

FUTURE NEWS

TO CONNECT, TO INFORM AND TO INSPIRE

IN THIS EDITION

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TRUTH IN A NETWORKED FUTURE

by Casper Skowgaard Petersen

“ While online discussion on social platforms is free and open in theory, it is heavily reliant on the non-transparent workings of the algorithms that curate our experience.



It is difficult to imagine we will ever return to a world where most of our news, information and entertainment was covered by a few big, trusted media institutions - and where individuals were mostly passive recipients of media. Yet, this has been the way of things for most of human history, from the dawn of writing up until the spread of the internet.

In a span of just a few decades, the global media landscape has changed drastically. Much of our consumption of news, information and entertainment has moved online, and

individuals have gone from being passive media consumers to active prosumers. Changes in the digital media landscape are happening at breakneck speed, and a fast-growing share of our media consumption is happening on social platforms. In 2016, 45 percent of Americans aged 50 or older reported getting news from social media sites. One year later, the number had already risen by 10 percent. The 2018 Reuters Digital News Report showed that 40% of respondents in 38 countries use Facebook for news, and 87 percent of respondents find their news online (including on social media). The media we consume on these platforms is determined by our previous habits or our peers' recommendations, and as a result, our identities, tastes and political beliefs are increasingly formed through online networks. In some ways, universally used social media such as Facebook have become monopoly platforms for social life.

The rise of social platforms for sharing knowledge and information has empowered ordinary citizens and led to an explosive growth in amateur knowledge, and the diminishing role of experts as gatekeepers of knowledge. A 2017 Google report found that 67 percent of millennials use YouTube to find tutorials to help them learn new skills. The same study found that 91 percent of mobile users search for how-to content online when working on a project, and that 'how-to' searches on YouTube have been growing 70 percent year over year.

On the flip side, this trend has also led to the undermining of the legitimate gatekeepers of truth: academics, scientists and others who speak from a position of authority and whose information and advice we used to trust almost unconditionally. According to the Weill Cornell Department of Healthcare Policy and Research in the US, more than 75 percent of people trusted their doctor's advice in 1966; in 2018, only 34 percent did. RAND Corporation describes the diminishing role of facts and analysis in public life in a 2018 report titled Truth Decay. The report lists the increasing relative volume and resulting influence of opinion and personal experience over fact as one of the primary drivers for this development.

While online discussion on social platforms is free and open in theory, it is heavily reliant on the non-transparent workings of the algorithms that curate our experience. As we have seen in the last few years, this has made public dialogue vulnerable to political and scientific misinformation, which can spread like wildfire among like-minded peers. An outcome of sharing and communication of information becoming frictionless – meaning that the filters or barriers that usually exist between sender and receiver disappear – is that fringe groups like anti- vaxxers, flat-earthers, 5G scaremongers, political conspiracy theorists and troll bots have become staples of social media and the internet, and by extension, of public discourse. In this new environment, it is more difficult for individuals to navigate the maelstrom of information and misinformation. This information overload leads many to pick and choose from the available information and piece together their own individual truths.

A recent report by Oxford University looked into the phenomenon of ‘Computational Propaganda’, a term used to denote “the use of algorithms, automation, and human curation to purposefully distribute misleading information over social media networks.” The research project tracked online misinformation on social media and found that a lot of so-called “junk news and automated accounts” could be traced to programmers and businesses in Germany, Poland and the United States. Further, the study found that no less than 45 percent of Twitter activity in Russia is managed by highly automated accounts, and that a significant portion of the political conversation over Twitter in Poland is produced by a handful of right-wing and nationalist accounts. Ironically, the free and open structure of the internet has led to a centralisation of misinformation designed to shape and control public discourse.

“Technology, which can be used to spread misinformation, can also do much to combat it.

What will the shift from broadcasted to networked truth mean in the long term? In 2017, Pew and Elon University conducted a research project where they asked more than 1,000 media experts the following question: “In the next 10 years, will trusted methods emerge to block false narratives and allow the most accurate information to prevail in the overall information ecosystem? Or will the quality and veracity of information online deteriorate due to the spread of unreliable, sometimes even dangerous, socially destabilizing ideas?”

The results showed uncertainty about the future, as respondents were divided equally on the positive and negative sides of the question. 51 percent of the respondents believed that the information environment will not improve. 49 percent believed it will. The 51 percent with a negative outlook believed that efforts to correct the situation will be stifled by bad actors, who will continue to use social media to appeal to the lowest common denominator: “selfish, tribal, gullible, and greedy information consumers who will believe whatever they are told.” To these respondents, technology will cause more problems than it will solve, as it will allow users to be bombarded with even more misleading information. One expert even referred to our present time as a “nuclear winter of misinformation”. The 49 percent with a positive outlook believed that we will find solutions to our current problems with mis- information, and they expressed a belief that technology, which can be used to spread misinformation, can also do much to combat it.

