

FUTURE NEWS

TO CONNECT, TO INFORM AND TO INSPIRE

IN THIS EDITION

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REIMAGINING THE FUTURE OF WORK

HOW TO ENSURE EQUITY IN AN AUTOMATED WORLD

by Joe Tankersley



Joe Tankersley

Joe Tankersley is a futurist and advocate for better tomorrows. He helped to found and lead Walt Disney Imagineering's Strategic Foresight group and currently advises corporate and nonprofit clients on how to reimagine their futures. He served on the board of directors for the Association of Professional Futurists for six years and currently sits on the board of The Blue Community, the nonprofit group that oversees the UN Sustainable Tourism Observatory for Florida. His book, "Reimagining Our Tomorrows: Making Sure Your Future Doesn't SUCK," was released in September 2018.

"Hey, boss—sorry to interrupt, but it's time."

Andy was so engrossed with the painting she was working on that it took her a moment to realize that the voice was talking to her. She leaned back and considered the canvas. It was an arid wasteland rendered in bright neon colors. Rusting hulks of automobiles littered what was once the Pacific Coast Highway. It was the background for Andy's latest virtual reality project, an afro-cyberpunk reimagining of Octavia Butler's *Earthseed* stories.

She live-streamed her painting sessions to her nearly 2 million followers. Working this way, she could build an audience for her projects as they developed. By the time she was ready to release, there would already be a substantial fan base anxiously awaiting the new project.

She rubbed her eyes. "Wow, Lacey, is it already 3:00?"

Lacey responded with a laugh. "More like 5:45."

"You let me work that long?"

"You seemed to have some serious flow going on. I didn't want to interrupt, so I just rearranged the afternoon to give you max time," Lacey explained.

"Thanks."

"Just doing my job, boss. And now you should have just enough time to take a short break before the walk-through of the Rodríguez home."

Andy stood and crossed the small, cluttered studio. Her eyes roamed across the dozens of different projects in varying stages of completion. They ranged from computer screens covered in complex mathematical calculations to hand-built art objects. Andy thrived on the chaos. She would shift seamlessly from one project to the next, often working on as many as six or seven throughout the day. When she was deeply engrossed in one project, she often had unexpected insights into another. When an epiphany struck, she would drop what she was doing to capture the moment.

Of course, that kind of creative freedom could have its downside since Andy's projects were her livelihood. Keeping Andy focused and making sure that projects got done on time was Lacey's job. Well, one of Lacey's jobs. As Andy's personal smart agent—think: Alexa on steroids—Lacey was responsible for coordinating Andy's work, running the house, and managing her social calendar. Every successful gigger had an advanced smart agent these days. Some people had separate ones for work and personal life. Andy didn't see the point. For her, the boundaries between work and private life had dissolved more than a decade ago, when she first started gig-hopping in 2020. Since then she had worked as an experimental mathematician, virtual reality designer, and sustainable architect, to name a few of her more esoteric occupations.

Andy loved the nomadic nature of her work. She might join a team for a few months, but most of the time she worked alone. It wasn't that Andy was antisocial. She got plenty of human interaction during her workday. Most of her meetings happened in VR spaces so advanced that it was impossible to distinguish the virtual from the real. Plus, she had Lacey as her constant companion, making sure that Andy was always free to follow her passion without sacrificing the need to create an income.

“ In the last two decades, automation has eliminated two jobs for each job it has created in manufacturing and skilled labor occupations.

Is this the future of work?

It could easily be imagined as one possibility in a world where artificial intelligence takes on more of the organizational and management jobs that traditionally required scores of individual employees. As work becomes increasingly dispersed and tasks replace jobs, there will certainly be plenty of opportunities for talented solopreneurs to compete with much larger organizations.

No doubt, this particular scenario is one of privilege, reserved for those with access to just-in-time education, the latest digital tools, and the confidence to carve their own path in an increasingly complex environment. How do we make sure those same opportunities are spread across the workforce so that everyone can thrive in this digitally empowered future?

Answering that question begins with a deeper understanding of what the trends, especially in automation, artificial intelligence and the so-called gig economy, are telling us about the coming opportunities and challenges.

Despite a flood of studies on the topic of the automation of work, there is little conclusive evidence on the long-term impact on overall employment. If recent trends continue, it is reasonable to assume that automation will become a cost-competitive alternative to more and more jobs within the next decade. The unknown is where workers displaced by automation will land. Many experts hope that this latest wave of technological disruption will follow the classic curve and create more jobs than it eliminates. However, the only reliable data we have tends to belie that assumption.

In the last two decades, automation has eliminated two jobs for each job it has created in manufacturing and skilled labor occupations. Displaced workers end up in lower-paying jobs, and the ripple effect of automation across the broader economy has been downward in terms of overall job creation.

The expectation is that many of these newly ‘freed’ employees will turn to the gig economy for income. In fact, it was the availability of a large pool of recently unemployed workers created by the Great Recession of 2008 that helped Uber launch the gig economy. If these trends accelerate and collide, they could create significant barriers to building a future of work that is inclusive, diverse, and fulfilling.

So, how do we build a foundation for a future of work where everyone can experience the same success and freedom as Andy? It begins with a commitment to universal digital access and lifelong learning opportunities. It will require teaching every child critical thinking, entrepreneurship, and mindfulness.

For conscious business leaders, it will mean deeper dedication to a broader group of stakeholders. As temporary, project-based assignments replace full-time employment, businesses will become more like dispersed tribes. Leaders will have to invent new forms of connection and engagement. Already flattening hierarchies will be pressed to become even flatter.

Creating a future where digitally empowered individuals can reach their highest potential, and realize their desire for purpose and profit, will be challenging. But the technologies that are disrupting our traditional ideas of work and employment also hold the potential for us to reimagine a better tomorrow. As long as we continue to expand access to opportunities and remember that the goal of business is to improve the larger community, then we can create a future of work where everyone thrives.

