense jungles and mountains of Peru. Today a network of broadband-beaming balloons floats above rural areas outside of Lima, delivering the internet through the provider Telefónica.

Improving internet access in Latin America, Africa, and Asia to levels now seen in developed countries would generate more than $2 trillion in additional GDP, according to a recent study by Deloitte. Loon is still far from its global vision, but capturing even a sliver of one percentage point of that growth would make it a multibillion-dollar business.

III. The Fail

Astro teller likes to recount an allegorical tale of a firm that has to get a monkey to stand on top of a 10-foot pedestal and recite passages from Shakespeare. Where would you begin? he asks. To show off early progress to bosses and investors, many people would start with the pedestal. That's the worst possible choice, Teller says. "You can always build the pedestal. All of the risk and the learning comes from the extremely hard work of first training the monkey." An X saying is "#MonkeyFirst"—yes, with the hashtag—and it means "do the hardest thing first."

But most people don't want to do the hardest thing first. Most people want to go to work and get high fives and backslaps. Despite the conference-keynote pabulum about failure ("Fail fast! Fail often!"), the truth is that, financially and

psychologically, failure sucks. In most companies, projects that don't work out are stigmatized, and their staffs are fired. That's as true in many parts of Silicon Valley as it is anywhere else. X may initially seem like a paradise of curiosity and carefree tinkering, a world apart from the drudgery required at a public company facing the drumbeat of earnings reports. But it's also a place immersed in failure. Most green-lit Rapid Eval projects are unsuccessful, even after weeks, months, or years of one little failure after another.

At X, Teller and his deputies have had to build a unique emotional climate, where people are excited to take big risks despite the inevitability of, as Teller delicately puts it, "falling flat on their face." X employees like to bring up the concept of "psychological safety." I initially winced when I heard the term, which sounded like New Age fluff. But it turns out to be an important element of X's culture, the engineering of which has been nearly as deliberate as that of, say, Loon's balloons.

Kathy Hannun told me of her initial anxiety, as the youngest employee at X, when she joined in the spring of 2012. On her first day, she was pulled into a meeting with Teller and other X executives where, by her account, she stammered and flubbed several comments for fear of appearing out of her depth. But everyone, at times, is out of his or her depth at X. After the meeting, Teller told her not to worry about making stupid comments or asking ignorant questions. He would not turn on her, he said.

Hannun now serves as the CEO of Dandelion, an X spin-off that uses geothermal technology to provide homes in New York State with a renewable source of heating, cooling, and hot water. "I did my fair share of unwise and inexperienced things over the years, but Astro was true to his word," she told me. The culture, she said, walked a line between patience and high expectations, with each quality tempering the other.

X encourages its most successful employees to talk about the winding and potholed road to breakthrough invention. This spring, André Prager, a German mechanical engineer, delivered a 25-minute presentation on this topic at a company meeting, joined by members of X's drone team, called Project Wing. He spoke about his work on the project, which was founded on the idea that drones could be significant players in the burgeoning delivery economy. The idea had its drawbacks: Dogs may attack a drone that lands, and elevated platforms are expensive, so Wing's engineers needed a no-landing/no-infrastructure solution. After sifting through hundreds of ideas, they settled on an automatic winching system that lowered and raised a specialized spherical hook—one that can't catch on clothing or tree branches or anything else—to which a package could be attached.

In their address, Prager and his team spent less time on their breakthroughs than on the many failed cardboard models they discarded along the way. The lesson they and Teller wanted to communicate is that simplicity, a goal of every product, is in fact extremely complicated to design. "The best designs—a bicycle, a paper clip—you look and think, Well of course, it always had to look like that," Prager told me. "But the less design you see, the more work was needed to get there." X tries to

celebrate the long journey of high-risk experimentation, whether it leads to the simplicity of a fine invention or the mess of failure.

Because the latter possibility is high, the company has also created financial rewards for team members who shut down projects that are likely to fail. For several years, Hannun led another group, named Foghorn, which developed technology to turn seawater into affordable fuel. The team appeared to be on track, until the price of oil collapsed in 2015 and its members forecast that their fuel couldn't compete with regular gasoline soon enough to justify keeping the project alive. In 2016, they submitted a detailed report explaining that, despite advancing the science, their technology would not be economically viable in the near future. They argued for the project to be shut down. For this, the entire team received a bonus.

Some might consider these so-called failure bonuses to be a bad incentive. But Teller says it's just smart business. The worst scenario for X is for many doomed projects to languish for years in purgatory, sucking up staff and resources. It is cheaper to reward employees who can say, "We tried our best, and this just didn't work out."

Recently, X has gone further in accommodating and celebrating failure. In the summer of 2016, the head of diversity and inclusion, a Puerto Rican–born woman named Gina Rudan, spoke with several X employees whose projects were stuck or shut down and found that they were carrying heavy emotional baggage. She approached X's leadership with an idea based on Mexico's Día de los Muertos, or Day of the Dead. She suggested that the company hold an annual celebration to share stories of pain from defunct projects. Last November, X employees gathered in the main hall to hear testimonials, not only about failed experiments but also about failed relationships, family deaths, and personal tragedies. They placed old prototypes and family mementos on a small altar. It was, several X employees told me, a resoundingly successful and deeply emotional event.

