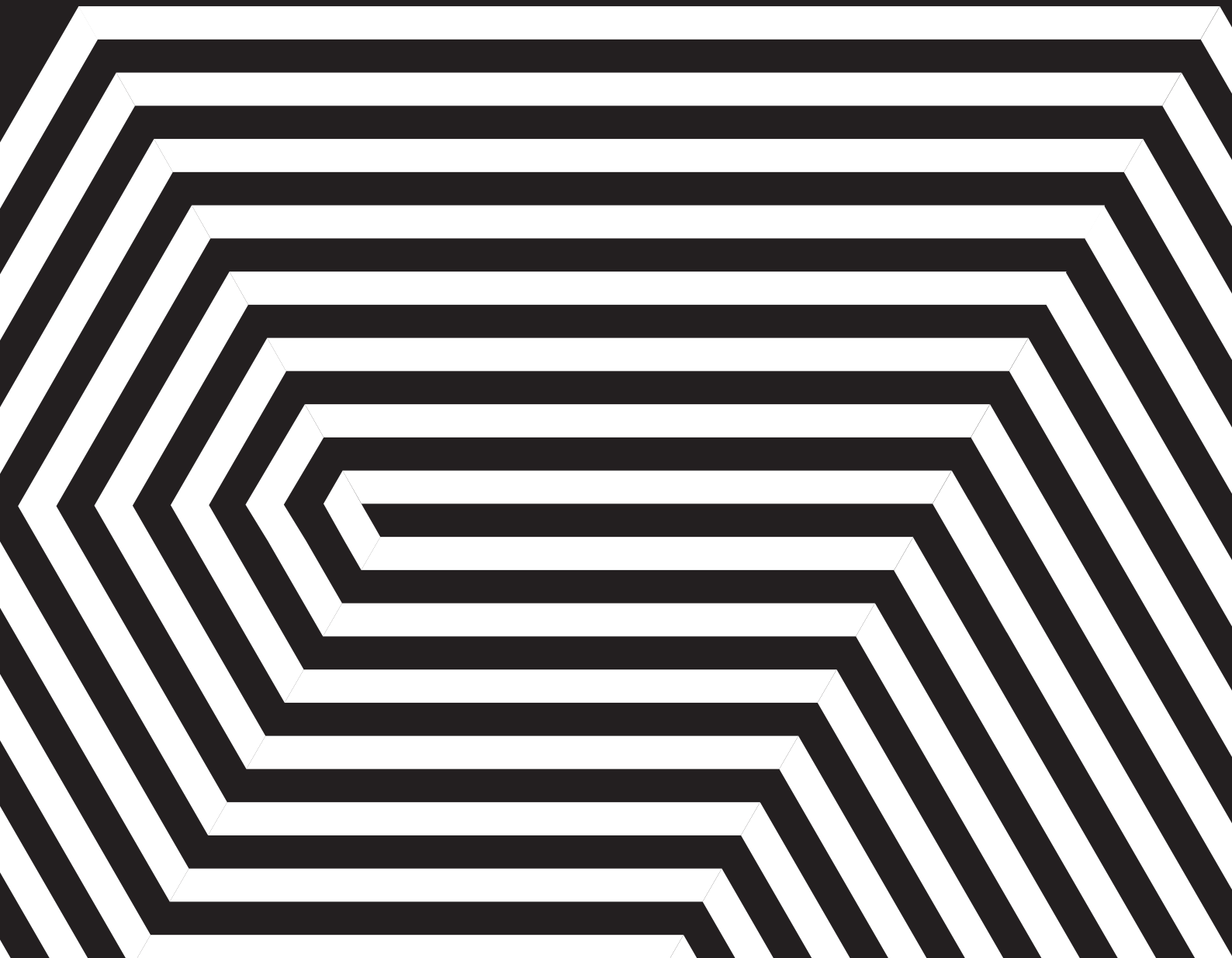
Imperial College London

2038 Tech Foresight

SHIFTING REALITIES

Tech Foresight 2038

Snapshot from 14 June 2018



TF2038

Provocative future visions

SHIFTING REALITIES

The Tech Foresight 2038: Shifting Realities event took place on 14 June 2018 at the British Library, London. The event explored technological breakthroughs stemming from Imperial College London, investigating how these could change the world around us.

This summary snapshot shares some of the ideas that came out on the day, including academic visions, future application of new technologies, and summaries of panel debates.

If you have any questions please get in touch.

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ACADEMIC VISIONS

DATA-CENTRIC FUTURE CITIES

PROFESSOR MARK GIROLAMI, CHAIR IN STATISTICS, FACULTY OF NATURAL SCIENCES,
AND DIRECTOR OF THE ALAN TURING INSTITUTE

In his talk, Professor Mark Girolami explored how we might use data to better understand the world around us. His research combines data understanding with uncertainty, to develop realistic digital twin models that mirror the real world. His work considers the synthesis of mathematical and statistical modelling to quantify and propagate uncertainty. The research is starting to be used in a variety of applications, such as the first ever 3D-printed bridge, constructed in Amsterdam. The bridge will have a digital twin, using sensors and digital models to assess its performance and create responsive infrastructure. But, what might the evolutions of these technological developments entail? What might the world look like in 2038? Let's imagine what potential futures may emerge.

What if London had a digital twin?

When cities enable data to be collected and responded to, how can we use this for the benefit of the city? We could imagine cities having their own digital twins, which become increasingly accurate, developing a responsive layer to the city that reacts to autonomous mobility and other digitally enabled products. By creating a digital twin, we could imagine the city as being in 'perpetual beta'. Each part of the city would have its own heartbeat. Each city could have a simulation, where we could trial the smallest decisions in the virtual city before presenting it to human beings. It would help us build cities that can assess intervention on a systematic level and predict even the most uncertain of consequences. It would also give us an opportunity to model cities that can be reconfigurable at their core, turning them into beta experiences that are changeable for the many.

What if the digital twin could test the city to its limits without any repercussions?

What if we could test cities and regions to their limits? Could we accurately predict consequences of minor changes? Imagine a future London formed by millions of complex data points, all interconnected and measurable, allowing us to test how changes in individual data points will affect the rest and impact the city. This would mean that policy makers might be able to test how changes in transport, for example, no matter how small, might affect healthcare, the environment, education or social services. Everything in the city could be built on testing and simulation and every decision, project and service could be trialed to assess even the most uncertain outcomes. There won't be room for improvisation, instead change is tested on the digital twin rather than on a static city.