Both the optimists and pessimists agreed that there is no quick fix to the challenges posed, and that technology alone cannot provide the solution to the situation it has helped create. What’s needed, they believe, is a

“ Fact-checking, while important and no doubt beneficial, is treating the symptoms, not engaging with the root cause.

renewed focus on objective, accurate information fostered in all levels of education, and greater support for quality journalism. Similarly, a 2018 report by the EU Commission’s High Level Expert Group on Fake News and Online Disinformation recommended five steps to counter disinformation and fake news in the future: enhancing transparency of online news through better data sharing; promoting media and information literacy to help users navigate the digital media environment; developing tools to empower users and journalists to tackle disinformation; safeguarding the diversity and sustainability of the European news media ecosystem; and promoting continued research on the impact of disinformation in Europe.

One thing is clear: in a future of networked truth, the need for trusted and balanced channels of information is greater than ever. Some countries have already taken measures achieve this. In Norway, the fact-checking site Faktisk.no has been established for the purpose of preventing the spread of fake news and misleading information. In other countries, the measures have been more extensive. In France, for example, a law was passed in 2018 which allows authorities to remove fake content and block sites that publish it. Singapore also recently instated harsh laws punishing those who spread fake news by lengthy prison sentences or hefty fines.

Assuming the role of ‘fact-checker’ may help alleviate some of the problems caused by the rise of networked truth, but it is also a reactive position to take. Lies spread faster than facts – much faster, in fact. A recent investigation by Science magazine monitored about 126,000 rumours spread on Twitter between 2006 and 2017. They found that false news cascades reached between 1000 and 100,000 people whereas the truth rarely reached more than 1000. Fact-checking, while important and no doubt beneficial, is treating the symptoms, not engaging with the root cause. In the long-term, proactive measures that focus on fostering information-, news-, and media literacy will likely have a more significant impact.

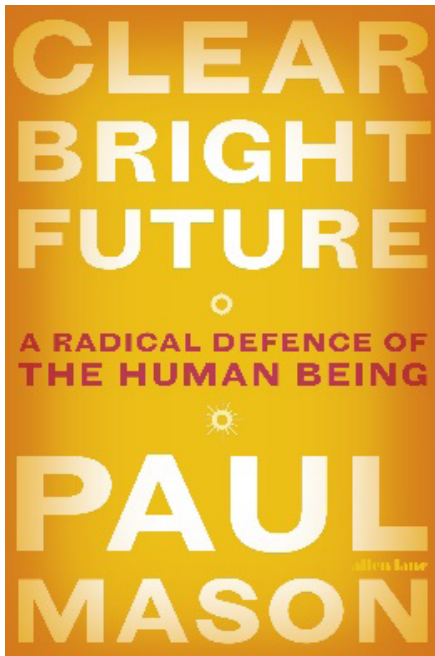
Looking closer at individual media users, a central question for the future is the extent to which the need for trusted and more transparent sources of information will outweigh the desire for more convenient products and services. The horizontalisation and hyper-personalisation of digital ecosystems, which happen when digital giants leverage their vast insights into individual consumer behaviours across platforms, mean that citizens must often trade off transparency for convenience. Unless a different model gains ground – for instance, one where citizens have complete control over the data they allow platforms to access, and the situations in which they allow it – the question of whether fostering information literacy will have the desired effect, or if it will be overshadowed by the temptation of highly personalised offerings, remains open.

This is an outtake from Copenhagen Institute for Futures Studies recent members’ report *Future Media: Key Trends and Technologies*.

Bright Clear Future
by Paul Mason

Book Review

by Charles Brass – Chair, futures foundation



Paul Mason is an activist journalist, and this book is both a compilation of his experiences around the world and a call to action – action to radically change the way the human world works.

His first paragraph neatly sums up his intentions: “By the end of reading I want you to make a choice. Will you accept the machine control of human beings, or resist it? And if the answer is resist, on what basis will you defend the rights of humans against the logic of machines?” (pxi).

His fundamental premise is that the logic of our current economic system (often called neo-liberalism) is inevitably leading to a de-humanisation of the world (ie people becoming

subordinate to algorithms and artificial intelligence). This, Mason argues, is how those currently enjoying power and wealth intend to “keep themselves rich, powerful and unaccountable” (pxiii).

The book is in five parts. Firstly, he situates a whole slew of recent events (such as Brexit, Trump’s election, the GFC, post-modernism and Russian and Chinese politics) at the centre of a “day zero” inflection point in the history of *Homo sapiens*. Mason summarises this inflexion point this way: “Trump was produced by a broken economic system and a geopolitical instability that are only going to intensify. Even if Trump were swept from office, we are now in a world where every four years a new, crazier, more vicious version of Trump is possible” (p34).