No failure at x has been more public than Google Glass, the infamous head-mounted wearable computer that resembled a pair of spectacles. Glass was meant to be the world's next great hardware evolution after the smartphone. Even more quixotically, its hands-free technology was billed as a way to emancipate people from their screens, making technology a seamless feature of the natural world. (To critics, it was a ploy to eventually push Google ads as close to people's corneas as possible.) After a dazzling launch in 2013 that included a 12-page spread in Vogue, consumers roundly dissed the product as buggy, creepy, and pointless. The last of its dwindling advocates were branded "glassholes." I found that X employees were eager to talk about the lessons they drew from Glass's failure. Two lessons, in particular, kept coming up in our conversations. First, they said, Glass flopped not because it was a bad consumer product but because it wasn't a consumer product at all. The engineering team at X had wanted to send Glass prototypes to a few thousand tech nerds to get feedback. But as buzz about Glass grew, Google, led by its gung-ho co-founder Sergey Brin, pushed for a larger publicity tour—including a ted Talk and a fashion show with Diane von Furstenberg. Photographers captured Glass on the faces

of some of the world's biggest celebrities, including Beyoncé and Prince Charles, and Google seemed to embrace the publicity. At least implicitly, Google promised a product. It mailed a prototype. (Four years later, Glass has reemerged as a tool for factory workers, the same group that showed the most enthusiasm for the initial design.)

But Teller and others also saw Glass's failure as representative of a larger structural flaw within X. It had no systemic way of turning science projects into businesses, or at least it hadn't put enough thought into that part of the process. So X created a new stage, called Foundry, to serve as a kind of incubator for scientific breakthroughs as its team develops a business model. The division is led by Obi Felten, a Google veteran whose title says it all: head of getting moonshots ready for contact with the real world.

"When I came here," Felten told me, "X was this amazing place full of deep, deep, deep geeks, most of whom had never taken a product out into the world." In Foundry, the geeks team up with former entrepreneurs, business strategists from firms like McKinsey, designers, and user-experience researchers.

One of the latest breakthroughs to enter Foundry is an energy project code-named Malta, which is an answer to one of the planet's most existential questions: Can wind and solar energy replace coal? The advent of renewable-energy sources is encouraging, since three-quarters of global carbon emissions come from fossil fuels. But there is no clean, cost-effective, grid-scale technology for storing wind or solar energy for those times when the air is calm or the sky is dark. Malta has found a way to do it using molten salt. In Malta's system, power from a wind farm would be converted into extremely hot and extremely cold thermal energy. The warmth would be stored in molten salt, while the cold energy (known internally as "coolth") would live in a chilly liquid. A heat engine would then recombine the warmth and coolth as needed, converting them into electric energy that would be sent back out to the grid. X believes that salt-based thermal storage could be considerably cheaper than any other grid-scale storage technology in the world.

The current team leader is Raj B. Apte, an ebullient entrepreneur and engineer who made his way to X through parc. He compares the project's recent transition to Foundry to "when you go from a university lab to a start-up with an A-class venture capitalist." Now that Apte and his team have established that the technology is viable, they need an industry partner to build the first power plant. "When I started Malta, we very quickly decided that somewhere around this point would be the best time to fire me," Apte told me, laughing. "I'm a display engineer who knows about hetero-doped polysilicon diodes, not a mechanical engineer with a background in power plants." Apte won't leave X, though. Instead he will be converted into a member of the Rapid Eval team, where X will store his creative energies until they are deployed to another project.

Thinking about the creation of Foundry, it occurred to me that X is less a moonshot factory than a moonshot studio. Like MGM in the 1940s, it employs a wide array of talent, generates a bunch of ideas, kills the weak ones, nurtures the survivors

for years, and brings the most-promising products to audiences—and then keeps as much of the talent around as possible for the next feature.

IV. The Invention

Technology is feral. It takes teamwork to wrangle it and patience to master it, and yet even in the best of circumstances, it runs away. That's why getting invention right is hard, and getting commercial innovation right is hard, and doing both together —as X hopes to—is practically impossible. That is certainly the lesson from the two ancestors of X: Bell Laboratories and Xerox parc. Bell Labs was the preeminent science organization in the world during the middle of the 20th century. From 1940 to 1970, it gave birth to the solar cell, the laser, and some 9 percent of the nation's new communications patents. But it never merchandised the vast majority of its inventions. As the research arm of AT&T's government-sanctioned monopoly, it was legally barred from entering markets outside of telephony.

