Chapter 5

Healthcare and Medicine

can we ever acquire immunity against loneliness?

What if the cost of machines that think is people who don't?

George Dyson

Shane Warne with contact lenses or elbow surgery is accepted as human and is allowed to play professional cricket. But how about Shane with bionic eyes, a prosthetic arm, video tattoos (showing advertisements for Bundaberg rum), and augmented-reality sunglasses? Given what's happened to Warne's external appearance lately, the mind truly boggles as to what might have happened if he and Liz Hurley had decided on having genetically modified children.

Human enhancement is not unusual. We've been doing it for centuries. Our methods for enhancing ourselves have just become more sophisticated, whether it's tattoos, piercings, plastic surgery, botox, or hearing aids. It is also a matter of opinion whether enhancement has improved the human body or not. Hearing implants can not only restore hearing, but also improve it.

People with disabilities are using prosthetics to replace parts that are missing or that don't work, but now prosthetic designers are creating parts that are better than normal human ones. For example, Oscar Pistorius's 'Cheetah' legs were seen to give him an unfair advantage in the Paralympics. Similar controversy occurred when Ian Thorpe wore a 'sharkskin' swimsuit. Such augmentation, especially when physically part of the human body, will have huge implications, and the ethical debate has barely begun.

Nobody can fail to be moved one way or another by the audacity of enhancement, nor the promise it holds for future generations to be healthier. The question is whether it's interfering with what's natural, although this is an equally subjective question. Moreover, the devices that we constantly carry with us could be regarded as forms of enhancement.

Silicon dreaming

With improvements to our health, our population is ageing, and with this comes an increased fear of Alzheimer's. Memory is a hot issue for this part of the population, but research in this area could have pervasive effects.

Fans of the movie *The Matrix* may recall the scene where the character Neo downloads the skills of a kung-fu master. Connecting a digital system to your human brain might sound impossible, yet only ten years after seeing that movie, I bought a toy called a *Star Wars* Force Trainer: this was a headset that allowed its wearer to control a simple machine with their thoughts. A modest connection, perhaps, but suggestive. A few years later, my brain brimming with machine-interface enthusiasm, I found myself working with the Tech Foresight practice at Imperial College London, where I had a discussion about whether it might one day be possible to interface with a machine and directly download skills or experience into the human brain — foreign-language mastery or kung-fu skills, perhaps. The academic view was that this would not be possible, although they did concede that the downloading and remote viewing of dreams could be commonplace by 2040.

I mention this because things are afoot that are equally weird. In December 2013, a scientist called Sam Deadwyler published a paper documenting a series of experiments that involved transplanting memories into the brains of rats. We have, or soon will have, thought-controlled wheelchairs, robotic limbs, and cochlear and retinal implants, all of which depend on some level of direct brain–machine communication. So why can't we treat the memory loss associated with human ageing by replacing or bypassing damaged parts of the brain?

Conversely, if you could turn off or remove memories, this might also be useful for soldiers or civilians suffering from post-traumatic stress disorder. The US Defence Advanced Research Projects Agency aims to conduct human trials on precisely such technology by 2020. But developments such as these raise a host of dilemmas.

Some of the most interesting implications of the digital era concern transformations of power, community, allegiance, and identity. With identity, memories are critical. They define us as unique human beings and allow us to reflect on who we are. Some people say that if your memory is lost, as it is in some forms of dementia, you become someone else and to some extent can't be held legally responsible for your

actions.

Replicating our memory isn't easy. Human memory works on numerous levels, but if we could crack the code then all kinds of things would be possible. There's no reason why one day it won't be possible to buy electronic memory implants or e-pills that polish a perfectly normal brain. A student study chip, perhaps? Yet we shouldn't think of such ideas in isolation.

I'm sure we'll invent technologies that allow older people to remember events, although in the shorter term it might be far easier to record everything that happens to us and then to rewind to find whatever we need.