The second part consists of five chapters exploring the evolution of our sense of self. The first two of these chapters summarise the development of neo-liberal thought (something Mason has explored in other books such as “Postcapitalism – a guide to our future” and “Why it’s kicking off everywhere – the new global revolutions”), which is why I won’t try to precis this analysis any further here. He ultimately concludes that neo-liberal thought is no longer relevant (though he acknowledges there are plenty of powerful people who are yet to recognize this) by saying: “One by one the illusions built

up over thirty years, around which millions had structured their lives, vanished. The belief that complex financial systems enhance the stability of the real economy? Over. The assumption that nothing bad every happens when a speculative bubble bursts? Dust. The idea that politics is about technocratic parties arguing with each other about minor details from here to eternity? Gone. The religion of cheap credit? Debunked. The dogma that if everybody competes with everybody else, things can only get better? Disproven in every welfare office, at every food bank with every sorry doorway filled with a human being huddled in a sleeping bag” (p66).

Calling this quote a conclusion is somewhat inaccurate since there are 50 further pages of analysis and insight, combining Mason’s first hand experiences in Egypt’s Tahrir Square during the Arab Spring, and Barcelona in Spain during the Catalan independence movement, with a detailed explanation of why Hannah Arendt (who wrote so compellingly about the rise of Nazism) put too much weight on the ability of the American political system to avoid totalitarianism.

Mason uses the 5 chapters in Part 3 to explore how neo-liberal economic thought has inevitably lead to the increasing dominance of machines, and the consequential alienation of human beings.

“ Do we use technology to improve human beings incrementally, or do we consciously try to create something better than *Homo sapiens* to which we ‘surrender control’?”

– Paul Mason

He begins by tracing the history of machines, starting with Galileo who wrote the first truly scientific book about them, then explaining the development of silicon based machines in the twentieth-century. He points out that modern computers are in the information processing business (surprise, surprise) and quotes James Gleick in saying: “history is the story of information becoming aware of itself” (p124). This leads naturally into a lengthy exploration of what is meant by ‘reality’ in an era that includes quantum mechanics, artificial intelligence and movies like the Matrix series (all of which Mason writes about).

This exploration of what is reality and its impact on what it means to be human is one of the three key threads that knit this book together. The other two are the rise of current economic thinking (which has already been described) and the Marxist ideas that provide a way forward (this is the ‘radical defence’ in the sub-title) which will be discussed below.

Along the way Mason inevitably discusses religious thought, because it has had such a profound impact on how human beings see the world and how the world sees human beings. Mason debunks those who claim that science has proven human beings do not have free will (their main argument appears to be that neuroscientists can detect activity in the human brain some milliseconds before the person actually takes any action). Personally I find Mason’s debunking compelling, but readers will have to make up their own mind (start around page 138).

Chapter 10 explores the extension of computers into neural networks and ultimately to what is called artificial intelligence. Having written carefully about this he concludes that “at root, then, AI has to be programmed with an ethical system reflecting a view of human nature” (p166). Readers interested in exploring this aspect are encouraged to read “Superintelligence” by Nick Bostrom.

The last two chapters in this part explore so-called transhumanism and postmodernism by attempting to answer the question “do we use technology to improve human beings incrementally, or do we consciously try to create something better than *Homo Sapiens* to which we ‘surrender control’?” (p167.)

Mason answers this question (some 30 pages later) saying: “I want everyone reading this book to make a conscious choice, to answer no (to the second part of the question)” (p190).

Part 4 of the book concentrates on the life and theories of Karl Marx. As Mason says (I am paraphrasing): “If I could outline a project that could link all struggles around race, class, sexuality and gender into a single project of human liberation without reference to Marx I would do so” (p210). His core idea is that humanity as a species is biologically capable of setting itself free through technological innovation, self-transformation and work – something he believes is needed to form the basis of a twenty-first century radical humanism.

“The radical defence of the human being starts with you.

– Paul Mason

Over perhaps 30 pages he explores, and critiques, Marx’s theories and how they were informed. He isn’t blind to the “major gaps, mistakes, non-sequiturs and false turns” (p241) in Marx’s thinking, but nonetheless he concludes that Marx is the one to lead us all into a world in which human beings matter, because we are human not because we have blindly followed some algorithm.

In part 5 of the book (the final 50 or so pages) Mason tentatively sets out some action steps that “we might encourage each other to adopt” (p246). He outlines what he calls four strategic projects, each one matched to one of the effects that information technology has created within capitalism:

“To combat monopolies and price-fixing: break up the information monopolies and promote the socialization of basic digital infrastructure, in the form of non-profit companies or state-owned utilities similar to the energy grid.

To combat precarious work and stagnant wages: accelerate automation by de-linking work from wages. This involves paying everyone a citizens’ basic income, out of taxation, plus the universal provision of four basic services – healthcare, transport, education and housing – either ultra-cheap or free. These measures should act as a transitional subsidy to offset the impact of rapidly automating the world.