What if we could re-engineer single data points in the city to achieve desired outcomes?

Pollution is already a health hazard in London. Cities will need to 'detoxify', which could be done by shifting transport and people flows to enable cleaner air. Real-time digital twins may in the future be used to create and suggest gamified routes that may reconfigure existing patterns of work, making the people flows responsive to the levels of pollution and transport congestion. Individuals could even help to monitor the city. Those who work in co-working spaces would be able to change where they work to help create a cleaner and more seamless city. Professor Girolami's team is already working with the Lord Mayor's office on improving monitoring and measurement of air quality across London – the first small step.

And finally, what would be the individual's experience of this?

If these algorithms work well on cities, what if we as individuals each had a digital twin? Perhaps we could use this twin to assess our reaction to medicine, to start the most suitable fitness routine, or perhaps even model how, mentally, we would react to the city. Digital twinning has already been used in modelling how the heart moves under certain diseases.

In summary...

Data-centric engineering will be at the heart of every facet of engineering. Digital tools will be used to assess and build more effective structures and respond better to their environment. This understanding will enable us to create materials and buildings that may be able to last forever. Testing new materials and environments to the extreme by using as good as real digital models.

Professor Mark Girolami

ACADEMIC VISIONS

FROM LASERS TO A HYPERSENSITIVE WORLD

DR RICCARDO SAPIENZA, READER IN PHYSICS, FACULTY OF NATURAL SCIENCES

For centuries, we have manipulated light by shaping the interface between glass and air, and only recently we have realised that it is also possible to manipulate light at a wavelength scale. By being able to exploit light at this scale, we will be able to control light in currently impossible ways, bending it to our needs. Today we use hard materials to control light, like glass or silicon, but what if instead we exploited soft biomaterials, like cellulose, silk or chitin (shrimp shell)? Dr Sapienza's group focuses on nanophotonics, in particular on complex disordered materials, which give us the ability to trap light in new ways, allowing us to create new to the world technologies. So, what are the future scenarios for these technologies?

What if nanophotonics enabled sensing to be reactive to things around you?

As nanophotonics becomes biocompatible, we may see a future with body tattoos that tell you if you have been excessively exposed to pollution, sun, radiation, magnetic fields or other health hazards invisible to the naked eye. This could see a world of continuous health monitoring with sensors that become part of our bodies. The easiest way to read a signal inside the body is optically, as light is non-invasive, and this is therefore an area where we can integrate biocompatible lasers.

Imagine you wake up in the morning and a biocompatible and implantable sensor scans your body and gives you a status for the day, advising how to keep your health at the optimal level. You can see that there has been a plethora of activity overnight and that sensors have been overstimulating your immune system to protect you against infection. With your small scanner, you can easily read any issues in your body and detect how they could be assessed. The biocompatible sensors, combined with theranostics, mean that you no longer need to care about taking medicines, and instead a photonic pill releases the drug you need.

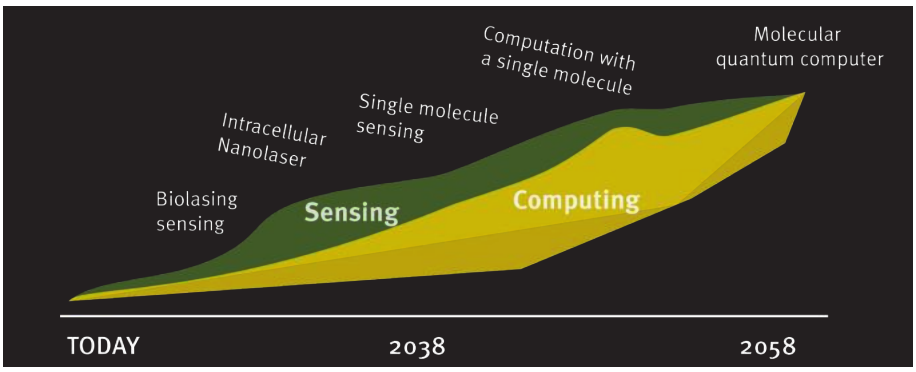
What if we could bring lasers to life and build hyper sensitivity into our world?

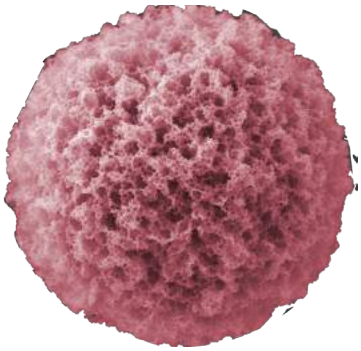
Could we perform a suite of blood tests from a single drop of blood? Could we sense a toxic or explosive compound from a single contaminated molecule? With the current breakthroughs and further research, we could imagine 'digital noses' that can sense minor shifts in the invisible atmosphere; from knowing when a tiny gas leak has happened before it becomes a big problem, to understanding the properties of our blood through just a drop, to assessing the safety of food or other goods with a simple test.

Nanoplasmonic sensing creates new opportunities for analytical platforms to detect diseases like cancer. Next-generation nano-optical sensors will be able to detect chemicals and/or biological species and simultaneously detect multiple analytes. Photonic sensing also creates the ability to test things that could be impacted by electricity, but wouldn't be impacted by photonic light.

Can we go even smaller? As small as a molecule?

Think even smaller than the size of a wavelength… think about the smallest bit of matter capable of emitting light. This would be a molecule, that is smaller than a molecule, 1,000 times smaller than the nanometre. Sensing to an even smaller scale is possible using nanoantennas. We are now capable of directing light to a single molecule by using a nanoantenna, which enables us to detect a single molecule of a target compound. Dr Sapienza is exploring how to make molecules interact with one another, with a single molecule. This could be the beginning of molecular computers, where molecules are linked by optical connections and information is shared between individual photons.





So what might the future of nanophotonics look like?

Speculative potential development for nanophotonic technology includes the following:

- By 2020 we may have nanophotonic connections in chips that overcome some of the current challenges, such as increasing the inability to increase the speed of chips without transistors melting.
- By 2030 it might be possible to have biolaser sensing capabilities.
- By 2038 we might be able to implement single molecule sensing, by adding nanoantennas to a molecule, which may enable multiscreening in a drop of blood, currently impossible in industry.
- Beyond 2038, possibly beyond 2059, if we are able to exchange information with a molecule, we may be able to build molecular computers through self-assembly blocks by replacing transistors with single molecules and electrical wires by photons in optical connections.