I've already mentioned the problem of never being allowed to digitally forget things: embarrassing images and hastily composed tweets never really go away. Viktor Mayer-Schonberger points out that, in 1950, the storage cost for digital data was $70,000 per megabyte, whereas by1980 this had fallen to $500, by 2000 was around one cent, and by 2008 had plummeted to 1/100th of a cent. This might be useful for older people wishing to remember everything, but perhaps not so good for younger people wishing to forget things.

Mayer-Schonberger has one intriguing solution to this problem, in the form of digital data with automatic decay dates. This would save us from social awkwardness as well as suffocating amounts of digital garbage. Google has voiced a similar idea regarding clean-slate digital identities once people reach adulthood.

Again, don't think of these ideas in isolation, but always in combination. It may not be what implantable memory or the recording of your entire life means per se, but what they mean in conjunction with other technologies, such as gesture control armbands, mood enhancers, mood recognition, digital drugs, or highly immersive virtual reality.

If this is starting to sound a little like a plot for another science fiction movie, buckle up, because it gets better. If our memories (i.e. our memory of events) define us then what happens if you modify or change someone's memories? Are they still them? At the extreme, would they still be human — and if not, why not?

Data exhibitionism

In my view, the ability to control information about oneself, especially information we

ourselves create, is vital. For instance, I can foresee a future situation where a major pharmaceuticals company is subject to a legal class action for using aggregated, anonymised personal data to develop profit-making drugs, the argument being that at least part of the profits belong to the people who generated the data.

One estimate is that we already give away up to £5,000 worth of personal data every year. The film *Terms and Conditions May Apply* reckons that 'The greatest heist in history wasn't about taking money; it was about taking your information — and you agreed to all of it.'

If you are a member of the quantified-self, or 'lifelogging', movement, you may be proud of the fact that you can optimise your cardiovascular activity or sleep hours using wearable devices. Apps such as Timehop even allow you to view your activity on the same day weeks, months, or even years previously. Rather than keeping such personal data to yourself, you might choose to share it with others, which may facilitate social interaction, which is in turn vital for mental and physical health.

But what if, for one reason or another, you went through a period of prolonged inactivity — or activity that is best kept private — and this data were shared or hacked? You might be subject to networked humiliation or you might receive a letter from your health insurer downgrading your insurance cover. You could almost certainly expect pop-up ads from heart surgeons and sleep doctors offering discount services if your data suggests they may be of interest.

Once information is digitised, it longs to wander. As the writer Stewart Brand famously declared, 'Information wants to be free', although nowadays it also wants to multiply like a plague of locusts and obliterate any surrounding ecosystems.

When information is placed on a sharing network like the internet, you have immediately lost control of it, forever. Others may copy it, forward it, or strip it of its original context. And don't forget that if you entrust your data to third-party services, these can be hacked, too. Indeed, there's nothing about the word 'cloud' that implies permanence or security. I'm sure the many thousands of people who have already had their credit-card details stolen might agree.

Clearly, sharing certain types of information is a force for good. If individual health data is collected, it can change behaviour for the better. User-generated data

ranging from wellness wikis to bulimia blogs do change lives. Using millions of patients to report on treatments via websites such as patientslikeme.com is an excellent example of how the medical establishment is being challenged by digitally empowered patients, and I'm sure we've only scratched the surface in terms of open medicine's potential. Increasing aggregation of self-recorded data will likely lead to better and often less expensive treatments and care.

Watch yourself

Where most tracking devices can only track one thing, a Google app called PACO (Personal Analytics Companion) can be set up to track any kind of behaviour or event. You might want to track how drinking coffee makes you more productive or what brings on headaches. Your data may be private or you can share it with somebody, depending on your need or mood.

The value of self-tracking regularly is it doesn't rely on memory, it can be used over time, and it's easy to do. In the medical world, trials are expensive, hard to administer, and generally short. Data tracking could help monitor cognitive impairment, clinical depression, or the onset of infectious disease — and reassure people who falsely represent their own symptoms or habits. Social workers might be able to find out the triggers for feeling negative towards their clients, or teachers might want to monitor how exercise and food affect the behaviour of classes.