To combat rent-seeking: legislate to make data into a public good, while giving ultimate control of how each person’s data is used to the individual, not the state. Suppress all business models

based on rent-seeking; indeed make the seeking of economic rent socially unacceptable.

To fight information hoarding: outlaw all business models based on asymmetric access to information. I should have the right to know, and to see, what any state, any bank or any social media company knows about me. I should have the right to delete the information, to correct it and to limit its use. I should have the right to know if an algorithm is being used to control, monitor or predict my behavior. I should have the right to know if an artificial intelligence is being used on the other side of a transaction, game or conversation (p253)”

However, he is not satisfied simply outlining these objectives. He also wants to “(craft) a vision for the future and a path towards it” (p255).

Here he walks a fine line between advocating revolution (with all its potential downsides) and proposing reform. He describes his writing as offering an achievable roadmap towards what he acknowledges is a radically different future. Mason critiques Foucault’s call for a ‘non-fascist life’, proposing instead an “antifascist life” (the title of his last chapter). He is a profound advocate of creating a ‘networked generation’ (by which he means something much deeper and more significant than simply being friends on Facebook) as a way towards creating: “a profound humaneness and empathy that could easily be the foundation of a new social ethos” (p299). And he finishes this book by calling us all to action: “The radical defence of the human being starts with you” (p300).

FUTURISTS IN ACTION

IS CANADA READY TO TURN AND FACE THE STRANGE FUTURE?

A new report uses strategic foresight methods to look at potential trends that might shape the future of work in Canada over the next 10 to 15 years

by Jessica Thornton



Most conversations about the future of work tend to focus on the potential impacts of automation or other technological trends. While these trends will certainly impact employment in the future, what is less talked about is how broader environmental, social and political developments could converge to drive change as well. What if Canada sees a rise in wildfires? What if mental health issues associated with technology continue to proliferate? How will these rising trends impact Canada's labour market? This type of "what if" inquiry is a useful exercise for thinking about the range of possible futures.

To support future-focused dialogue and help leaders avoid blind spots, the Brookfield Institute's recent report *Turn and Face the Strange*

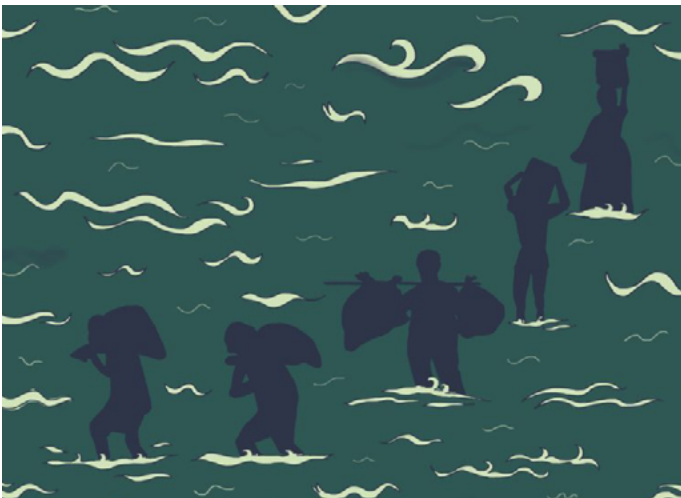
outlines 31 broad trends with the potential to impact employment in the next 10 to 15 years. This report, the first in the institute's new Employment in 2030 project, provides a glimpse into a range of mature, emerging and weak signals of change and explores what could happen if various trends interact and evolve over time.

Turn and Face the Strange is not a prediction of the future or a deep analysis of any one trend. It uses a strategic foresight method called horizon scanning to draw broad connections between a range of changes currently at play. While it is impossible to say exactly which trend will be the most important to watch or the most impactful, the following sample draws attention to the breadth of possible impacts driving change.



WORKING RETIREMENT

Canadians, like people in many advanced economies, are growing older as a population. In fact, the number of people who celebrate their 100th birthday is on the rise. A World Economic Forum white paper highlights that while individuals may live to see 100, they likely can't afford it. Accordingly, it's no wonder that the most recent census found that 53 percent of Canadian men aged 65 were still working. Will there be a "retirement age" in the future? How will employers accommodate a workforce that spans multiple generations? How will 75-year-old workers impact demand for products and services currently used by retirees? Working retirement is a mature trend likely to put pressure on job vacancy rates, while impacting industries such as health and wellness, housing, transportation and education.