In the 1970s, just as the golden age at Bell Labs was ending, its intellectual heir was rising in the West. At Xerox parc, now known as just parc, another sundry band of scientists and engineers laid the foundation for personal computing. Just about everything one associates with a modern computer—the mouse, the cursor, applications opening in windows—was pioneered decades ago at parc. But Xerox failed to appreciate the tens of trillions of dollars locked within its breakthroughs. In what is now Silicon Valley lore, it was a 20-something entrepreneur named Steve Jobs who in 1979 glimpsed parc's computer-mouse prototype and realized that, with a bit of tinkering, he could make it an integral part of the desktop computer.

Innovators are typically the heroes of the story of technological progress. After all, their names and logos are the ones in our homes and in our pockets. Inventors are the anonymous geeks whose names lurk in the footnotes (except, perhaps, for rare crossover polymaths such as Thomas Edison and Elon Musk). Given our modern obsession with billion-dollar start-ups and mega-rich entrepreneurs, we have perhaps forgotten the essential role of inventors and scientific invention.

The decline in U.S. productivity growth since the 1970s puzzles economists; potential explanations range from an aging workforce to the rise of new monopolies. But John Fernald, an economist at the Federal Reserve, says we can't rule out a drought of breakthrough inventions. He points out that the notable exception to the post-1970 decline in productivity occurred from 1995 to 2004, when businesses throughout the economy finally figured out information technology and the internet. "It's possible that productivity took off, and then slowed down, because we picked all the low-hanging fruit from the information-technology wave," Fernald told me.

The U.S. economy continues to reap the benefits of IT breakthroughs, some of which are now almost 50 years old. But where will the next brilliant technology shock come from? As total federal R&D spending has declined—from nearly 12 percent of the budget in the 1960s to 4 percent today—some analysts have argued that corporate America has picked up the slack. But public companies don't really invest in experimental research; their R&D is much more D than R. A 2015 study from Duke University found that since 1980, there has been a "shift away from

scientific research by large corporations"—the triumph of short-term innovation over long-term invention.

The decline of scientific research in America has serious implications. In 2015, MIT published a devastating report on the landmark scientific achievements of the previous year, including the first spacecraft landing on a comet, the discovery of the Higgs boson particle, and the creation of the world's fastest supercomputer. None of these was an American-led accomplishment. The first two were the products of a 10-year European-led consortium. The supercomputer was built in China.

As the MIT researchers pointed out, many of the commercial breakthroughs of the past few years have depended on inventions that occurred decades ago, and most of those were the results of government investment. From 2012 to 2016, the U.S. was the world's leading oil producer. This was largely thanks to hydraulic fracturing experiments, or fracking, which emerged from federally funded research into drilling technology after the 1970s oil crisis. The recent surge in new cancer drugs and therapies can be traced back to the War on Cancer announced in 1971. But the report pointed to more than a dozen research areas where the United States is falling behind, including robotics, batteries, and synthetic biology. "As competitive pressures have increased, basic research has essentially disappeared from U.S. companies," the authors wrote.

It is in danger of disappearing from the federal government as well. The White House budget this year proposed cutting funding for the National Institutes of Health, the crown jewel of U.S. biomedical research, by $5.8 billion, or 18 percent. It proposed slashing funding for disease research, wiping out federal climate-change science, and eliminating the Energy Department's celebrated research division, arpa-e.

The Trump administration's thesis seems to be that the private sector is better positioned to finance disruptive technology. But this view is ahistorical. Almost every ingredient of the internet age came from government-funded scientists or research labs purposefully detached from the vagaries of the free market. The transistor, the fundamental unit of electronics hardware, was invented at Bell Labs, inside a government-sanctioned monopoly. The first model of the internet was developed at the government's Advanced Research Projects Agency, now called darpa. In the 1970s, several of the agency's scientists took their vision of computers connected through a worldwide network to Xerox parc.

"There is still a huge misconception today that big leaps in technology come from companies racing to make money, but they do not," says Jon Gertner, the author of The Idea Factory, a history of Bell Labs. "Companies are really good at combining existing breakthroughs in ways that consumers like. But the breakthroughs come from patient and curious scientists, not the rush to market." In this regard, X's methodical approach to invention, while it might invite sneering from judgmental critics and profit-hungry investors, is one of its most admirable qualities. Its pace and its patience are of another era.

V. The Question, Again

Any successful organization working on highly risky projects has five essential features, according to Teresa Amabile, a professor at Harvard Business School and a co-author of The Progress Principle. The first is "failure value," a recognition that mistakes are opportunities to learn. The second is psychological safety, the concept so many X employees mentioned. The third is multiple diversities—of backgrounds, perspectives, and cognitive styles. The fourth, and perhaps most complicated, is a focus on refining questions, not just on answers; on routinely stepping back to ask whether the problems the organization is trying to solve are the most important ones. These are features that X has self-consciously built into its culture.

The fifth feature is the only one that X does not control: financial and operational autonomy from corporate headquarters. That leads to an inevitable question: How long will Alphabet support X if X fails to build the next Google?