Google is also working on a contact lens with sensors that measure the amount of glucose present in the tears of a person with diabetes. For a wide variety of physical tests, there are already numerous medical devices, such as wireless scales, electrocardiograms on smartphones, and the new otoscope, a device that looks inside the ear and sends its results via an iPhone app.

There's also a computer the size of this full stop. If you are suspected of suffering from glaucoma, you can put this tiny machine in your eye to measure the pressure of liquid against your eyeball. Data is sent wirelessly to your doctor.

One company is even testing a sensor that can assess stomach fluids to find out whether patients have taken their medicine or not.

Wait a little longer and we'll see wearable medical devices disguised as jewellery

and watches. Also: analytical e-skins. This would be clothing, especially underwear, made from conductive fibres containing gyroscopes, GPS, transmitters, and kinetic-energy batteries to monitor vital signs, detect medical emergencies, and call an ambulance when necessary.

There could also be bio-sensor toilets, digital sticking plasters, e-pills, wireless medical monitoring patches, ingestible robots that dissolve once their task is done, and wirelessly powered sensors embedded in the human body producing full body telemetry, at which point the human body gradually transforms into a technology platform, possibly controlled by Google.

If the thought of all this does not enthuse, you grasp the reticence and conservatism of the healthcare industry, as opposed to the tech head's fascination for novel gadgets. Moreover, doctors are often paid per consultation, and they may be less enamoured with less-frequent visits. On the other hand, insurers are worried such devices may lead to hypochondria — the worried well might fuss over anomalous readings and so make even more visits to the doctor.

Keeping this in mind, we should always assess new medical devices in the same way that we assess new drugs.

The power of networking

Ultimately, healthcare data could be stored within our bodies and we might become nodes on a network. More people means more tracking means more data to feed into Google Flu trends, which identifies flu outbreaks up to seven times faster than conventional methods.

Google Flu Trends is an example of Big Data, which is the name given to the huge sets of data generated in our increasingly digital world, for instance records relating to consumer behaviour or data collected from smartphone sensors and geotags. Simply by looking at internet search terms, Google can predict flu outbreaks. This worked for a while, although some of the forecasts of late have predicted things that didn't happen. This is a big problem with Big Data.

Unless you have *all* the data, big isn't necessarily better, as the economist Tim Harford has pointed out. It's usually better to have a fully representative sample than a

big dataset. There's also the problem of becoming over-reliant on historical patterns to predict future behaviour. Nevertheless, assuming we continue to refine our use of Big Data, a key problem remains: what should companies and governments in the 21st century do with all the data they collect, and who ultimately owns or controls this data?

One very interesting development in healthcare is the arrival of Google and Apple on the scene, so it's not too far-fetched to suggest that, some day, doctors may prescribe apps. Unlike Nike or Garmin, these consumer technology brands are not usually associated with wellness, but they are perfectly positioned to offer advice either via mobile devices or by their knowledge of who we are and what we do.

One indication of how things may progress is an app called StudentLife, which was initially designed to find out how students cope at university. Researchers found that flourishing students were generally among other people and had longer conversations, while struggling students spent more time alone, often indoors, and had disrupted or extended sleep patterns. The results of StudentLife suggest that phones can be used for continuous mental-health tracking, and should be more reliable than self-completion questionnaires. Questions of privacy emerge, as they always do, but in this case the user has complete control.

Another favourite development of mine is a tooth from Taiwan that watches what your mouth is doing. Developed at National Taiwan University, this 'oral activity recognition' device can monitor when you eat, how much you eat, how fast you chew, whether you cough, and even how often you talk. The artificial tooth would work best fitted into a set of false teeth, but could be a single implant or, potentially, a cap (equipped with Bluetooth?) to send data to your dentist or doctor.

If an e-tooth were connected to a wearable device — a contact lens, for instance — a camera could recognise what pills people take. Or what they are eating, and offer dietary suggestions. It could even photograph food packaging and have the wisdom of online crowds suggest recipes.

Virtual tertiary specialists and virtual hospital wards could follow. Medical cards linked to retail loyalty cards could provide further personalised recommendations or might flag unhealthy purchasing behaviour. Perhaps one end result might be individual health ratings, similar to that of credit ratings. People with good health scores would be

offered health-insurance discounts and access to premium healthcare choices, such as access to top-rated surgeons or to the latest medicines.