CLIMATE REFUGEES

Climate change is a global challenge, creating devastating circumstances for people everywhere. As Canadian communities struggle to cope with wildfires, flooding and landslides, people

further afield are experiencing even more dramatic consequences. According to the Internal Displacement Monitoring Centre, an average of 22.5 million people are forced to leave their homes each year due to flooding, storms and other extreme weather. Meanwhile, the United Nations suggests that anywhere from 200 million to 1 billion people will be displaced due to disaster, conflict and climate by 2050. Currently, climate-related displacement is outside of the legal definition of a refugee, but what if that changes? What if Canada welcomes climate change refugees from all over the world? How might this impact labour supply? How might Canada's green economy grow, driven by talent with first-hand knowledge of the impacts of climate change? In 2017, New Zealand explored the creation of a visa program for climate change refugees, signalling the potential reality of this emerging trend.



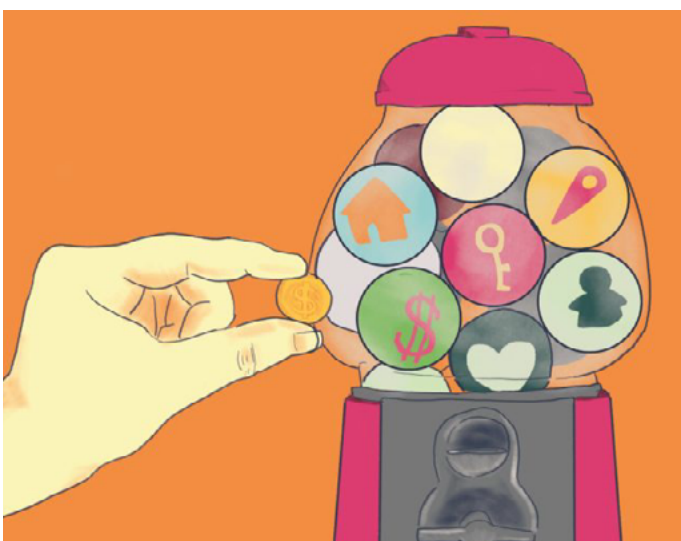
SUBURBAN BOOM

Half of the global population lives in cities. In Canada, cities are our main hubs for economic activity — a fact highlighted by a recent Neptis Foundation study showing a hyperconcentration of knowledge economy jobs in downtown Toronto. As cities continue to grow in economic importance, they also create growing problems of affordability for residents, forcing Canadians to settle farther from city centres. In fact, two-thirds of Canadians now live in suburbs, a number increasing faster than Canada's overall population growth. As employers continue to relocate offices in urban centres, and workers continue to move to suburbs, what will be the impact on overall productivity? How will this mature trend drive demand for infrastructure investments and economic activity in related industries?



HUMANS AUGMENTED

A start-up called Kernel is developing a “neural prosthetic” that will expand human cognition by uniting our minds and bodies with machine interfaces. Meanwhile, American scientists recently connected the brains of three people through BrainNet, enabling them to share thoughts with each other. What could happen if technologies like these become widely adopted? Currently, 66 percent of Americans say they would “definitely not or probably not” want to get a brain chip implant to improve their ability to process information. However, as more forms of brain enhancement become available, will people become more open to it? Imagine the potential disruption that education programs might experience if you could upload information directly. Could this make it possible for older workers to enhance their mental capacities to continue working longer?



PERSONAL DATA OWNERSHIP

With our every online click and transaction recorded, concerns over personal data collection continue to grow. As a result, new models of data ownership are being explored. Central to this

conversation is the idea of third-party governance systems, such as data trusts, which may move ownership of personal data from the hands of private companies to public institutions. Data trusts are being explored in Zurich, the UK and recently Toronto. If Canadians gain control of their data and potentially have the option to monetize them, what new products and services would emerge? How would data-reliant business models, such as Facebook or Amazon, be disrupted? Could this push even more people toward disconnecting from technology altogether?



INTERNATIONAL TENSIONS

International tensions are not new; however, they continue to evolve. Today, acts of conflict are taking new forms, including cyber warfare, autonomous warfare and the immediate recall of students and foreign workers. The 2018 Global Peace Index found that global levels of peace have deteriorated by 0.27 percent in the last year alone. Canada could see a 70 percent increase in defence spending from 2017 to 2027. Will this result in a booming tech-defence sector in Canada? Will Canadians be less likely to travel to other countries because of potential conflict? This increase in public spending could have significant impacts on Canada’s defence and security industry, while potentially incentivizing further investment in AI and robotics.