HOW TO DESIGN FUTURE-PROOF EDUCATION SYSTEMS?

by Dr Cristóbal Cobo



**Director, Center for Research –
Ceibal Foundation;
Associate researcher at the
Oxford Internet Institute,
University of Oxford**

In different moments of the 20th century, we have witnessed various trends in technology that promised to “revolutionize” education. Nothing can be more charming than watching children learning by themselves only with the use of technology. This techno-enthusiasm is connected with good intentions such as reducing inequalities, enhancing learning opportunities, enabling self and lifelong learning, etc. However, it is fair to say that the interest has also been driven by vendors and others interested in selling devices, content, software, connectivity, or simply, influence. Some examples can be found with the educational television, educational CD-Roms, smart boards, massive open online courses, and now, apparently through artificial intelligence. All of them are presented as “silver bullets” that in different moments have promised to transform the education sector.

Today, the education market is very big and the interest to improve education in every country is arguably one of the top priorities of any government (likewise many international organizations). Thus, what is at stake is far from insignificant.

After revising hundreds of research papers in the field, in a large number of cases, the adoption and use of education technology has mainly focused on technological deployment and not necessarily on the other dimensions that need to be taken into account when technologies land in classrooms. Therefore a large volume of research and public policy impact evaluations focus on the following question: What is the impact of technology in learning? Unfortunately, the other dimensions (e.g. social, organizational, political, and contextual factors) are rarely considered (or controlled) in these studies. As a consequence, the result that we see most often is that the deployment of new technologies by itself does not lead to a clear impact in learning outcomes. Even worse, there are a number of studies that show that large exposure to digital technologies without support and guidelines might lead to worse performance results versus those who do not use it at all.

We may ask ourselves why it is so difficult to identify the impact of technology as a driver for change. How can these tools help us transform educational systems that resist embracing the transformations required in the current century? As Clay Shirky rightly says, “A revolution doesn’t happen when society adopts new tools. It happens when society adopts new behaviors”. This is probably one of the most relevant reasons to explain why it is so difficult to see radical transformations only within the field of education technology.

After having worked with dozens of countries in this field, I suggest taking into account at least five critical dimensions before planning the implementation of education technology or when preparing an assessment of the impact of these tools.



1. Providing pre-established educational content will be less relevant than facilitating and promoting their connection and combination with different sources of knowledge and information (within and outside the educational program or curriculum).
2. When transitioning to new technology, learning how to teach with technology regardless of the context is pivotal. Digital and peer based pedagogies are a good starting point.
3. Understanding that traditional divisions of knowledge are not suitable within the digital landscape. It is critical to develop new ways of thinking such as network literacy, computational thinking, collaborative problem-solving, inquiry based learning, among other multi-literacies.
4. If you want to understand the role of technology, you can't keep using the old fashioned instruments to assess learning. Keep in mind that digital devices go beyond disciplines, contexts and ages. It is necessary to be equally innovative in the adoption and creation of instruments for assessing new forms of learning. This also applies to adopting alternative forms for recognizing informal learning.
5. Learning happens all the time and everywhere (even if we don't know how to measure it). The use of education technology at home differs from that in the classroom. It is necessary to overcome physical limitations of formal learning. Today's learning can take place anywhere, anytime and almost with anybody. So the best cognitive tool that educational systems can develop is learning how to explore new questions at an individual and collective level regardless of the environment.

In any case, I am optimistic in the long run. We are confident that we will finally learn that we have to innovate not only in the adoption of devices but also in the assessment of new forms of learning. We also envision that sooner rather than later that the education system will keep moving from an encyclopedic to a more flexible system focused on critical thinking, promoting multi-literacies as well as social-emotional skills. We hope that a new generation of decision-makers will resist the temptation of relying only on artificial intelligence and other new gadgets and will help design long-term innovations in their education systems that can be seriously future-proof.

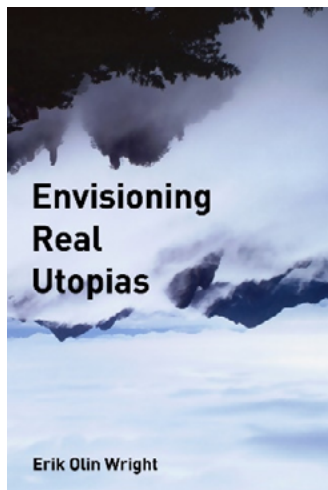
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Book Review

by Charles Brass – Chair, futures foundation

Envisioning Real Utopias

by Erik Olin Wright



Futurists are unsurprisingly interested in utopias (although recently there seems to be rather more interest in dystopias). In part this is because we are always encouraging clients to pay appropriate attention to the existence of multiple alternative possible futures. But it is also partly because at the end of the day decision making means choosing from among these possible futures, and utopian futures are generally more appealing.

Erik Olin Wright has been imagining alternative futures for all his academic life (he is over 70) and all his thinking came together in his 2010 volume “Envisioning Real Utopias”. I am personally disappointed I didn’t come across this book until now, but that doesn’t make it any less relevant today. Olin Wright does not believe that our current economic system is the best we can construct, and this work is a serious theoretical examination both of what alternatives might exist, and what might need to be done to actually achieve any of these alternatives.

Olin Wright starts from the observation that capitalism preferentially benefits some members of society over others. He asks first whether this is an inevitable feature of capitalism, and in his first three chapters concludes that it is, and then devotes the rest of the book to first considering alternatives and then exploring how these alternatives might actually work in practice – hence his interest in ‘real’ utopias.

Olin Wright is an academic and this book has a strong academic flavor (something he acknowledges in the preface), but for those interested in actually engaging in any form of social change the rigor with which he challenges every assumption he makes in the book is extremely helpful (if sometimes somewhat pedantic).