The co-founders of Google, Brin and Larry Page, clearly have a deep fondness for X. Page once said that one of his childhood heroes was Nikola Tesla, the polymath Serbian American whose experiments paved the way for air-conditioning and remote controls. "He was one of the greatest inventors, but it's a sad, sad story," Page said in a 2008 interview. "He couldn't commercialize anything, he could barely fund his own research. You'd want to be more like Edison … You've got to actually get [your invention] into the world; you've got to produce, make money doing it."
Nine years later, this story seems like an ominous critique of X, whose dearth of revenue makes it more like Tesla's laboratory than Edison's factory. Indeed, the most common critique of X that I heard from entrepreneurs and academics in the Valley is that the company's prodigious investment has yet to produce a blockbuster.

Several X experiments have been profitably incorporated into Google already. X's research into artificial intelligence, nicknamed Brain, is now powering some Google products, like its search and translation software. And an imminent blockbuster may be hiding in plain sight: In May, Morgan Stanley analysts told investors that Waymo, the self-driving-car company that incubated at X for seven years, is worth $70 billion, more than the market cap of Ford or GM. The future of self-driving cars—how they will work, and who exactly will own them—is uncertain. But the global car market generates more than $1 trillion in sales each year, and Waymo's is perhaps the most advanced autonomous-vehicle technology in the world. What's more, X may benefit its parent company in ways that have nothing to do with X's own profits or losses. Despite its cuddly and inspirational appeal, Google is a mature firm whose 2017 revenue will likely surpass $100 billion. Growing Google's core business requires salespeople and marketers who perform ordinary tasks, such as selling search terms to insurance companies. There is nothing wrong with these jobs, but they highlight a gap—perhaps widening—between Silicon Valley's world-changing rhetoric and what most people and companies actually do there.

X sends a corporate signal, both internally and externally, that Page and Brin are still nurturing the idealism with which they founded what is now basically an advertising company. Several business scholars have argued that Google's domination of the market for search advertising is so complete that it should be

treated as a monopoly. In June, the European Union slapped Google with a $2.7 billion antitrust fine for promoting its own shopping sites at the expense of competitors. Alphabet might use the projects at X to argue that it is a benevolent giant willing to spend its surplus on inventions that enrich humanity, much like AT&T did with Bell Labs.

All of that said, X's soft benefits and theoretical valuations can go only so far; at some point, Alphabet must determine whether X's theories of failure, experimentation, and invention work in practice. After several days marinating in the company's idealism, I still wondered whether X's insistence on moonshots might lead it to miss the modest innovations that typically produce the most-valuable products. I asked Astro Teller a mischievous question: Imagine you are participating in a Rapid Eval session in the mid-1990s, and somebody says she wants to rank every internet page by influence. Would he champion the idea? Teller saw right through me: I was referring to PageRank, the software that grew into Google. He said, "I would like to believe that we would at least go down the path" of exploring a technology like PageRank. But "we might have said no."

I then asked him to imagine that the year was 2003, and an X employee proposed digitizing college yearbooks. I was referring to Facebook, now Google's fiercest rival for digital-advertising revenue. Teller said he would be even more likely to reject that pitch. "We don't go down paths where the hard stuff is marketing, or understanding how people get dates." He paused. "Obviously there are hard things about what Facebook is doing. But digitizing a yearbook was an observation about connecting people, not a technically hard challenge."

X has a dual mandate to solve huge problems and to build the next Google, two goals that Teller considers closely aligned. And yet Facebook grew to rival Google, as a platform for advertising and in financial value, by first achieving a quotidian goal. It was not a moonshot but rather the opposite—a small step, followed by another step, and another.

Insisting on quick products and profits is the modern attitude of innovation that X continues to quietly resist. For better and worse, it is imbued with an appreciation for the long gestation period of new technology.

Technology is a tall tree, John Fernald told me. But planting the seeds of invention and harvesting the fruit of commercial innovation are entirely distinct skills, often mastered by different organizations and separated by many years. "I don't think of X as a planter or a harvester, actually," Fernald said. "I think of X as building taller ladders. They reach where others cannot." Several weeks later, I repeated the line to several X employees. "That's perfect," they said. "That's so perfect." Nobody knows for sure what, if anything, the employees at X are going to find up on those ladders. But they're reaching. At least someone is.

Adapted from The Atlantic

The First Person to Hack the iPhone Built a Self-Driving Car. In His Garage

George Hotz is taking on Google and Tesla by himself.

A few days before Thanksgiving, George Hotz, a 26-year-old hacker, invites me to his house in San Francisco to check out a project he's been working on. He says it's a self-driving car that he had built in about a month. The claim seems absurd. But when I turn up that morning, in his garage there's a white 2016 Acura ILX outfitted with a laser-based radar (lidar) system on the roof and a camera mounted near the rearview mirror. A tangle of electronics is attached to a wooden board where the glove compartment used to be, a joystick protrudes where you'd usually find a gearshift, and a 21.5-inch screen is attached to the center of the dash. "Tesla only has a 17-inch screen," Hotz says.