Dr Riccardo Sapienza

ACADEMIC VISIONS

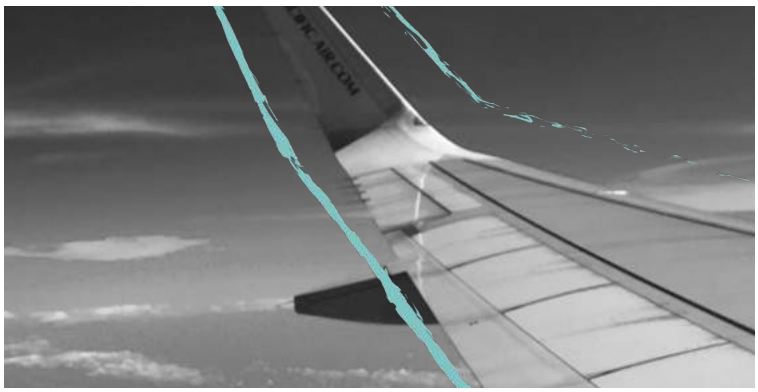
FUTURE OF 4D PRINTING

DR CONNOR MYANT, LECTURER, DYSON SCHOOL OF DESIGN ENGINEERING

3D printing is used in a number of industries, from manufacturing to the promises of the pharmaceutical and healthcare industry. Now that 3D printing is three decades old, Dr Connor Myant is looking at the next logical step: 4D printing, which involves the creation of objects that change shape over time and in response to stimulus. Until now, 4D printing has been used to create unravelling flowers and artefacts, but we are now nearing the point where we can employ 4D printing in commercial applications, by creating deployable structures that self-assemble on demand. This presents a huge opportunity in terms of developing complex products that perform a multitude of functions.

What if we could enable seamless systems?

What if we could create structures that self-assemble on demand, significantly reducing construction times? What if we could create objects that change their shape intelligently, in a pre-programmed manner or in response to their environment? At present, an aeroplane consists of 6 million parts and takes around 80 days to build. Imagine instead an aeroplane wing with no hydraulic rams, with no oil pipes, with no machine elements; just a single, responsive surface that can be tuned to the optimal aerodynamic shape. The ability to create such objects will dramatically affect build times, assembly times and maintenance protocols, improve performance and ultimately reduce cost.

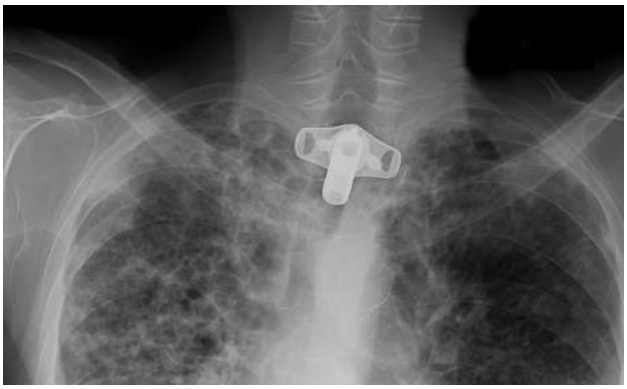


4D printing in the near future...

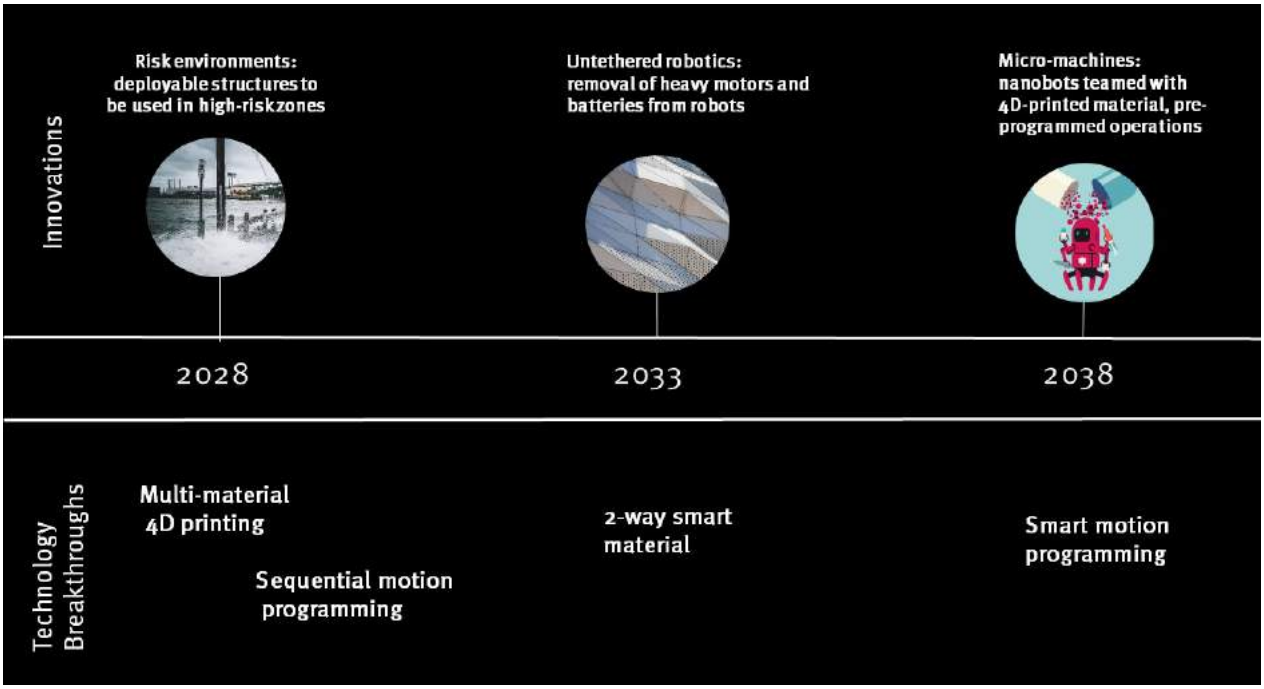
4D-printed deployable structures could be used in consumer goods, for example flat pack furniture or clothes and trainers that react to their environment to improve comfort. Moving forward, we could also imagine building facades that react to the weather to regulate building temperatures, or deployable buildings to be used in high-risk zones. Reaching further afield, because construction in space is difficult, dangerous and expensive, the ability to launch self-assembling structures into space could dramatically improve space exploration.