Hardly surprisingly the work of Karl Marx informs much of Olin Wright’s critique of capitalism. Marx and his contemporaries and followers have been the most stringent critics of capitalism for over 100 years. Olin Wright is much more than a Marxist, however. While he finds much to applaud in Marx’s thinking, he also identifies where history has clearly proved Marx wrong and, perhaps, more importantly he explores the various elements of modern society much more comprehensively than Marx ever did.

Marx concluded that capitalism would simply self-destruct, but 150 years later that doesn’t seem to have happened (and Olin Wright devotes many pages to exploring just why that might be). Having concluded that this is therefore unlikely to happen, Olin Wright then creates what he calls a ‘socials compass’ designed to point the way towards a ‘radical democratic egalitarian alternative to capitalism’ (p 110).

He argues that there are three alternative ways of organizing power over the economy: capitalism, statism and socialism and critically examines the power and ownership dynamics expressed in each alternative. He graphically expresses the six pathways to social empowerment through the interaction of each alternative like this (p131):

FIGURE 5.1 Linkings in the Pathways to Social Empowerment

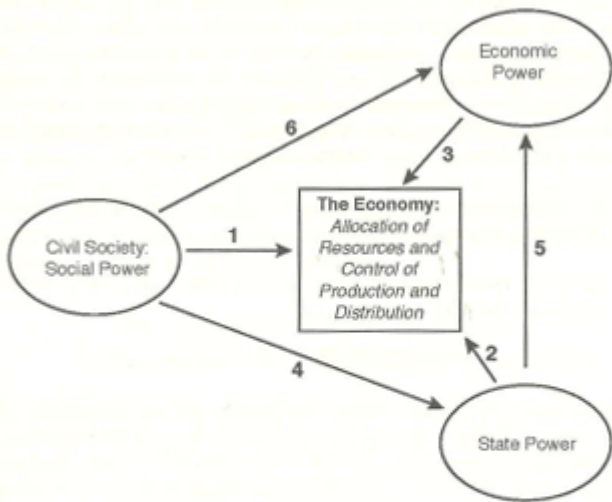


FIGURE OF THE INDIVIDUAL LINKAGES

1. Social economy: social provision of needs
2. State economy: state produced goods and services
3. Capitalist market economy
4. Democratic control over state power
5. State regulation of capitalist firms
6. Social participation in controlling economic power

and considerable space is given to exploring how each pathway might operate in practice, and in Chapters 6 and 7 to providing current world examples of some of them. Without going into detail, the Mondragon Cooperatives, Municipal Participatory Budgeting (which has grown globally since introduced in Porto Allegro in Brazil in 1988), Wikipedia, Citizen Assemblies and the *Chantier de l'économie sociale*, an autonomous public policy organisation in Quebec Canada are examples worked through in quite some detail.

This all sets up the final 100 pages of the book in which Olin Wright considers what sorts of transformations might facilitate the broader adoption of some of these examples. He describes three types of transformation: radical (most often associated with violence), interstitial (where alternative forms take hold in the gaps between parts of the capitalist world and, like weeds in a footpath, eventually take over), and symbiotic (where the capitalist and the socialist co-evolve, such as the Mondragon Cooperatives which now employ sizable numbers of workers who are not also owners).

Perhaps not surprisingly, Olin Wright concludes that neither of these alternatives can happen alone. For

example, he exhaustively explains why radical action in the current world is more likely to lead to destruction than transformation, but then notes that an increase in interstitial or symbiotic actions might move us to a place where radical action might actually succeed.

Olin Wright summarises the key lessons from his book as follows (actually only the first two are his, the last two are my summary of a more complex argument):

Capitalism obstructs the realization of both social justice and political justice

Economic structures are always hybrid (a point he particularly wants to make in the face of much current commentary that we live in a 'capitalist' economy – something he doesn't think can ever exist in a pure form)

Socialist hybrids exist and are achievable – in fact there are multiple pathways towards such achievement

The future is inherently uncertain ("We cannot know in advance how far we can go in this trajectory of social empowerment" (p371)) but this doesn't mean we shouldn't take steps that seem to be appropriate, and then monitor progress before deciding what next steps to take.

His last words summarise the book succinctly:

"The best we can do, then, is treat the struggle to move forward on the pathways of social empowerment as an experimental process in which we continually test and retest the limits of possibility and try, as best we can, to create new institutions which will expand those limits themselves. In doing so we not only envision real utopias, but contribute to making utopias real" (p371).

FUTURISTS IN ACTION

THE SEVEN SUPER POWERS OF FUTURISTS

by Sohail Inayatullah



Source: Global Active

Sohail Inayatullah

When tomorrow is just like today, boredom can result. We seek novelty. However, in this phase in human history, tomorrow will certainly not be like today. Indeed, we are in the midst of dramatic social and technological change. This includes:

A demographic shift in Africa such that 40% of all children worldwide by 2050 live in Africa and by 2100, 39% of all adults globally will live in Africa.

Under-population in many Western and East Asian nations, creating labour shortages, and the possibility of steady-state economics.

The rise of new technologies such as 3d printing, drones, artificial intelligence, driverless cars dramatically increasing productivity, reducing costs, and among other impacts, reconfiguring city design (why parking spaces? or why not cars as mobile homes?).

The likely major disruption in the global food industry through cellular agriculture – the new pure meat and pure milk and the end of the animal based food supply chain, the possibility of the narrative shift from slaughter houses to greenhouses and food labs.

The shift from coal based energy to solar and wind (and other alternatives) renewable systems.

The beginning of the rise of the peer to peer economy and possibly platform cooperativism, certainly the possibility of the uber-ification of energy, that is: AI, plus solar, plus energy sharing. This challenges energy hierarchy, changing consumers into prosumers and foundationally challenging energy producers – are fossil fuels the new stranded assets?