He's been keeping the project to himself and is dying to show it off. We pace around the car going over the technology. Hotz fires up the vehicle's computer, which runs a version of the Linux operating system, and strings of numbers fill the screen. When he turns the wheel or puts the blinker on, a few numbers change, demonstrating that he's tapped into the Acura's internal controls.

After about 20 minutes of this, and sensing my skepticism, Hotz decides there's really only one way to show what his creation can do. "Screw it," he says, turning on the engine. "Let's go."

As a scrawny 17-year-old known online as "geohot," Hotz was the first person to hack Apple's iPhone, allowing anyone—well, anyone with a soldering iron and some software smarts—to use the phone on networks other than AT&T's. He later became the first person to run through a gantlet of hard-core defense systems in the Sony PlayStation 3 and crack that open, too. Over the past couple years, Hotz had been on a walkabout, trying to decide what he wanted to do next, before hitting on the self-driving car idea as perhaps his most audacious hack yet.

"Hold this," he says, dumping a wireless keyboard in my lap before backing out of the garage. "But don't touch any buttons, or we'll die." Hotz explains that his self-driving setup, like the autopilot feature on a Tesla, is meant for highways, not chaotic city streets. He drives through San Francisco's Potrero Hill neighborhood and then onto Interstate 280.

With Hotz still holding the wheel, the Acura's lidar paints a pixelated image on the dash screen of everything around us, including the freeway walls and other cars. A blue line charts the path the car is taking, and a green line shows the path the self-driving software recommends. The two match up pretty well, which means the technology is working. After a couple miles, Hotz lets go of the wheel and pulls the trigger on the joystick, kicking the car into self-driving mode. He does this as we head into an S curve at 65 miles per hour. I say a silent prayer. Hotz shouts, "You got this, car! You got this!"

The car does, more or less, have it. It stays true around the first bend. Near the end of the second, the Acura suddenly veers near an SUV to the right; I think of my soon-to-be-fatherless children; the car corrects itself. Amazed, I ask Hotz what it felt like the first time he got the car to work.

"Dude," he says, "the first time it worked was this morning."

Breakthrough work on self-driving cars began about a decade ago. Darpa, the research arm of the Department of Defense, sponsored the Grand Challenge, a contest to see how far autonomous vehicles could travel. On a course through the desert in the inaugural 2004 event, the top vehicle completed just 7 of 150 miles. In subsequent years, the vehicles became quite good, completing both desert and city courses.

It took a great deal of sophisticated, expensive technology to make those early cars work. Some of the Grand Challenge contestants lugged the equivalent of small data centers in their vehicles. Exteriors were usually covered with an array of sensors typically found in research labs. Today, Google, which hired many of the entrants, has dozens of cars in its fleet that use similar technology, although dramatic advances in computing power, sensors, and the autonomous software have lowered the overall cost.

Artificial-intelligence software and consumer-grade cameras, Hotz contends, have become good enough to allow a clever tinkerer to create a low-cost self-driving system for just about any car. The technology he's building represents an end run on much more expensive systems being designed by Google, Uber, the major automakers, and, if persistent rumors and numerous news reports are true, Apple. More short term, he thinks he can challenge Mobileye, the Israeli company that supplies Tesla Motors, BMW, Ford Motor, General Motors, and others with their current driver-assist technology. "It's absurd," Hotz says of Mobileye. "They're a company that's behind the times, and they have not caught up."

Mobileye spokesman Yonah Lloyd denies that the company's technology is outdated. "Our code is based on the latest and modern AI techniques using end-to-end deep network algorithms for sensing and control," he says. Last quarter, Mobileye reported revenue of $71 million, up 104 percent from the period a year earlier. It relies on a custom chip and well-known software techniques to guide cars along freeways. The technology has been around for a while, although carmakers have just started bragging about it. Tesla, in particular, has done a remarkable job remarketing the Mobileye technology by claiming its cars now ship with "Autopilot" features. Tesla's fans have peppered the Internet with videos of its all-electric Model S sedans driving themselves on freeways and even changing lanes on their own. (In an e-mailed statement, Tesla spokesman Ricardo Reyes writes: "Mobileye is a valued partner, but supplies just one of a dozen internally and externally developed component technologies that collectively constitute Tesla Autopilot, which include radar, ultrasonics, GPS/nav, cameras and real-time connectivity to Tesla servers for fleet learning.")

Hotz plans to best the Mobileye technology with off-the-shelf electronics. He's building a kit consisting of six cameras—similar to the $13 ones found in smartphones—that would be placed around the car. Two would go inside near the rearview mirror, one in the back, two on the sides to cover blind spots, and a fisheye camera up top. He then trains the control software for the cameras using what's known as a neural net—a type of self-teaching artificial-intelligence mechanism that

grabs data from drivers and learns from their choices. The goal is to sell the camera and software package for $1,000 a pop either to automakers or, if need be, directly to consumers who would buy customized vehicles at a showroom run by Hotz. “I have 10 friends who already want to buy one,” he says.