4D printing in the far future...

There stand to be many benefits of 4D printing in the healthcare sector; for example, imagine implants that don't require evasive, time consuming, hazardous surgical procedures. Dr Myant is currently working on windpipe surgery to imagine how we can move from using current bulky products to a simple foldable structure.



What might other future applications of 4D printing be? Here are some technological speculations:



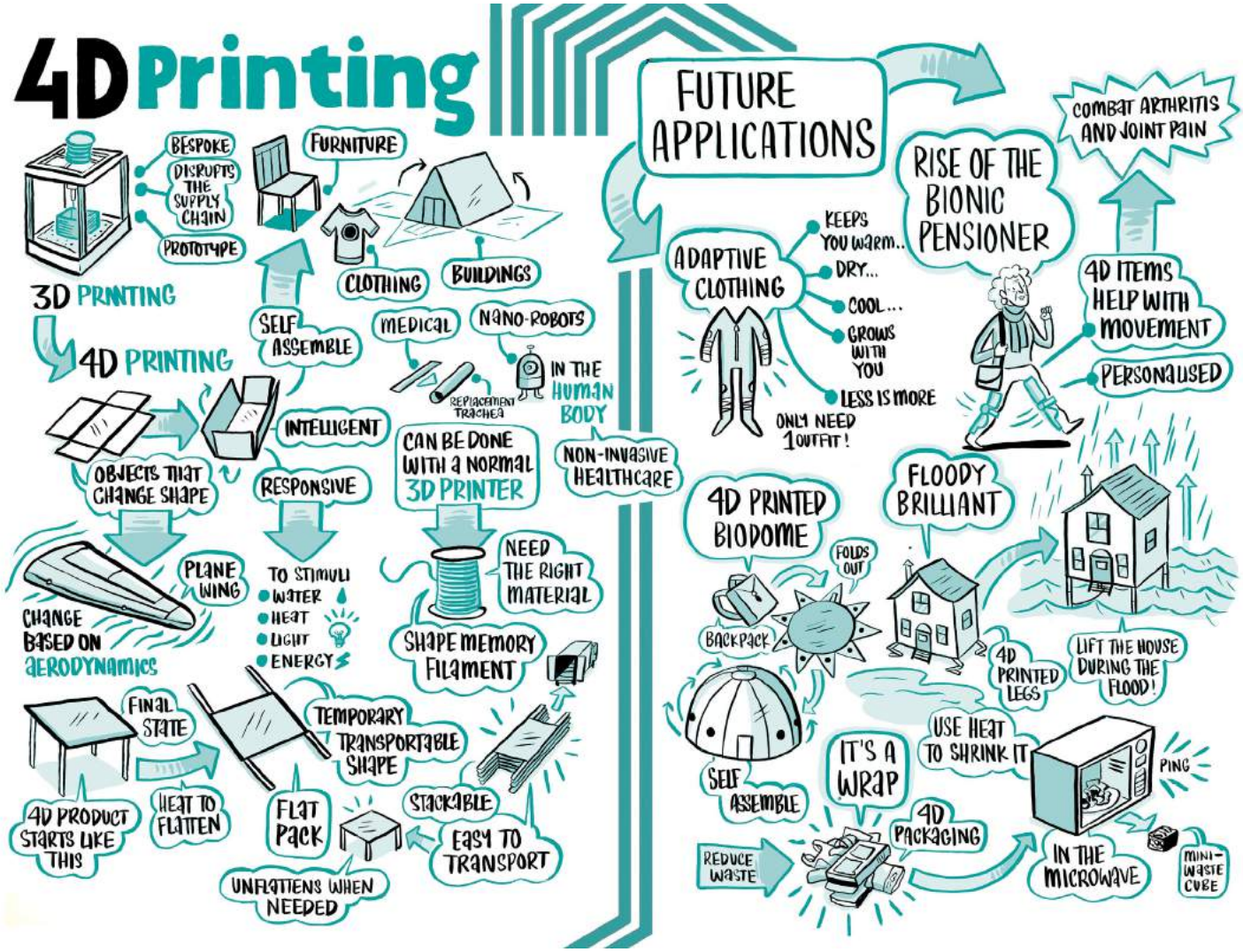
- By 2028 4D printing could be used to produce deployable structures to be used in high-risk zones.
- By 2033 it could create 2-way smart materials that could allow the removal of heavy motors and batteries from robots.
- By 2038, nanobots could be teamed with 4D-printed materials that perform pre-programmed operations.

Dr Connor Myant

WORKSHOP FINDINGS

FUTURE OF 4D PRINTING

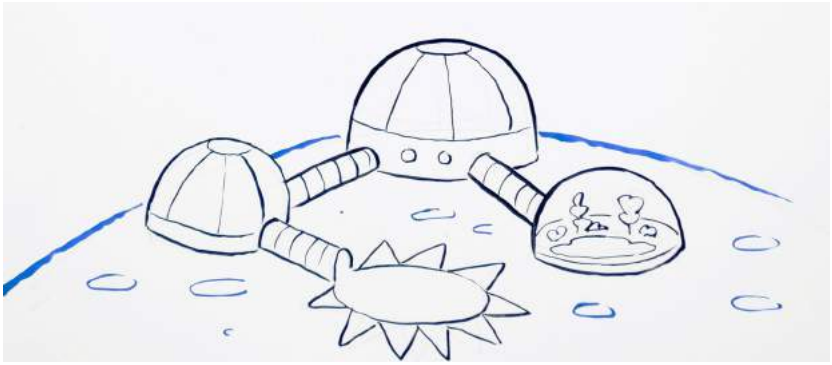
We asked participants to think about speculative headlines of the future. The following illustrations from the workshop showcase where these new ideas could go.