A likely hegemonic shift from an American centric world to a China and Asian-centric century, changing what we value, the global hierarchy of truth, knowledge, and beauty.

On top of that, perhaps the most profound shift is the rise of gender equity – the beginning of true diversity and inclusion.

For many these changes are heralded as the beginning of a new era, the end of empire, the end of the patriarchy, the end of the coal-oil era, the end of poverty, the end of man over nature – a transition to a new era, what Sarkar has called, neohumanism.

For others, these are frightening as the assets they have held – physical as in coal mines, psychic as in male domination, cultural as in Empire-first are all under threat. “They vow to make their tribe great again”

For sure, in these times of transition, finding a centre to hold on to can become difficult. We feel powerless, vulnerable, lost. Our normal day way of thinking and being may not be enough. We may need super-powers to stay calm, afloat, strong, focused during these *tsunamis of change*, as the futurist James Dator has written.



Source: shindonga.donga.com

Jim Dator

In my work in Futures Studies and as a student of the mystic, P.R. Sarkar, I offer the following ideas or super-powers, if you will. I have used these with dozens of nations, hundreds of international organizations, and hundreds of citizens groups throughout the world. May futurists use some or all of these powers. We hope they help in avoiding the pitfalls and perils coming, and to create the futures you wish for.



Source: upliftconnect.com

First, as everything changes, find a quiet time – meditation is best for this. Breathe in, breathe out. Make this a practice, such that the feeling of quietness carries throughout the day. Meditation, mindfulness, zikr, zen, or other methods that help focus on one thought – the mantra, the sound that transports one to shanti, stillness – even when hundreds of thoughts race.

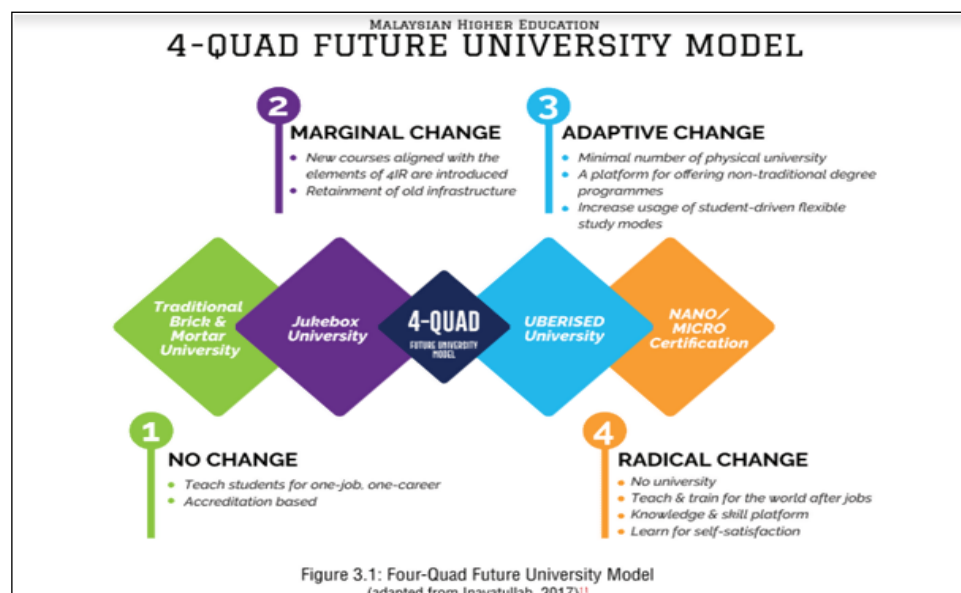
Second, see the future as an asset, part of a learning and creation journey. Instead of being worried about what will happen, use the future to start to create realities you would like to see happen (within your zone of control). Insights about the changing world, what you can do, what your organization can do, to help one chart their way forward. Instead of being lost in the day to day, the litany of events, we find that by challenging one's assumptions about reality or double loop learning, the future is easier to create since one is watching for weak signals, watching for what works and what does not. Indeed, misleading assumptions are considered one of the leading causes of strategy failure. Often, we double down, argue even more belligerently for our view even as the data suggests otherwise, as in climate change.

Or we rush to create a list of things to do. But double loop learning is questioning our assumptions. Is the future created or given to us? Do I believe the future is bright or bleak? One large organization paid its managers to conduct a review on the changing external world – the environmental scan – and paid experts to comment on this review. However, it had no intent, as evidenced in board meetings, to change their strategy. They merely wished to inform regulators that they had done due diligence on the emerging future. They did not wish their assumptions challenged.

Third, find the used future. The used future is a practice we engage in that no longer works. For example, many institutions wish to be part of the knowledge revolution but they still engage in clock in and clock out behavior. They remain focused on the assembly line, instead of creating metrics where it is out come not time spent that truly matters. As institutions remain mired in the 19th century, workers experience fatigue, tired of surveillance, and feeling what makes them special is not being counted.

Fourth, understand which disruptions or technologies, cultural mind-set shifts, demographic changes will impact them. And, this is crucial, discern the first and second order implications of these changes. Many argue which will be the correct impact. They seek certainty in a world where the future keeps on changing. Wiser is to ascertain the alternatives. For example, with the rise of cellular agriculture, is it wiser to (1) move towards regenerative agriculture, where farmers are stewards of the land, (2) shift toward pure meat and make the land that was used for animal farming for other purposes, or (3) become a niche organic meat seller, or (4) all the above, or (5) to do nothing in the hope the new technology does not disrupt you and your industry? Instead of being focused on the right answer, the future is full of possibilities. However, without going through the implications, we often resort to defensive postures. One farming federation when presented with the possible future of lab meat becoming prevalent suggested that they needed to eliminate vegetarians and scientists. While this was done in humor, the challenge to move from “there is nothing we can do” to alternative strategies became apparent to all participants.