CANNABIS ECONOMY

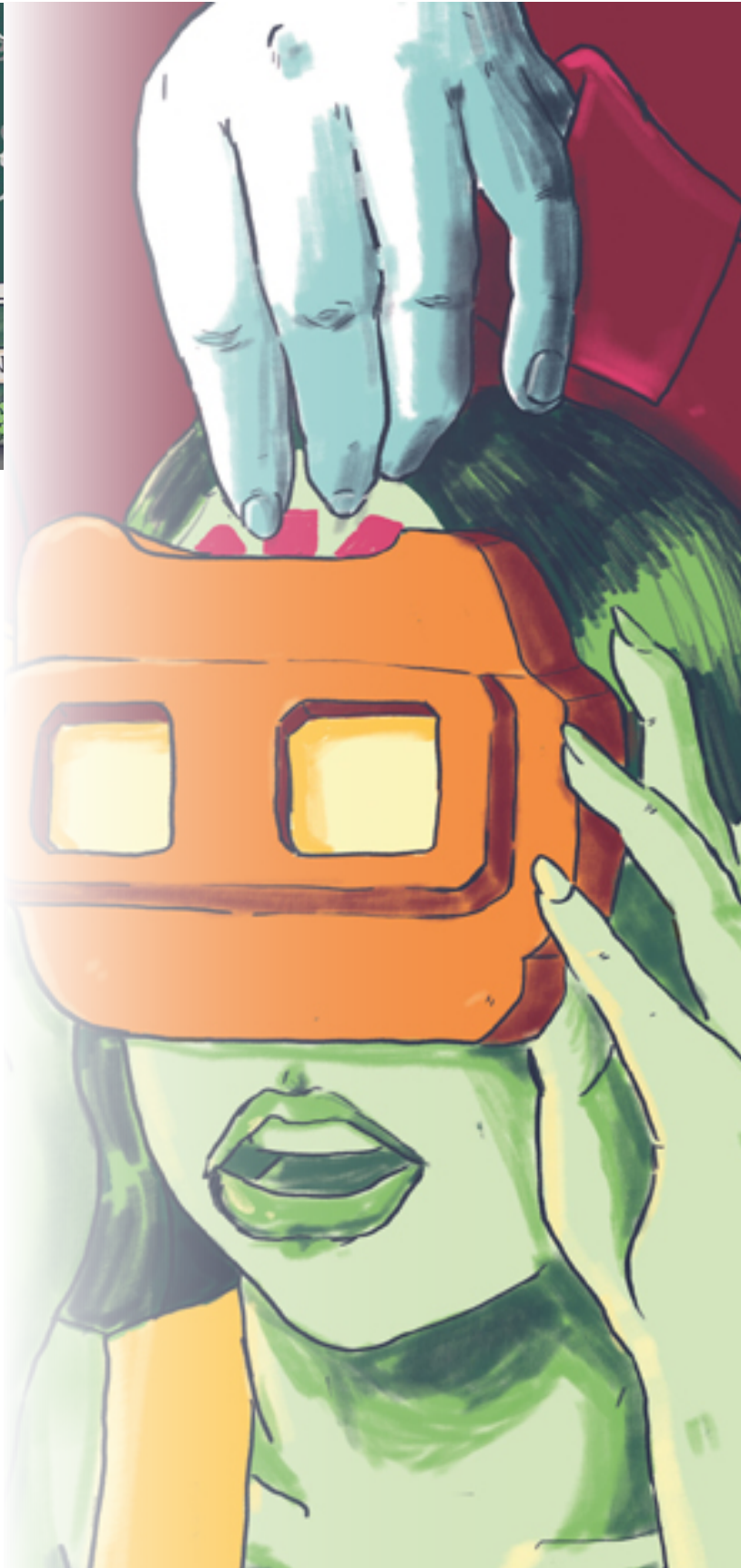
Canada's legalization of cannabis in 2018 has sparked the growth of an entirely new market (at least, a legal version of it), forecasted to be worth up to \$22 billion. As we watch companies such as Molson develop cannabis-infused products and see a tripling of cannabis-related jobs in the last year, it is clear that Canada's cannabis economy is booming. Early signals suggest changes for Canada's food and beverage industries, but what about health care, insurance and entertainment? While cannabis may not be embraced by all Canadians, legalization will no doubt open up new types of economic opportunities.

In order to prepare fully for the future of work, it is critical to understand the broad range of potential changes on the horizon. *Turn and Face the Strange* paints a complex picture intended to spark exploratory and imaginative thinking, pushing leaders from all sectors to consider the potential for different trends to interact in ways that are not always obvious. This research serves as a framework for the expert workshops taking place across the country as part of the Brookfield Institute's multi-stage project on employment in 2030. We're also sharing this work with broader audiences so that we can collaborate to build upon these ideas and explore how strategic foresight can be applied to other areas in Canada's innovation economy.

JESSICA THORNTON



Jessica Thornton uses human-centred design, strategic foresight and design research to explore policy topics at the Brookfield Institute. She currently leads two major projects: *Employment in 2030* and *Digitally Lit*



Illustrations by Jesseca Buizon. Buizon is a Toronto-based illustrator and graduate of OCAD University's illustration program. She creates her illustrations by merging traditional and digital mediums.

Signals in the Noise

TOP 10 EMERGING TECHNOLOGIES 2019

Technologies don't have to be cutting edge to make a profound difference in people's lives.



1. Bioplastics for a circular economy

Advanced solvents and enzymes are transforming woody wastes into better biodegradable plastics.