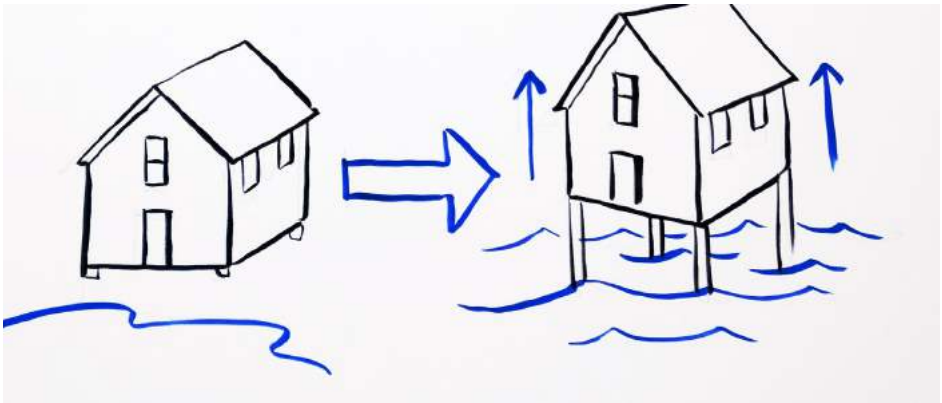


The workshop produced many ideas to address how 4D printing could help reduce and react to global challenges. Some of the benefits covered include:

- The reactivity to radiation and light
- Space efficiency
- Waste reduction
- Adaptability.

Biodomers expelled from Mars by Musk set up on Titan. Biodomers are the new back-packers pioneering new communities using 4D-printed homes, coral reefs, healthcare farms and ecosystem.





4D-printed climate change protection stops catastrophic flooding and water damage in the UK.

The rise of the bionic pensioner is enabled by creating movements that change and can be personalised for each individual.

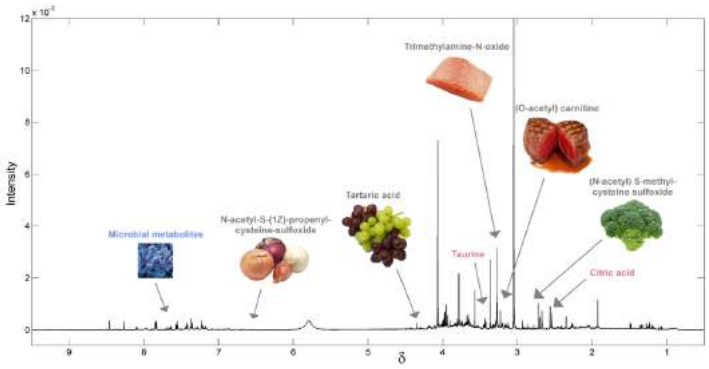
ACADEMIC VISIONS

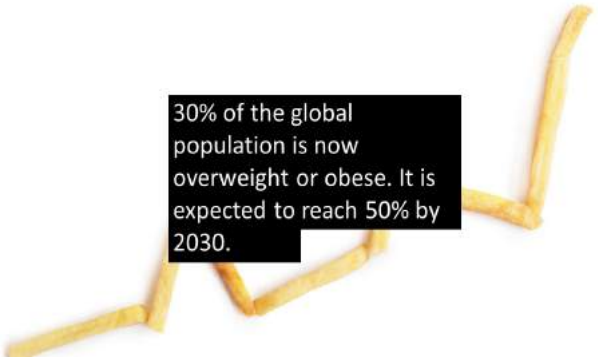
FUTURE OF FOOD

DR ISABEL GARCÍA PÉREZ, LECTURER IN PRECISION AND SYSTEMS MEDICINE, FACULTY OF MEDICINE

Lifestyle-driven diseases such as obesity are increasing and create a large health burden for societies globally. In the UK, in 2015, fifty-eight per cent of women and sixty-eight per cent of men were overweight or obese (UK statistics on obesity). Poor diet and nutrition are recognised as major contributory risk factors for ill health and premature death. To tackle obesity we rely on healthy diets, however, these diets often don't work because between thirty and eighty per cent of people claim they eat differently than they actually do. Each individual responds to diets in a different way, especially as food is more complex than many of us think, as each individual food product can have varying nutritional make-up.

Dr Isabel García Pérez was one of Tech Foresight's academics in the Future of Food session. She researches metagenomic and metabolomic analysis and has developed a quick urine diagnostic test that can precisely indicate nutrients that individuals have ingested in the day, helping to personalise diets and understand the real intake.





What might the impact of this technology be?

In five years...

This test might become a common tool used by dieticians. The results of this test, together with information about the physiology, genetics, exercise patterns and lifestyle of the individual, may provide an holistic understanding of dietary habits, improving the management of obesity and eating disorders.

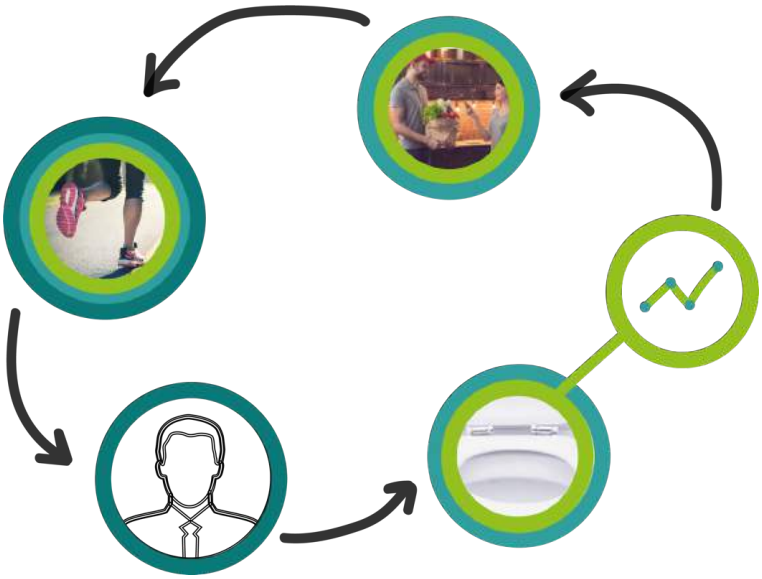
A range of services may integrate, allowing individuals to monitor and adapt themselves. The technology might suggest improvements to diet and lifestyle and may affect traditional diet services, like Weight Watchers, which might need to evolve to something more customised for individuals.

All of this might affect food policy, as industry may be required to provide more accurate nutritional information for products. Today, product descriptions are limited to carbohydrates, sugar, fat and salt. This could extend to new chemical compounds and more accurate information on the exact input.

In 10 years...