Fifth, we focus on scenarios, a number of possible stories about the future, instead of the right answer. These scenarios become alternative worlds that you, the organization, and the nation can inhabit. From these scenarios, options can emerge, choices can be created, and conflicts resolved since alternative futures are now clarified. They can help develop national strategy, for example, as with the recent scenarios below of the Malaysian Ministry of Education.



(Source: <https://www.nst.com.my/education/2018/04/361452/way-forward-higher-education-4ir-era>.)

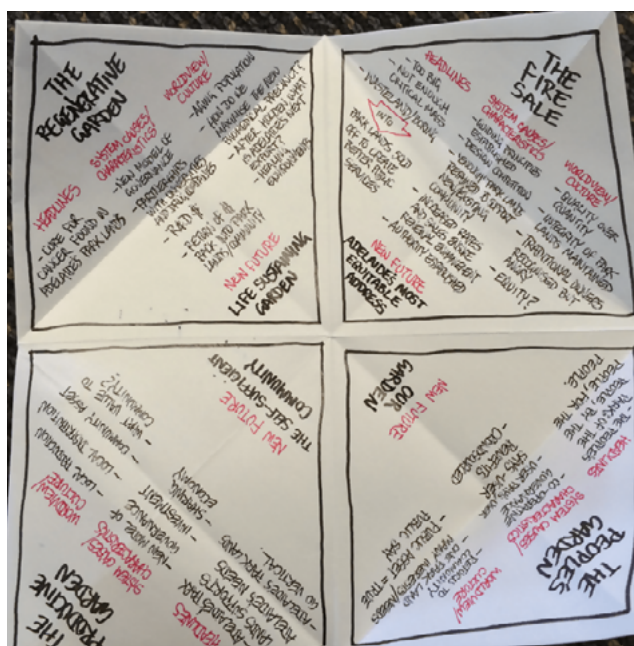
Sixth, the future strategy needs an enabling metaphor. Every person or organization has a narrative that underlies how they interact with the changing world. More often than not, when the external world changes, the story is left behind, and individuals live a metaphor that no longer creates the desired vision. Instead, suffering results. One global organization was looking to the future but their metaphor was an old crippled elephant. They needed to find a better story and then en-act from that story, the new future they wished for. In this case, they imagined themselves to be an octopus – intelligent, flexible, and swift to react. Individuals as well carry stories that do not work.

One CEO found that his core skills he had learned over 40 plus years were no longer useful. He described this as coming to play a game of tennis at a grass court only to find out that he was now playing on a clay court. His new narrative became someone who could play on multiple courts. For that, he needed to expand his life skills to include spiritual and emotional intelligence. However, in the long run, he realized, it was not winning (or losing) that mattered but the rally, the love of the game. Thus, a better narrative for him was that of the coach, teaching children how to play.

Seventh, and finally, and perhaps the most important superpower of all is to link the story to the system, to strategy, otherwise, the story is empty, mere words that lead to nothing. If, for example, the octopus is the new story, then power needs to be decentralized to the tentacles, to the field. If the octopus is the new story, then there needs to be funding for emerging threats and possibilities. In the elephant story, the organization is unable to see the future as the organization has no systematic ways to scan for trends and weak signals. If the octopus is the new metaphor, then the organization needs to focus on outcomes, to actually become flexible. Systemic change also means that the new measurements of

success are needed so that the story is not just valued but is the anchor to the desired future. Often organizations wish to move from crisis management (ambulance at the bottom of the hill) to prevention (fence at the top of the hill), however, when they do so, their budgets decline and accolades are not passed out since they have solved problems before they occurred. New measures of prevention are required, as for example, with the work of former deputy commissioner of Toronto Police, Peter Sloy. Elected representatives as well are hesitant since they need to be seen cutting the ribbon on new projects. Thus, new measures are required that ensure the vision – prevention, for example – is measured and rewarded.

With this final superpower, the subjective worlds of narrative and vision align with the objective worlds of systems and measurements. The future becomes real: the real becomes the future.



Scenarios on Adelaide Park Lands linking strategy with metaphor. David Chick.

To conclude, in times of dramatic change, we don't simply need better maps of the changing world, we need special powers or super powers to avoid the futures we don't want and create the futures we do. We need the super power of:

1. Being able to stay calm and focused through meditation;
2. We need the power to learn and reflect instead of acting from unchallenged assumptions and past behavior.
3. We need the superpower to challenge the used future – what we have been doing but no longer works.
4. We need the ability to understand how the world is changing, and the impacts of these disruptions on our day to day life and strategy.
5. We need the superpower to understand and create alternative futures instead of being fixated on one view: one future. This means letting go of the train-track worldview.
6. We need the super-power of narrative, of telling a different story about our lives. And, finally,
7. We need to link story to systemic change, creating a virtuous cycle of change, ensuring that what we value, we count.