Digital me

How about having a medically accurate digital body double? Why? Because, as we are continually being told, we are not all the same, and a physiological simulation of every person on Earth would flip healthcare as we know it upside-down.

We could all have real-time personal healthcare forecasts, which might include projected expiry (i.e. death) dates. This would change daily depending on diet, exercise, and lifestyle.

Looking at our genetic makeup via sites such as 23andme.com is useful because it offers a glimpse as to what we might suffer from in the future, allowing us to personalise our medicine. But genetics won't tell you everything, because it doesn't consider how we live on a daily basis and doesn't look at the complex linkages between different diseases or treatments.

Having a digital double that continually updates itself with healthcare data, including vital signs, would mean you could run virtual tests and even treatment scenarios. If you die, your virtual double could even be virtually dissected.

In theory, developments such as these would make patients pay more attention to the consequences of their own actions and allow doctors to further personalise treatments, but again it could turn people into hypochondriacs and, once more, raises numerous legal and ethical questions. For example, who would own your virtual twin and the data it collects? What if failure to maintain monthly payments meant withdrawal of service, which in turn meant you failed to receive life-saving information? And how about privacy, equality, or autonomy?

Possibly the biggest question is a concern over whether patients would trust the advice of a machine over human experience — something of a recurring theme in speculations about the future. We already delegate authority to all kinds of machines, but under what conditions would individuals trust fully autonomous machines, and how could such trust be verified?

Mobile risks

Apart from the ethical questions, staring at screens can have other downsides, too.

In many countries, such as America, Britain, and Australia, sedentary lifestyles mean that physical activity levels have fallen by 20 per cent over the past 50 years, and are forecast to fall an additional 15 per cent by 2030. Similarly, too much screen-based entertainment and an almost allergic reaction to being outdoors in the fresh air and sunlight means that children today are considerably less fit than their parents and grandparents at the same age. With this thought in mind, a reversal of long-established longevity trends isn't completely impossible.

Of course, there's already an app for this problem. But what about problems caused directly by the devices themselves?

A Swedish study of 1,200 people diagnosed with malignant brain tumours between 1997 and 2003 analysed their mobile- and cordless-phone use and found that those who started using mobiles as teenagers and continued to use them for ten years were 4.9 times more likely to develop malignant brain tumours. For cordless-phone users over ten years, the risk was 3.9 times. There's also evidence emerging that prolonged exposure to wi-fi signals could be having a serious impact on health. In 2015, France banned wi-fi in nursery schools and restricted availability in primary schools, while a Lloyd's insurance underwriter, CFC Underwriting, has told British schools that it was excluding liability for claims 'relating from or contributed to by electromagnetic fields, electromagnetic radiation, electromagnetism, radio waves or noise'. This means all wi-fi, smartphones, iPads, and other mobile devices.

Mobile phones have been called the 'new cuddly toys' for kids. Some countries take the risks seriously. In France, it's illegal to market mobiles to children under 12, and they can't use them in primary schools. Other countries, such as the UK, Israel, and Germany, merely discourage such use.

Disconnect by Devra Davis claims that children are more susceptible to radiation because their skulls are thinner and their brains are still developing. This leaves parents in a difficult position. Nobody is saying for sure that mobile phones cause cancer in children, but there's enough evidence gathering to make parents nervous.

This begs the question of how much mobile-phone use is safe for adults, given their ubiquity. It may turn out that the risk from radiation is negligible, partly because

phones are now better designed to shield against radiation and partly because we are now less inclined to clamp phones to our heads. But there's also evidence emerging that reading using a phone or iPad at night has an 'extremely powerful effect' on sleep length and quality.

How sleep became the new sex

A decade or two ago, taking an electronic device to bed meant only one thing. Nowadays, reading or playing computer games while in bed is fairly normal. Bedrooms are turning into media rooms and workplaces, symbolic and symptomatic of a restless, globalised, ubiquitously connected world. But all at the expense of a good night's sleep.