On a personal level, greater awareness of metabolomics might mean that we will know more about food and its impact on individuals. On a food industry level, it may mean that companies will start to label the nutrients of food in a much more detailed manner. It might be that food labels no longer contain a product's protein, sugar or fat levels but instead go into more detail on specific metabolites, such as quantities of rhamnitol, carnitine or tartaric acid, amongst hundreds of others.

From a health perspective, this might affect prevention strategies as it will allow understanding what food works for every individual.



In 20 years...

We might see high-street chemists becoming drop-off points for urine samples, as they can handle samples quickly and send results instantly. This would allow individuals to use such tests to improve their health.

It might even be possible that metabolomic testing becomes so common that we have smart toilets that collect urine samples on a daily basis, sending a metabolomics profile to our doctors to give accurate recommendations.

Dr Isabel García Pérez

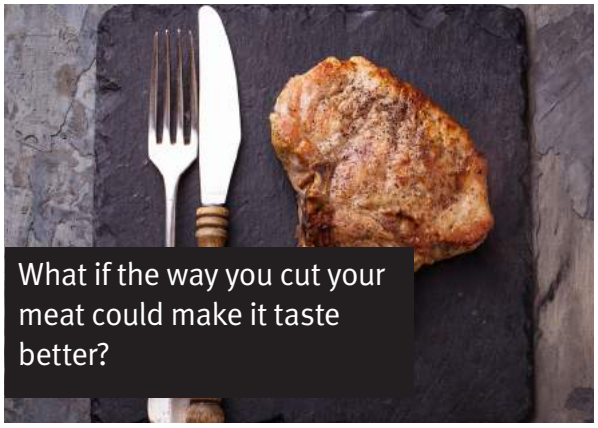
ACADEMIC VISIONS

FUTURE OF FOOD

DR WESTON BAXTER, LECTURER, DYSON SCHOOL OF DESIGN ENGINEERING

We often think of rituals as being associated with religious ceremony, steeped in hundreds or even thousands of years of tradition. At their core, however, rituals are extreme forms of user or customer experience that are infused with meaning. Within technology design, rituals are rarely considered, and there are often negative results. New technology fails when it doesn't deliver real value. Dr Baxter works on human-centred design and has quantified the effects of rituals on consumer patterns. In particular, Weston is developing a systematic ritual design process to craft value-creating rituals for tomorrow's interactions.

Dr Baxter is interested in the impact of rituals on nutrition and dieting to combat obesity. So, how can we create a ritual to improve the start of a new diet? How could we create a ritual around the specific behaviours performed to track nutrition? How might we create rituals to increase the sense of control over appetite?



What if the way you cut your meat could make it taste better?

New technology fails when it doesn't deliver real value.

What might such rituals look like in the next five years?

Augmentation rituals with technology might develop. For example, xH A (by Andriana Nassou and Andrea Pisa) is a tool that helps you learn to maintain your focus during meditation. xH A senses when you lose focus and gives you a gentle reminder to bring your attention back to your practice by playing the audio of your own breath in real time. When you have resumed focus, the audio disappears so you can focus on your natural breathing.

And within the next ten years?

Over the next ten years, the real focus will be on exploring how to enhance or create the rituals people perform with new technology.

A project that helps promote mindful rituals,
xH A by Andriana Nassou and Andrea Pisa

A project to enable new social rituals through the use of technology,
Meyu by Niki Göransson, Simon Cundall, Yuanjing Dong, and Davor Petricio Heredia

And within the next 20 years?

In 20 years, we will hopefully do away with tech foresight and focus on creating meaningful interaction for people. We will have a list of topics such as:

- How can we make consumption so meaningful that people eat less and enjoy more?
- How can we create better workplace cohesion to facilitate innovation?

In 20 years, social rituals could, for example, address loneliness and thoughtlessness, things that have increased when eating alone.

Dr Weston Baxter

WORKSHOP FINDINGS

FUTURE OF FOOD

In the workshop we asked participants to think about the dinner plate of the future and how it might be characterised. The following is an illustration of some of the ideas that arose, giving an overview of the content and discussions.

Some of the common themes emerging from the workshop conversations centred on how we can move towards more sustainable approaches to food and agriculture. The culture of zero waste was also emphasised and participants speculated about how packaging could be completely waste-less in the future, an interesting discussion surely driven by some of the current discourse on plastic-free societies. Veganism was also discussed as an area of interest, opening up alternative proteins and plant-based consumption.

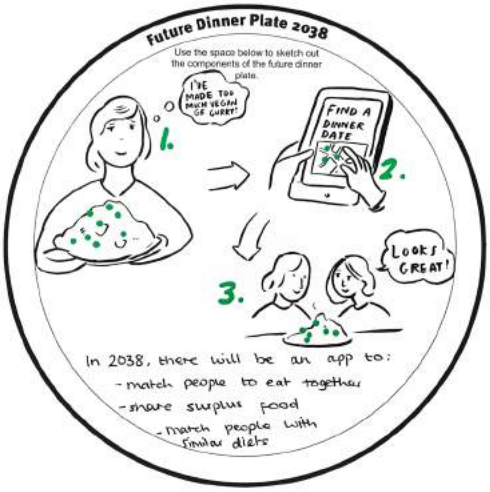
We also discussed rituals and people's experience around food, and some considered a need for food that promotes social cohesion and mindfulness. Most of our food is now consumed in front of devices, which means that we eat more and some experience unfortunate social exclusion. Food could actually be a new form of social 'glue'.

Human augmentation as a way to influence the way we eat and consume food was also discussed. Some said that new technology can create artificial sensorial stimuli which will perhaps mean that we eat healthier.

The future dinner plates included the following:

Bionic tastebuds

In 2038, personalised nutrition will be facilitated through bionic coated chewing gum. This chewing gum will help individuals enhance their flavour perception of food, so they are more likely to eat food that is good for them.



Food buddying experiences

In 2038, there will be a technology to match people to eat together, share surplus food, and match themselves with people who have the same diets, helping to combat elements of loneliness.

Zero waste food experiences

In 2038, the food will be plant-based and zero waste with high nutritional value. We will be looking to create food that is better for people and the planet.