Signals in the Noise

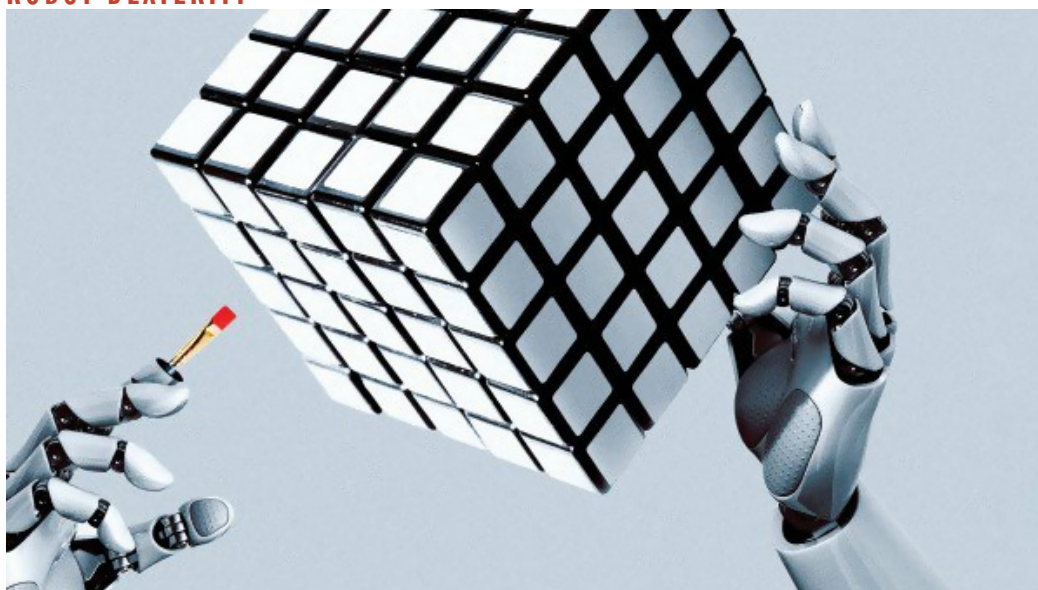
HOW WE'LL INVENT THE FUTURE

by Bill Gates

An extract from the March/April 2019 edition of MIT Technology Review

10 BREAKTHROUGH TECHNOLOGIES

ROBOT DEXTERITY



NICOLAS ORTEGA

Robots are teaching themselves to handle the physical world.

For all the talk about machines taking jobs, industrial robots are still clumsy and inflexible. A robot can repeatedly pick up a component on an assembly line with amazing precision and without ever getting bored—but move the object half an inch, or replace it with something slightly different, and the machine will fumble ineptly or paw at thin air.

But while a robot can't yet be programmed to figure out how to grasp any object just by looking at it, as people do, it can now learn to manipulate the object on its own through virtual trial and error.

One such project is Dactyl, a robot that taught itself to flip a toy building block in its fingers. Dactyl, which comes from the San Francisco nonprofit Open AI, consists of an off-the-shelf robot hand surrounded by an array of lights and cameras. Using what's known as reinforcement learning, neural-network software learns how to grasp and turn the block within a simulated environment before the hand tries it out for real. The software experiments, randomly at first, strengthening connections within the network over time as it gets closer to its goal.

It usually isn't possible to transfer that type of virtual practice to the real world, because things like friction or the varied properties of different materials are so difficult to simulate. The OpenAI team got around this by adding randomness to the virtual training, giving the robot a proxy for the messiness of reality.

Signals in the Noise

HOW WE'LL INVENT THE FUTURE

NEW-WAVE NUCLEAR POWER



BOB MUMGAARD/PLASMA SCIENCE AND FUSION CENTER/MIT

Advanced fusion and fission reactors are edging closer to reality.

New nuclear designs that have gained momentum in the past year are promising to make this power source safer and cheaper. Among them are generation IV fission reactors, an evolution of traditional designs; small modular reactors; and fusion reactors, a technology that has seemed eternally just out of reach. Developers of generation IV fission designs, such as Canada's Terrestrial Energy and Washington-based TerraPower, have entered into R&D partnerships with utilities, aiming for grid supply (somewhat optimistically, maybe) by the 2020s.

Small modular reactors typically produce in the tens of megawatts of power (for comparison, a traditional nuclear reactor produces around 1,000 MW). Companies like Oregon's NuScale say the miniaturized reactors can save money and reduce environmental and financial risks.

There has even been progress on fusion. Though no one expects delivery before 2030, companies like General Fusion and Commonwealth Fusion Systems, an MIT spinout, are making some headway. Many consider fusion a pipe dream, but because the reactors can't melt down and don't create long-lived, high-level waste, it should face much less public resistance than conventional nuclear. (Bill Gates is an investor in TerraPower and Commonwealth Fusion Systems.)

Signals in the Noise

HOW WE'LL INVENT THE FUTURE

PREDICTING PREMIES



NENOV | GETTY

A simple blood test can predict if a pregnant woman is at risk of giving birth prematurely.

Our genetic material lives mostly inside our cells. But small amounts of “cell-free” DNA and RNA also float in our blood, often released by dying cells. In pregnant women, that cell-free material is an alphabet soup of nucleic acids from the fetus, the placenta, and the mother.

Stephen Quake, a bioengineer at Stanford, has found a way to use that to tackle one of medicine’s most intractable problems: the roughly one in 10 babies born prematurely.

Free-floating DNA and RNA can yield information that previously required invasive ways of grabbing cells, such as taking a biopsy of a tumor or puncturing a pregnant woman’s belly to perform an amniocentesis. What’s changed is that it’s now easier to detect and sequence the small amounts of cell-free genetic material in the blood. In the last few years researchers have begun developing blood tests for cancer (by spotting the telltale DNA from tumor cells) and for prenatal screening of conditions like Down syndrome.

The tests for these conditions rely on looking for genetic mutations in the DNA. RNA, on the other hand, is the molecule that regulates gene expression—how much of a protein is produced from a gene. By sequencing the free-floating RNA in the mother’s blood, Quake can spot fluctuations in the expression of seven genes that he singles out as associated with preterm birth. That lets him identify women likely to deliver too early. Once alerted, doctors can take measures to stave off an early birth and give the child a better chance of survival.

Signals in the Noise

HOW WE'LL INVENT THE FUTURE

GUT PROBE IN A PILL



BRUCE PETERSON

A small, swallowable device captures detailed images of the gut without anesthesia, even in infants and children.