Our civilization is built on plastics. In 2014 alone, industry generated 311 million tons, an amount expected to triple by 2050....yet less than 15% of it is recycled.

Recent breakthroughs in producing plastics from cellulose or lignin (the dry matter in plants) promise to replicate the mechanical strength and visual characteristics of the current kinds of plastics mostly derived from petrochemicals.

The emerging methods for producing biodegradable plastic offer a perfect example of how greener solvents and more effective biocatalysts can contribute to generating a circular economy in a major industry.

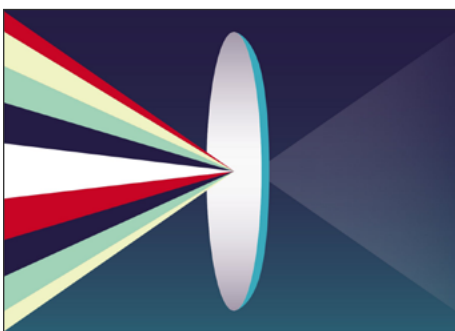


2. Social Robots

Droid friends and assistants penetrating deeper into our lives

In industry and medicine, robots routinely build, break down and inspect things; they also assist in surgery and dispense prescription drugs in pharmacies. Neither they nor 'social' robots – which are designed to engage with people and elicit an emotional connection – behave like The Jetsons' maid, Rosie, or other beloved droids of fiction. Even so, expect social robots to become more sophisticated

and prevalent in the next few years.

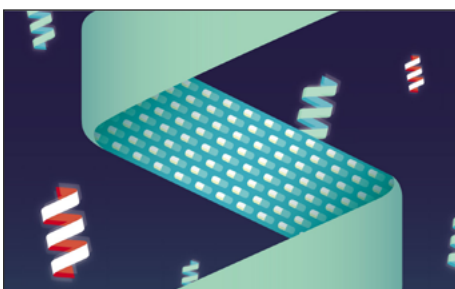


3. Tiny lenses for miniature devices

Thin, flat metalenses could replace bulky glass for manipulating light

As phones, computers and other electronics have grown ever smaller, their optical components have stubbornly refused to shrink. Engineers have recently figured out much of the physics behind much smaller, lighter alternatives known as metalenses. A metalens consists of a flat surface, thinner than a micron, that is covered with an array of nanoscale objects such as jutting pillars or drilled holes. As incident light hits these elements, many of its properties change....

Researchers can precisely position the nanoscale objects to ensure that light that exits the lens has selected characteristics.



4. Disordered proteins as drug targets

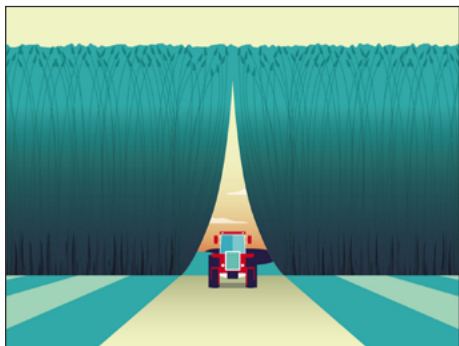
New possibilities for treating cancer and other ills.

Decades ago, scientists identified a particular class of proteins driving illnesses from cancer to neurodegenerative disease. These 'intrinsically disordered proteins' (IDP) looked different from the proteins with rigid structures that were more familiar in cells. Their loose structure allows the

Signals in the Noise

TOP 10 EMERGING TECHNOLOGIES 2019

IDPs to being together a wide variety of molecules at critical moments, such as during a cell's response to stress. When IDPs do not function properly, disease can ensue. Scientists are using rigorous combinations of biophysics, computational power and a better understanding of the way that IDPs function to identify compounds that inhibit these proteins, and some have emerged as bona fide drug candidates.



5. Smart fertilizers can reduce environmental contamination

New formulations deliver nourishment on demand

To feed the world's growing population, farmers need to increase crop yields. Applying more fertilizer could help, but standard versions work inefficiently and often harm the environment. Fortunately, products that are more ecologically sound – controlled release fertilizers – are available and becoming increasingly smart. Controlled release fertilizers are part of a sustainable approach to agriculture known as precision farming.

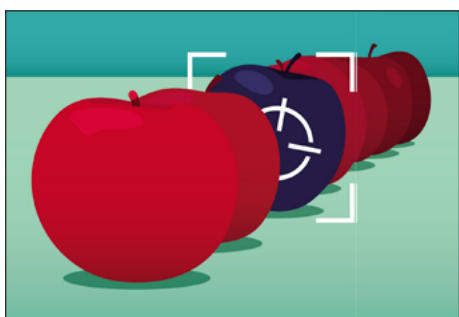


6. Collaborative telepresence

Soon participants in virtual gatherings will feel like they are physically together

Imagine a group of people in different parts of the world smoothly interacting as if they were physically together, down to being able to feel one another's touch. The components that will enable such 'collaborative telepresence' could transform how we work and play together, rendering physical location irrelevant. Telecom companies are

rolling out 5G networks fast enough to handle masses of data from advanced sensor arrays without lag times. Innovators are perfecting technologies that enable people to physical interact with remote environments.