DATA DISRUPTED

A CONVERSATION ON THE FUTURE OF DATA OWNERSHIP

The Data Disrupted session at Tech Foresight 2038 assembled a panel to consider the changing landscape of data collection and privacy. The word 'disrupted' proved, in the event, to have a double meaning. The panel examined how new technology could harness data in ways that transform industry and society. They also explored the dark side of data – including the Facebook/Cambridge Analytica scandal, misbehaving machine learning and pervasive surveillance – and asked if pushback could mean organisations that rely on data in problematic ways will ultimately find themselves disrupted.*

The value of data

The panel agreed that innovative uses of personal data have benefits for individuals and businesses. One panellist mentioned devices that monitor driving, which allow car insurers to better assess risk and young but safe drivers to pay lower premiums. In the future, a panellist said, body sensors will be able to monitor health in increasingly sophisticated ways.

It was also agreed that in some cases the interests of individuals and those of governments or businesses are not so clearly aligned. The discussion covered, for instance, the growing use of data by governments to monitor and control populations. In China, the network of CCTV cameras is set to be six hundred million strong and using face recognition technology can locate an individual in moments. In the city of Shenzhen, where road rules are strictly enforced, the faces of jaywalkers are displayed in public on an LCD screen, and face recognition will reportedly soon be used to automatically fine offenders.

Concerning business, the panel observed that an individual's personal data has relatively little value on its own, but is hugely valuable to businesses in aggregate – raising questions of whether individuals value their personal data appropriately. "It's easy for an individual to trade their individual data. The value is in large data sets. That's how you get Gmail," one panellist said. "The more you have of it the more powerful it is – a network effect," another agreed.

Machine learning

Looking ahead, one panellist said the most pressing future concern is not data by itself but machine learning, since the technology fuses data collection with decision-making in an opaque procedure that humans find hard to understand and predict. This sometimes has sinister consequences, as Microsoft discovered with Tay, the Twitter chatbot that was taken offline after it emulated grossly racist comments tweeted by humans.

"Blaming machine learning is abdicating responsibility. There are still decisions to be made. For a company to deploy it without understanding what they are doing is no excuse," said one panel member.

Researchers at Imperial are tackling this problem with recently launched research projects aimed at verifying machine learning systems, and developing machine learning architectures whose procedures humans can more easily understand.

The pushback

The panel also examined the pushback against big data. Changing customer opinions following the Facebook and Cambridge Analytica case are worrying for business strategies requiring unrestricted access to personal data.

An audience member said that people sometimes use multiple online identities to stop businesses tracking them. One panellist said they register for public Wi-Fi with the provider's name in the place reserved for the customer's, so they can tell if the provider sells their data for direct marketing.

"Playing the multiple IDs game is subterfuge. If you are a government or corporate and having this game played at you, you have to ask questions of yourself. Are you transparent and giving people equity and control?", one panellist said.

"The thing I find shocking is just how much data the government requires us to give, and we have no choice. This enables third parties, friend or foe, to start analysing who we are and what assets we have. I can see a future where people start to say no to government," said another.

A data privacy divide

The panel also raised the prospect of a future in which privacy is a luxury that only some can afford. Businesses, a panellist said, do not force individuals to give away personal data. But pressures to give away data will nonetheless remain: "Those of us who have economic privilege don't need to monetise our data. For another class, finances dictate that the economic thing to do is sell highly invasive data, despite the erosion of quality of life and privacy," one panellist argued.

Another said that businesses seek personal data to avoid adverse selection, a situation where one party benefits from a transaction by having information the other lacks. In insurance, this means that insurers might decline to insure a customer who withholds health information. This will be increasingly important in future as richer forms of health-related data, such as genomic data, become increasingly widespread.

For those who can afford it, premium services could help protect privacy. One panellist noted, "there is a company which does a deep search and provides all the data available on you. You can also pay for a service where they will help remove it for you. So you will at least know what data there is on you and go some way to controlling it". But this may only be available in 20 years to a restricted few.

"I think privacy is dead," said one panel member. "A lot of startups are going to jump into this business. But really, there are going to be so many ways of measuring stuff. To predict consumption, we use satellite images to count cars parked in the supermarket. We're not going to put things on our cars to stop that. There is a niche market for privacy, but that is going to be small and a luxury."

** To meet the Chatham House rule, those present at the meeting are not named here.*

ARTIFICIAL SCIENTIFIC DISCOVERY

A CONVERSATION ON THE FUTURE OF SCIENTIFIC DISCOVERY

AI and its application are being hyped and discussed across a range of industries. These new technologies are helping researchers explore fundamental processes in chemistry and biology from photosynthesis to the development of new molecules. As new technologies impact on scientific discovery and society more broadly, we will begin to see more interesting symbiotic relationships between AI and humans. In a session at Tech Foresight 2038, Professor Mimi Hii and Dr Mark Kennedy discussed whether we should outsource our discovery to AI and what it might mean for the future.

How do we ensure the foundational data used is of high enough quality for efficient artificial discovery?

Mimi Hii: There is a saying: "Your conclusion is only as good as your data". I will extend this to "artificial discovery is only as good as the data".

Mark Kennedy: We can do a lot with data science to refine junky data to make it useful, but there are limits. By analogy to petroleum, refining your data can translate crude into something high octane, albeit at some cost of hassle and processing power. Even so, you can't refine rubbish, only crude. So it's still "garbage in, garbage out".

The real skill of a scientist is to ask the right question. Can AI just find answers or also questions?

MH: It depends on the question. If the question is black and white (if I do A what would happen to B, and what are the tangible consequences), then the answer is yes: mathematically, this can be described as a problem with discreet variables, and the development of AI (in part) is about solving problems with continuous variables (the 'what if' questions). I can imagine an AI to be able to spot inconsistencies/ contradictions in human knowledge, for example, theory A conflicts with theory B and cannot be resolved by existing data – thus generating questions in that way. Questions that do not have a definitive answer (as it cannot be tested) may be difficult, for example, is Brexit a good idea? For these questions, the best thing a machine can do is to provide statistical probabilities (which can be as reliable as the results of the last few elections!), so I think it will be left to a human to make the final judgement call, or to place further constraints and assumptions.

MK: I would say the skill of a scientist is less about asking the right question than it is about asking questions that matter. I was just having this conversation with a PhD prospect yesterday. I explained that most academics have to be quite focused in their work, so the job is to identify a question or topic that is focused enough that you can aspire to it in a way that genuinely advances knowledge – but with the proviso that we want to create knowledge that really matters. AI can help us assess the impact of ideas, but it's not (yet) as useful for saying what will be important because that takes the savvy to participate in deciding what is important.