It's common, especially among alpha males, to brag about how little sleep one has had or needs. Some day, someone might wake up to the idea that an alternative way to extend human lifespans would be to spend less time sleeping. Perhaps it will be someone that remembers reading *Beggars in Spain* in bed — this is a science fiction novella where genetic advances have made it possible to live without sleep. But the fact is that until someone comes up with nightcaps that use transcranial magnetic stimulation to trigger on-demand deep sleep, a proper night's sleep is essential. A continual lack of sleep can affect alertness, attention, judgement, problem-solving, and ideas. It can even affect ageing and our ability to combat infection.

Sleep isn't only restorative, it's where we make sense of things. The phrase 'sleep on it' has been around for a while, yet it wasn't until 1953 that people realised that the brain doesn't switch off when we sleep. Instead, our brains are busy processing information. More specifically, when we sleep the brain takes recent experiences and stabilises them as memories. Our brains do this all the time, but it's only when we're sleeping that we actively filter this information, sorting out what's useful and what's not and linking information together to extract meaning, solve problems, and dream up new ideas. When people try to survive on less than six hours sleep per night, aspects of memory stabilisation and learning do not work as well — or in extreme cases, do not work at all.

Using phones and other mobile devices in bed or anywhere else is, like most things, a matter of common sense. Putting to one side marital risks, health concerns are

an issue, but only when devices are used to excess.

Goodbye to the family doctor

Marriage isn't the only relationship that could be harmed through digital interaction.

Doctors' notes and prescriptions may soon exist only as digital files. This is good news on a number of levels. For example, doctors' illegible handwriting can result in misdiagnosis and drug-delivery errors, while, in theory, e-notes mean that patients and doctors will be able to access medical histories anywhere in the world. On the other hand, my own doctor insists that he can talk to me and make handwritten notes at the same time, whereas with notes on a screen he can't. This reminds me of a policeman I once spoke to who said that with handwritten notes he could look a suspect in the eye to glean the truth while writing, something that isn't possible with a tablet computer. If he paid attention to any digital device, he couldn't pay close attention to any potential offender or eyewitness.

Electronic prescribing and dispensing will come, and will be linked with the widespread use of mobile health and telemedicine, although one suspects that a lack of common standards and platforms will create havoc in the early days. Despite this, I'm sure it won't be too long before we'll walk into a chemist with a QR-code prescription on our mobile device rather than handing over a crumpled piece of paper.

Generally speaking, there are two types of mobile health or telemedicine: one to monitor a wearer's physical fitness, such as Jawbone wristbands, and one to link patients to the healthcare system via sensors or other forms of digital monitoring. The second category appears to have the most potential, especially for people that live alone or in remote locations.

A US study in 2008 found chronically ill patients enrolled in a home telehealth programme in the US experienced a 25 per cent drop in bed days of care and a 19 per cent fall in hospital admissions, with an average cost of $1,600 each, compared to $13,121 for conventional care.

Looking at overall health spending in the US from 1970 to 2009, spending increased by around 9 per cent per annum. This is what you might expect with an ageing population, although the US isn't ageing as fast as some. But here's the thing: in 2009,

2010, and 2011, the average increase was less than 4 per cent. How come? The dire economic situation would have something to do with this, but a Harvard study suggests that structural changes — one of the most important of which is keeping people at home rather than in hospital — were a key component, and this is where digital monitoring and diagnosis comes in.

The end of modern medicine

Wait a little longer, and a visit to the doctor could be to use sensors more powerful than what can be embedded about your person — such as handheld medical tricorders that scan and sense illness (a *Star Trek* favourite).

As for surgery, the shift will be away from invasive procedures apart from childbirth. Before this happens, robotic surgery could become commonplace, and we may see automated robotic surgery without human oversight.

There will also be laboratory-made body parts — skin, kidneys, blood vessels, bladders, and even windpipes — all potentially 3D-printed at your local hospital from personalised specifications.