Environmental enteric dysfunction (EED) may be one of the costliest diseases you've never heard of. Marked by inflamed intestines that are leaky and absorb nutrients poorly, it's widespread in poor countries and is one reason why many people there are malnourished, have developmental delays, and never reach a normal height. No one knows exactly what causes EED and how it could be prevented or treated.

Practical screening to detect it would help medical workers know when to intervene and how. Therapies are already available for infants, but diagnosing and studying illnesses in the guts of such young children often requires anesthetizing them and inserting a tube called an endoscope down the throat. It's expensive, uncomfortable, and not practical in areas of the world where EED is prevalent.

So Guillermo Tearney, a pathologist and engineer at Massachusetts General Hospital (MGH) in Boston, is developing small devices that can be used to inspect the gut for signs of EED and even obtain tissue biopsies. Unlike endoscopes, they are simple to use at a primary care visit.

Tearney's swallowable capsules contain miniature microscopes. They're attached to a flexible string-like tether that provides power and light while sending images to a briefcase-like console with a monitor. This lets the health-care worker pause the capsule at points of interest and pull it out when finished, allowing it to be sterilized and reused. (Though it sounds gag-inducing, Tearney's team has developed a technique that they say doesn't cause discomfort.) It can also carry technologies that image the entire surface of the digestive tract at the resolution of a single cell or capture three-dimensional cross sections a couple of millimeters deep.

The technology has several applications; at MGH it's being used to screen for Barrett's esophagus, a precursor of esophageal cancer. For EED, Tearney's team has developed an even smaller version for use in infants who can't swallow a pill. It's been tested on adolescents in Pakistan, where EED is prevalent, and infant testing is planned for 2019.

Signals in the Noise

HOW WE'LL INVENT THE FUTURE

CUSTOM CANCER VACCINES



PAPER BOAT CREATIVE | GETTY

The treatment incites the body's natural defenses to destroy only cancer cells by identifying mutations unique to each tumor

Scientists are on the cusp of commercializing the first personalized cancer vaccine. If it works as hoped, the vaccine, which triggers a person's immune system to identify a tumor by its unique mutations, could effectively shut down many types of cancers.

By using the body's natural defenses to selectively destroy only tumor cells, the vaccine, unlike conventional chemotherapies, limits damage to healthy cells. The attacking immune cells could also be vigilant in spotting any stray cancer cells after the initial treatment.

The possibility of such vaccines began to take shape in 2008, five years after the Human Genome Project was completed, when geneticists published the first sequence of a cancerous tumor cell.

Soon after, investigators began to compare the DNA of tumor cells with that of healthy cells—and other tumor cells. These studies confirmed that all cancer cells contain hundreds if not thousands of specific mutations, most of which are unique to each tumor.

A few years later, a German startup called BioNTech provided compelling evidence that a vaccine containing copies of these mutations could catalyze the body's immune system to produce T cells primed to seek out, attack, and destroy all cancer cells harboring them.

In December 2017, BioNTech began a large test of the vaccine in cancer patients, in collaboration with the biotech giant Genentech. The ongoing trial is targeting at least 10 solid cancers and aims to enroll upwards of 560 patients at sites around the globe.

Signals in the Noise

HOW WE'LL INVENT THE FUTURE

THE COW-FREE BURGER



BRUCE PETERSON/STYLING: MONICA MARIANO

Both lab-grown and plant-based alternatives approximate the taste and nutritional value of real meat without the environmental devastation.

The UN expects the world to have 9.8 billion people by 2050. And those people are getting richer. Neither trend bodes well for climate change—especially because as people escape poverty, they tend to eat more meat.

By that date, according to the predictions, humans will consume 70% more meat than they did in 2005. And it turns out that raising animals for human consumption is among the worst things we do to the environment.

Depending on the animal, producing a pound of meat protein with Western industrialized methods requires 4 to 25 times more water, 6 to 17 times more land, and 6 to 20 times more fossil fuels than producing a pound of plant protein.

The problem is that people aren't likely to stop eating meat anytime soon. Which means lab-grown and plant-based alternatives might be the best way to limit the destruction.

Making lab-grown meat involves extracting muscle tissue from animals and growing it in bioreactors. The end product looks much like what you'd get from an animal, although researchers are still working on the taste. Researchers at Maastricht University in the Netherlands, who are working to produce lab-grown meat at scale, believe they'll have a lab-grown burger available by next year. One drawback of lab-grown meat is that the environmental benefits are still sketchy at best—a recent World Economic Forum report says the emissions from lab-grown meat would be only around 7% less than emissions from beef production.

The better environmental case can be made for plant-based meats from companies like Beyond Meat and Impossible Foods (Bill Gates is an investor in both companies), which use pea proteins, soy, wheat, potatoes, and plant oils to mimic the texture and taste of animal meat.

Beyond Meat has a new 26,000-square-foot (2,400-square-meter) plant in California and has already sold upwards of 25 million burgers from 30,000 stores and restaurants. According to an analysis by the Center for Sustainable Systems at the University of Michigan, a Beyond Meat patty would probably generate 90% less in greenhouse-gas emissions than a conventional burger made from a cow.

Signals in the Noise

HOW WE'LL INVENT THE FUTURE

CARBON DIOXIDE CATCHER



NICO ORTEGA

Practical and affordable ways to capture carbon dioxide from the air can soak up excess greenhouse-gas emissions.

Even if we slow carbon dioxide emissions, the warming effect of the greenhouse gas can persist for thousands of years. To prevent a dangerous rise in temperatures, the UN's climate panel now concludes, the world will need to remove as much as 1 trillion tons of carbon dioxide from the atmosphere this century.

In a surprise finding last summer, Harvard climate scientist David Keith calculated that machines could, in theory, pull this off for less than \$100 a ton, through an approach known as direct air capture. That's an order of magnitude cheaper than earlier estimates that led many scientists to dismiss the technology as far too expensive—though it will still take years for costs to fall to anywhere near that level.