The timing for all of this is vague. Hotz says he’ll release a YouTube video a few months from now in which his Acura beats a Tesla Model S on Interstate 405 in Los Angeles. The point of the exercise is twofold. First, it will—he hopes—prove the technology works and is ready to go on sale. Second, it will help Hotz win a bet withElon Musk, chief executive officer of Tesla.

Hotz lives in the Crypto Castle. It’s a white, Spanish-tiled house, which, other than the “Bitcoin preferred here” sticker on the front door, looks like any other in Potrero Hill. The inside is filled with a changing cast of 5 to 10 geeks. The bottom floor largely belongs to Hotz. His room is a 15-by-5-foot closet with a wedged-in mattress. The space is lined with shelves packed with boxes, car parts, towels, and a case of women’s clothes left behind by a former resident. There’s a living room in the back with couches and a television. “I hate living alone,” Hotz says. “I was playing Grand Theft Auto with my roommates last night. It was super fun.”

Just a couple feet from his closet is the garage where Hotz works. His two-monitor computer sits on a desk next to a water heater. On a wooden table, there’s a drill, a half-dozen screwdrivers, a tape measure, some black duct tape, a can of Red Bull, and a stack of unopened mail. Most of the garage is taken up by the white Acura. Hotz has decorated its hood with a large, black comma, and the back bumper reads “comma.ai”—the name of his new company—in big, black letters. “A comma is better than a period,” he says.

Hotz grew up in Glen Rock, N.J. His father oversees technology for a Catholic high school, and his mother is a therapist. “Like, Freud talking and stuff,” Hotz says. At 14, he was a finalist in the prestigious Intel International Science & Engineering Fair for building a robot that could scan a room and figure out its dimensions. A couple years later he built another robot called Neuropilot that could be controlled by thoughts. “It could detect different-frequency brain waves and go forward or left based on how hard you were focusing,” he says. The next year, 2007, he won one of the contest’s most prestigious awards, a trip to attend the Nobel prize ceremony in Stockholm, by designing a type of holographic display. “I did terrible in high school until I found these science fairs,” he says. “They were the best thing for me. I could build things, and there was the salesmanship, too, that I loved.”

He hacked the iPhone in 2007 while still in high school and became an international celebrity, appearing on TV news shows. Three years later, he hacked the PlayStation 3and released the software so others could use it. Sony responded by suing him, and the two parties settled their feud shortly after, with Hotz agreeing never to meddle with Sony products again. These achievements were enough to earn him a profile in the New Yorker when he was 22. “I live by morals, I don’t live by laws,” Hotz declared in the story. “Laws are something made by assholes.”

But Hotz wasn't a so-called black-hat hacker, trying to break into commercial systems for financial gain. He was more of a puzzle addict who liked to prove he could bend complex technology to his will.

From 2007 on, Hotz became a coding vagabond. He briefly attended Rochester Institute of Technology, did a couple five-month internships at Google, worked at SpaceX for four months, then at Facebook for eight. The jobs left him unsatisfied and depressed. At Google, he found very smart developers who were often assigned mundane tasks like fixing bugs in a Web browser; at Facebook, brainy coders toiled away trying to figure out how to make users click on ads. "It scares me what Facebook is doing with AI," Hotz says. "They're using machine-learning techniques to coax people into spending more time on Facebook."

On the side, Hotz produced an application called towelroot, which gave Android users complete control over their smartphones. The software is free to download and has been used 50 million times. He kept himself entertained (and solvent) by entering contests to find security holes in popular software and hardware. In one competition, Pwnium, he broke into a Chromebook laptop and took home $150,000. He scored another $50,000 at Pwn2Own by discovering a Firefox browser bug in just one day. At a contest in Korea designed for teams of four, Hotz entered solo, placed first, and won $30,000.

By the fall of 2012 he was bored with the contests and decided to dive into a new field—AI. He enrolled at Carnegie Mellon University with the hope of attaining a Ph.D. When not attending class, he consumed every major AI research paper and still had time for some fun. At one point, the virtual-reality company Oculus Rift failed to man its booth at a job fair, and Hotz took it over, posing as a recruiter and collecting résumés from his fellow students. None of this was enough to keep him interested. "I did two semesters and got a 4.0 in their hardest classes," he says. "I met master's students who were miserable and grinding away so that they might one day earn a bit more at Google. I was shocked at what I saw and what colleges have become. The smartest people I knew were in high school, and I was so let down by the people in college."