Serendipity has historically been critical in scientific discovery. Does AI eliminate or expand the need for it?

MH: It depends on what kind of 'serendipity' we are talking about. If these are 'accidental' because the scientist/machine is doing something it is not supposed to (human/machine error), then I would expect these to be much reduced, assuming that machines are built not to make errors! If we are talking about serendipity associated with something that should not, in theory, be possible, but the scientist did it anyway (either because they do not believe the theory, or are just ignorant/unaware), then these will be pretty much eliminated. That said, this pretty much depends on how AI is developed – which is a challenge itself.

MK: Data reduction techniques are already a stimulus for serendipity. When we use statistics and maths to reduce a complex high-dimensional data set to a smaller number of dimensions, the result is a whole set of models that suggest different ways the whole system is working. Most of these models are misleading epiphenomenal echoes of causal mechanisms, but some are clues to deeper insights.

What will be the role of scientists in the future? How will Artificial Discovery affect the profession? Will 'scientist' become a profession of the past?

MH: There will always be a need for scientists so long as there is a need for human input, where 'values' are evaluated differently, for example, respect for privacy.

MK: Same as before, except we will have help for some of the more blue-collar tasks scientists do.

What industries do we expect Artificial Discovery to touch first?

MH: If we learn something from history about disruptive technologies, AI is likely to influence the industries with low capital expenditure (CAPEX), for example, why invest in cars when you own a fleet of horses and have a workforce that knows how to direct horses (but doesn't know how to drive cars)? It will be the same story here – therefore, adoption of AI will be slowest with industries with the largest CAPEX investment. In my particular field of chemistry, this is likely to include the pharmaceutical manufacturing industry, who not only have significant capital investment around the world but also a large workforce trained in the 'classical' way (to be fair, they are justifiably conservative, as they can also least afford to make a mistake, as it can literally mean life and death!).

So, my bets are on companies who are now relying heavily on the 'gig' economy, that is mainly service industries that can change the nature of their workforce relatively easily without having to decommission a large manufacturing facility/fire lots of people. This inevitably includes the service industry that relies heavily on demand management (in some cases they are already making an impact), for example, cab and delivery services, certain financial services (accounting, investment) and – warning: this may be rather controversial – provision of primary healthcare.

MK: I expect there will be significant impact in fields where adaptations of search and dimensionality reduction can turbo-charge design. That would be things as disparate as structural engineering and fashion, to name just a couple.

Professor Mimi Hii Dr Mark Kennedy

SPECULATIVE TIMELINE

A snapshot of possible futures, including some of the speculations made in past years and ideas from TF2038 attendees.

2019: 3D printing of joints

3D printing of joints and surgical instruments will become more commonplace and bring down the price of orthopaedic surgery.

Year of speculation: 2014

Professor Justin Cobb

2022: Real sustainable cities

New cities will have sustainability ingrained into their footprint, showcasing where interactions have impact on a systems level.

Year of speculation: 2012

Professor Nilay Shah

2023: Wireless charging

As electric vehicles becon prevalant, we will start to vehicles using induction c motorways.

Year of speculation: 2014

Dr Gregory Offer

2018 2020 2022

2019: Hybrid human and machine learning

Virtual workforces (crowdsourcing) will be driving the economy.

Year of speculation: 2012

Professor Emil Lupu

2022: Upload data to the brain

New advances might give us the possibilities for brainwriting, uploading data directly to the brain.

Year of speculation: 2012

Professor Simon Schultz

2030: Electric flight

First commercial flights (+200 passengers) using electric power.

2030: Genetic dating apps

Dating apps will match people based on genetic profiles.

2034: Smart dust

Cybernetic ecologies, where the current miniaturisation allow sensors to be as small as dust.

Year of speculation: 2014

Professor Julie McCann

2030 2032 2034

2030: Smart energy grids

I would be able to trade with energy through my fridge and my toaster.

Year of speculation: 2017

Dr Simon Tindemans

2033: Drone mining of sea bed

Materials scarcity means mining inaccessible places, for example, rare earths on the sea bed.

2035: Fine structured materi

Our materials might be devel from the atomic level and the up, creating more efficient components.

Year of speculation: 2014

Dr Finn Giuliani

ne more
charge
on the

2024: DNA sequencing

Cheap DNA sequencing will be available. By 2030 this will conflict with data privacy.

2025: 100% mobile coverage

100% land, sea and polar.

2026: One size fits all clothing

Smart textiles that are automatically adaptive in size and/or colour.

2027: Plastic compost

Household compost bins with genetically modified caterpillars for plastic decomposition.

2024

2026

2028

2024: Neurotechnology decoding the brain

Brain – computer interfaces that allow us to control artificial limbs through eye movement.

Year of speculation: 2013

Dr Aldo Faisal

2026: Code that writes code

The processing techniques in oil and gas exploration are fully automated.

Year of speculation: 2017

Dr Gerard Gorman

2037: Neuromorphic computing

Developing a computerised brain might enable us to unlock the mysteries of mental health.

Year of speculation: 2017

Dr Thomas Heinis

2038: All your life in a box

4D printing could enable us to live more efficiently, fitting most of our belongings into a box that then can be unfolded through a small stimulus.

Year of speculation: 2018

Dr Connor Myant

2038: Precise health diagnosis

Metabolic testing might be an integral part of lifestyle, helping individuals live healthier lives. They will be tested through diagnostic toilets.

Year of speculation: 2018

Dr Isabel García Pérez

2036

2038

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2037: Advanced tissue repair

Living dressings for tissue regeneration might become the new beauty therapy, helping regenerate younger skin in face and body.

Year of speculation: 2017

Dr Ben Almquist

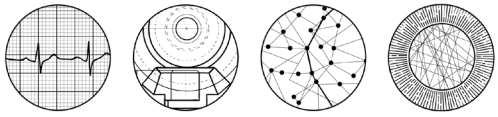
2038: Your body as a digital twin

Digital twins of most of our major organs will help us to make micro-changes in the way we live our lives for better health, productivity and wellbeing.

Year of speculation: 2018

Professor Mark Girolami

Imperial Business Partners



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Are you curious, afraid or just interested in the future? Drop us a line, we would love to have a conversation.

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Conversation
Anab Jain
Co-founder and director,
Superflux
Prof. David Gann, CBE
Vice President Innovation,
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Gareth Mitchell

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2038 Tech Foresight