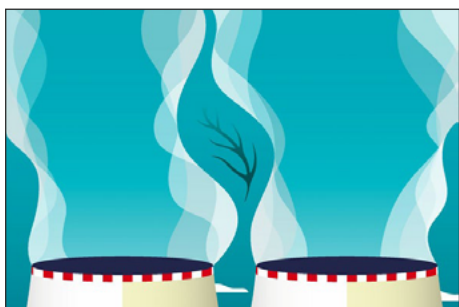


7. Advanced food tracking and packaging

A combination of two technologies could vastly improve food safety

About 600 million people suffer food poisoning ever year, according to the World Health Organization, and 420,000 die as a result. Together, a pair of technologies could reduce both food poisoning and food waste. The first, an innovative application of blockchain technology (better known for managing virtual currency) is beginning to solve the traceability problem. Enhanced food packaging, meanwhile, is

providing new ways to determine whether foods have been stored at proper temperatures and whether they might have begun to spoil. Cost remains are roadblock to the ubiquitous use of sensors.



8. Safer nuclear reactors

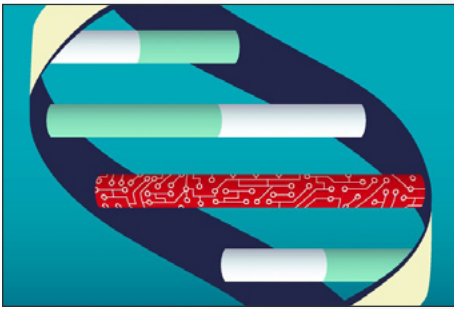
Resilient fools and innovative reactors could enable a resurgence of nuclear power

Controlling carbon in the atmosphere will require a mix of energy technologies – potentially including nuclear reactors that emit no carbon but are seen as risky because of a few major accidents. That risk could be greatly reduced. Manufacturers are hastening development of so-called accident-tolerant fuels that are less likely to overhead....

Manufacturers are also experimenting with 'fourth generation' models that use liquid sodium or molten salt instead of water to transfer heat from fission.

Signals in the Noise

TOP 10 EMERGING TECHNOLOGIES 2019

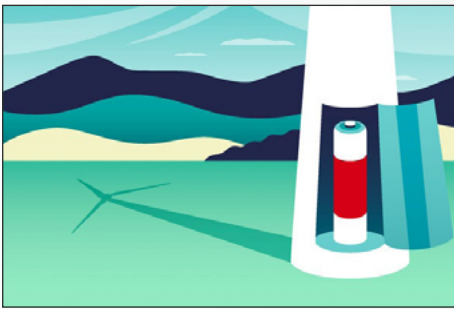


9. DNA data storage

Life's information storage system is being adapted to handle massive amounts of information

Every minute in 2018, Google conducted 3.88 million searches, people watched 4.33 million videos on YouTube, sent 159,362,760 emails, tweeted 473,000 times and posted 49,000 photos on Instagram. The magnetic or optical data-storage systems that currently hold this volume of 0s and 1s cannot last for more than a

century, if that. We are about to have a serious data-storage problem that will only become more severe over time. Progress is being made in an alternative to hard drives: DNA-based data storage....DNA can accurately store massive amounts of data at a density far exceeding that of electronic devices. The simple bacterium E.coli, for instance, has a storage density of about 10¹⁹ bits per cubic centimeter. At that density, all the world's current storage needs for a year could be well met by a cube of DNA measuring about one metre on a side. Among the challenges to making DNA data storage commonplace are the costs and speed of reading and writing DNA, which need to drop even further if the approach is to compete with electronic storage.



10. Utility-scale storage of renewable energy

A roadblock to sustainable energy solutions is coming unstuck

The way the world gets its electricity is undergoing a rapid transition, driven by both the increased urgency of decarbonizing energy systems and the plummeting costs of wind and solar technology. But the intermittent nature of those sources means that electric utilities need a way to keep energy in their back pocket when the sun is not shining and the winds are calm. That need is increasing interest in energy-

storage technology – in particular, lithium-ion batteries, which are finally poised to be more than just a bit player in the grid. Getting to the point where renewables and energy storage can handle the baseline load of electricity generation, however, will mean moving beyond lithium-ion batteries. It is uncertain whether and how much the costs of energy storage will continue to decline. Yet the accumulating pledges by governments to achieve carbon-free electricity production will provide a continued push to bring more and more storage online.

This is a summary of a report produced by the World Economic Forum. The entire report can be sourced from the futures foundation resources centre. Simply send an email to info@futuresfoundation.org.au.