Although Hotz makes his university experience sound depressing, it left him brimming with confidence and eager to return to Silicon Valley. He'd devoured the cutting-edge AI research and decided the technology wasn't that hard to master. Hotz took a job at Vicarious, a highflying AI startup, in January to get a firsthand look at the top work in the field, and this confirmed his suspicions. "I understand the state-of-the-art papers," he says. "The math is simple. For the first time in my life, I'm like, 'I know everything there is to know.' "

He quit Vicarious in July and decided to put his conviction to the test. A friend introduced him to Musk, and they met at Tesla's factory in Fremont, Calif., talking at length about the pros and perils of AI technology. Soon enough, the two men started figuring out a deal in which Hotz would help develop Tesla's self-driving technology. There was a proposal that if Hotz could do better than Mobileye's technology in a test, then Musk would reward him with a lucrative contract. Hotz, though, broke off

the talks when he felt that Musk kept changing the terms. “Frankly, I think you should just work at Tesla,” Musk wrote to Hotz in an e-mail. “I’m happy to work out a multimillion-dollar bonus with a longer time horizon that pays out as soon as we discontinue Mobileye.”

“I appreciate the offer,” Hotz replied, “but like I’ve said, I’m not looking for a job. I’ll ping you when I crush Mobileye.”

Musk simply answered, “OK.”

Hotz has filled out since his days as a scrawny teenage hacker, although he dresses the same. Most often, he wears jeans and a hoodie and shuffles around the garage in socks. He has a beard of sorts, and some long, stray whiskers spring out from his Adam’s apple. His demeanor doesn’t match the slacker get-up. Hotz’s enthusiasm is infectious, and he explains just about everything with flailing hands and the wide eyes of someone in a permanent state of surprise.

It’s easy enough to draw a connection between Hotz and Steve Wozniak. Like Hotz, Wozniak began his hacking days on the fringes of the law—in the early 1970s, before he and his pal Steve Jobs founded Apple. Woz was making small devices that let people place free long-distance phone calls. Even in Silicon Valley, few people are equally adept at hardware and software. Woz was, and so is Hotz.

Hotz began working in earnest on his self-driving technology in late October. He applied online to become an authorized Honda service center and was accepted. This allowed him to download manuals and schematics for his Acura. Soon enough, he’d packed the glove compartment space with electronics, including an Intel NUC minicomputer, a couple GPS units, and a communications switch. Hotz connected all this gear with the car’s main computers and used duct tape to secure the cables running to the lidar on the roof.

There are two breakthroughs that make Hotz’s system possible. The first comes from the rise in computing power since the days of the Grand Challenge. He uses graphics chips that normally power video game consoles to process images pulled in by the car’s camera and speedy Intel chips to run his AI calculations. Where the Grand Challenge teams spent millions on their hardware and sensors, Hotz, using his winnings from hacking contests, spent a total of $50,000—the bulk of which ($30,000) was for the car itself.

The second advance is deep learning, an AI technology that has taken off over the past few years. It allows researchers to assign a task to computers and then sit back as the machines in essence teach themselves how to accomplish and finally master the job. In the past, for example, it was thought that the only way for a computer to identify a chair in a photo would be to create a really precise definition of a chair—you would tell the computer to look for something with four legs, a flat seat, and so on. In recent years, though, computers have become much more powerful, while memory has become cheap and plentiful. This has paved the way for more of a brute-force technique, in which researchers can bombard computers with a flood of information and let the systems make sense of the data. “You show a computer 1 million images with chairs and 1 million without them,” Hotz says.

“Eventually, the computer is able to describe a chair in a way so much better than a human ever could.”

The theory behind this type of AI software has been around for decades. It’s embedded in products consumers take for granted. With the help of Google, for example, you can search for “pictures of the beach,” and AI software will comb through your photo collection to turn up just that. Some of the biggest breakthroughs have come in voice recognition, where smart assistants such as Apple’s Siri and Microsoft’s Cortana can pick up a person’s voice even in noisy situations. The same goes for instantaneous translation applications, which have largely been taught new languages via deep-learning algorithms that pore over huge volumes of text. With his car, Hotz wants to extend the same principles to the field of computer vision.

In the month before our first drive on I-280, Hotz spent most of his time outfitting the sedan with the sensors, computing equipment, and electronics. Once all the systems were up and running, he drove the vehicle for two and a half hours and simply let the computer observe him. Back in his garage, he downloaded the data from the drive and set algorithms to work analyzing how he handled various situations. The car learned that Hotz tends to stay in the middle of a lane and maintain a safe distance from the car in front of him. Once the analysis was complete, the software could predict the safest path for the vehicle. By the time he and I hit the road, the car behaved much like a teenager who’d spent only a couple of hours behind the wheel.

Two weeks later, we went on a second drive. He’d taken the car out for a few more hours of training, and the difference was impressive. It could now drive itself for long stretches while remaining within lanes. The lines on the dash screen—where one showed the car’s actual path, and the other where the computer wanted to go—were overlapping almost perfectly. Sometimes the Acura seemed to lock on to the car in front of it, or take cues around a curve from a neighboring car. Hotz hadn’t programmed any of these behaviors into the vehicle. He can’t really explain all the reasons it does what it does. It’s started making decisions on its own.

In early December, Hotz took me on a third ride. By then, he’d automated not only the steering but also the gas and brake pedals. Remarkably, the car now stayed in the center of the lane perfectly for miles and miles. When a vehicle in front of us slowed down, so did the Acura. I took a turn “driving” and felt an adrenaline rush—not because the car was all over the place, but because it worked so well.