But once you capture the carbon, you still need to figure out what to do with it.

Carbon Engineering, the Canadian startup Keith cofounded in 2009, plans to expand its pilot plant to ramp up production of its synthetic fuels, using the captured carbon dioxide as a key ingredient. (Bill Gates is an investor in Carbon Engineering.)

Zurich-based Climeworks's direct air capture plant in Italy will produce methane from captured carbon dioxide and hydrogen, while a second plant in Switzerland will sell carbon dioxide to the soft-drinks industry. So will Global Thermostat of New York, which finished constructing its first commercial plant in Alabama last year.

Still, if it's used in synthetic fuels or sodas, the carbon dioxide will mostly end up back in the atmosphere. The ultimate goal is to lock greenhouse gases away forever. Some could be nested within products like carbon fiber, polymers, or concrete, but far more will simply need to be buried underground, a costly job that no business model seems likely to support.

In fact, pulling CO₂ out of the air is, from an engineering perspective, one of the most difficult and expensive ways of dealing with climate change. But given how slowly we're reducing emissions, there are no good options left.

Signals in the Noise

HOW WE'LL INVENT THE FUTURE

AN ECG ON YOUR WRIST



BRUCE PETERSON

Regulatory approval and technological advances are making it easier for people to continuously monitor their hearts with wearable devices.

Fitness trackers aren't serious medical devices. An intense workout or loose band can mess with the sensors that read your pulse. But an electrocardiogram—the kind doctors use to diagnose abnormalities before they cause a stroke or heart attack—requires a visit to a clinic, and people often fail to take the test in time.

ECG-enabled smart watches, made possible by new regulations and innovations in hardware and software, offer the convenience of a wearable device with something closer to the precision of a medical one.

An Apple Watch-compatible band from Silicon Valley startup AliveCor that can detect atrial fibrillation, a frequent cause of blood clots and stroke, received clearance from the FDA in 2017. Last year, Apple released its own FDA-cleared ECG feature, embedded in the watch itself.

The health-device company Withings also announced plans for an ECG-equipped watch shortly after.

Current wearables still employ only a single sensor, whereas a real ECG has 12. And no wearable can yet detect a heart attack as it's happening.

But this might change soon. Last fall, AliveCor presented preliminary results to the American Heart Association on an app and two-sensor system that can detect a certain type of heart attack

Signals in the Noise

HOW WE'LL INVENT THE FUTURE

SANITATION WITHOUT SEWERS



THEDMAN | GETTY

Energy-efficient toilets can operate without a sewer system and treat waste on the spot.

About 2.3 billion people don't have good sanitation. The lack of proper toilets encourages people to dump fecal matter into nearby ponds and streams, spreading bacteria, viruses, and parasites that can cause diarrhea and cholera. Diarrhea causes one in nine child deaths worldwide.

Now researchers are working to build a new kind of toilet that's cheap enough for the developing world and can not only dispose of waste but treat it as well.

In 2011 Bill Gates created what was essentially the X Prize in this area—the Reinvent the Toilet Challenge. Since the contest's launch, several teams have put prototypes in the field. All process the waste locally, so there's no need for large amounts of water to carry it to a distant treatment plant.

Most of the prototypes are self-contained and don't need sewers, but they look like traditional toilets housed in small buildings or storage containers. The NEWgenerator toilet, designed at the University of South Florida, filters out pollutants with an anaerobic membrane, which has pores smaller than bacteria and viruses. Another project, from Connecticut-based Biomass Controls, is a refinery the size of a shipping container; it heats the waste to produce a carbon-rich material that can, among other things, fertilize soil.

One drawback is that the toilets don't work at every scale. The Biomass Controls product, for example, is designed primarily for tens of thousands of users per day, which makes it less well suited for smaller villages. Another system, developed at Duke University, is meant to be used only by a few nearby homes.

So the challenge now is to make these toilets cheaper and more adaptable to communities of different sizes. "It's great to build one or two units," says Daniel Yeh, an associate professor at the University of South Florida, who led the NEWgenerator team. "But to really have the technology impact the world, the only way to do that is mass-produce the units."

Signals in the Noise

HOW WE'LL INVENT THE FUTURE

SMOOTH-TALKING AI ASSISTANTS



BRUCE PETERSON

New techniques that capture semantic relationships between words are making machines better at understanding natural language.

We're used to AI assistants—Alexa playing music in the living room, Siri setting alarms on your phone—but they haven't really lived up to their alleged smarts. They were supposed to have simplified our lives, but they've barely made a dent. They recognize only a narrow range of directives and are easily tripped up by deviations.

But some recent advances are about to expand your digital assistant's repertoire. In June 2018, researchers at OpenAI developed a technique that trains an AI on unlabeled text to avoid the expense and time of categorizing and tagging all the data manually. A few months later, a team at Google unveiled a system called BERT that learned how to predict missing words by studying millions of sentences. In a multiple-choice test, it did as well as humans at filling in gaps.

These improvements, coupled with better speech synthesis, are letting us move from giving AI assistants simple commands to having conversations with them. They'll be able to deal with daily minutiae like taking meeting notes, finding information, or shopping online.

Some are already here. Google Duplex, the eerily human-like upgrade of Google Assistant, can pick up your calls to screen for spammers and telemarketers. It can also make calls for you to schedule restaurant reservations or salon appointments.

In China, consumers are getting used to Alibaba's AliMe, which coordinates package deliveries over the phone and haggles about the price of goods over chat.

But while AI programs have gotten better at figuring out what you want, they still can't understand a sentence. Lines are scripted or generated statistically, reflecting how hard it is to imbue machines with true language understanding. Once we cross that hurdle, we'll see yet another evolution, perhaps from logistics coordinator to babysitter, teacher—or even friend?

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