Hotz’s approach isn’t simply a low-cost knockoff of existing autonomous vehicle technology. He says he’s come up with discoveries—most of which he refuses to disclose in detail—that improve how the AI software interprets data coming in from the cameras. “We’ve figured out how to phrase the driving problem in ways compatible with deep learning,” Hotz says. Instead of the hundreds of thousands of lines of code found in other self-driving vehicles, Hotz’s software is based on about 2,000 lines.

The major advance he will discuss is the edge that deep-learning techniques provide in autonomous technology. He says the usual practice has been to manually

code rules that handle specific situations. There's code that helps cars follow other vehicles on the highway, and more code to deal with a deer that leaps into the road. Hotz's car has no such built-in rules. It learns what drivers typically do in various situations and then tries to mimic and perfect that behavior. If his Acura cruises by a bicyclist, for example, it gives the biker some extra room, because it's seen Hotz do that in the past. His system has a more general-purpose kind of intelligence than a long series of if/then rules. As Hotz puts it in developer parlance, " 'If' statements kill." They're unreliable and imprecise in a real world full of vagaries and nuance. It's better to teach the computer to be like a human, who constantly processes all kinds of visual clues and uses experience, to deal with the unexpected rather than teach it a hard-and-fast policy.

In the coming weeks, Hotz intends to start driving for Uber so he can rack up a lot of training miles for the car. He aims to have a world-class autonomous vehicle in five months, something he can show off for Musk. He's heard that Teslas struggle when going across the Golden Gate Bridge because of the poor lane markings. So he plans to film a video of the Acura outperforming a Tesla across the bridge, and then follow that up by passing the final test on I-405 in Los Angeles where Musk lives. Hotz's YouTube videos get millions of views, and he fully expects Musk will get the message. "I'm a big Elon fan, but I wish he didn't jerk me around for three months," he says. "He can buy the technology for double." (Says Tesla spokesman Ricardo Reyes: "We wish him well.")

There's really no telling how effective Hotz's software and self-learning technology ultimately will be. His self-funded experiment could end with Hotz humbly going back to knock on Google's door for a job. "Yeah, of course there will be skepticism," he says. "This is part of a great adventure. All I can say is, 'Watch.' " Sitting cross-legged on a dirty, formerly cream-colored couch in his garage, Hotz philosophizes about AI and the advancement of humanity. "Slavery did not end because everyone became moral," he says. "The reason slavery ended is because we had an industrial revolution that made man's muscles obsolete. For the last 150 years, the economy has been based on man's mind. Capitalism, it turns out, works better when people are chasing a carrot rather than being hit with a stick. We're on the brink of another industrial revolution now. The entire Internet at the moment has about 10 brains' worth of computing power, but that won't always be the case.

"The truth is that work as we know it in its modern form has not been around that long, and I kind of want to use AI to abolish it. I want to take everyone's jobs. Most people would be happy with that, especially the ones who don't like their jobs. Let's free them of mental tedium and push that to machines. In the next 10 years, you'll see a big segment of the human labor force fall away. In 25 years, AI will be able to do almost everything a human can do. The last people with jobs will be AI programmers."

Hotz's vision for the future isn't quite as bleak as The Matrix, where robots mine our bodies for fuel. He thinks machines will take care of much of the work tied to producing food and other necessities. Humans will then be free to plug into their

computers and get lost in virtual reality. “It’s already happening today,” he says. “People drive to work, sit in front of their computer all day, and then sit in front of their computer at home.” In 20 years, the sitting in front of the computer part will be a lot more fun, according to Hotz, with virtual worlds that far exceed anything we’ve managed to build on earth. “Stop worrying about the journey,” he says. “Enjoy the destination. We will have a better world. We will be able to truly live in a society of the mind.”

Hotz started the autonomous car work because he sees it as Step 1 in the revolution. Transportation is an area where AI can have a massive impact. He hopes to take his technology to retail next, building systems that provide flawless self-checkout at stores. His desire to have AI take over so many jobs stems partly from a near-religious belief in the power and ultimate purpose of technology. “Technology isn’t good or bad,” he says. “There are upsides like nuclear power and downsides like nuclear bombs. Technology is what we make of it. There’s a chance that AI might kill us all, but what we know is that if you’re on the other side of technology, you lose. Betting on technology is always the correct bet.”

All this talk represents an evolution in Hotz’s hacker ethos. He used to rip apart products made by Apple and Sony, because he enjoyed solving hard puzzles and because he reveled in the thought of one person mucking up multibillion-dollar empires. With the car, the retail software, and the plans to roil entire economies, Hotz wants to build a reputation as a maker of the most profound products in the world—things that forever change how people live. “I don’t care about money,” he says. “I want power. Not power over people, but power over nature and the destiny of technology. I just want to know how it all works.”

Adapted from Bloomberg