3D printing has certainly caught the imagination of many, including Lee Cronin at the University of Glasgow, who has fabricated simple chemicals such as ibuprofen using a digital blueprint and a 3D printer. While currently intended for chemists, there's no reason why printers like this can't be used by anybody, as long as the software prevents them from making unsafe or illegal drugs. Lee's team is working on a mass-produced kit to make ibuprofen so that the developing world has access to it via their mobile phones. This sounds crazy, but most drugs are just combinations of carbon, hydrogen, and oxygen, helped with a little corn syrup, glycerol, and paraffin.

OMG, we're all going to live!

Some people are worried. They think that there are too many people on our supposedly small planet. We've been breeding like rabbits for too long, and logic would suggest that any ever-increasing population that consumes a finite supply of resources is heading for trouble.

This argument is as old as the hills, going back to the Club of Rome and the publication of *The Limits to Growth* in the 1970s — and further, to Malthus and his

doomsday forecasts of mass starvation in the 1800s. Yet to say there are too many humans is nonsense.

The reason there are over seven billion people on our planet is not because we've been breeding like rabbits, but because we no longer drop dead like flies. We've experienced a healthcare revolution during the last century, and average human lifespans have almost doubled. To my mind, this is far more a blessing than a curse.

Having more humans does indeed have serious implications for resources, but these can be made secure through careful conservation, proper pricing, regulation, and behavioural change. We can also switch resources. More importantly, the human species is imaginative — that's why we're still here, and more people also means more brains to fix more problems and invent things.

When it comes to food, water, energy, climate change, and other concerns, I'm fairly certain that we will invent our way out of trouble — possibly at the last minute in many instances. We are on the cusp of a series of inventions, especially around energy and agriculture, and these could be transformational.

In the case of healthcare, we will cure many common conditions and extend longevity still further, although the equitable distribution of such gains is in doubt.

As for the future of medicine itself, the overall prognosis is excellent, although we should be careful not to blindly turn to technology as a cure all. An article in the *British Medical Journal* has made the point that the supply of technology drives demand. The more technology exists, the more we'll rely on it, and there is already a problem with the over-diagnosis and over-treatment of perfectly normal human conditions.

Around 50 per cent of the increased cost of healthcare is believed to arise from technology, far outweighing the impacts of ageing populations, rising prices, or increased demand. Tech push is a particularly pernicious problem, which alongside myths such as 'new ideas are always better than old ideas' and 'advanced medicine is always better than simple solutions', causes us to over-prescribe technological cures.

A healthy dose of scepticism

Another major concern is what happens if future medical marvels aren't equally shared. Gordon Moore, the father of Moore's Law, has commented that we now live in two

societies divided by education. What if society is further divided by health? What happens if the rich have access to treatments that the poor don't? This happens already, but I suspect that affordability of care will become a greater issue as societies age and consume more healthcare. For example, at the moment around 35 million people suffer from Alzheimer's, and older patients need expensive care. In the US, more than 25 per cent of Medicare is spent on people in the last 365 days of their life.

By 2050, the number of Alzheimer's patents is forecast to triple. Some observers predict 114 million cases worldwide by 2050, largely due to ageing. Worrying as this is, a scarier thought is that Alzheimer's is a late stage of type 2 diabetes, of which around 270 million people currently suffer. Hopefully, since type 2 diabetes is largely a dietary and lifestyle problem, this can be fixed, especially with some of the new tracking technologies and gamification techniques.

As I've mentioned, rising social inequality can lead to more rapid ageing as immune systems are compromised. In one sense, regenerative medicine — finding ways to repair worn-out old bodies — is a terrific idea, but taken to extremes it will cause problems. At the moment, nobody has had much success extending the human body beyond the current upper limit of around 120 years. Yet if we do, and fertility rates continue to fall, we will inherit societies that are bursting at the seams with older people, with fewer younger people to provide care. Perhaps robotics, for instance exoskeletons (mechanical skeletons wrapped around the human body), will allow ageing populations to remain mobile and independent. But again, who's paying? Maybe it's Google.

It's rather unclear at the moment what Google is searching for, but if recent acquisitions are anything to go by then we are in for interesting times. A few years ago, Google became involved with the longevity business via a biotech start-up called Calico. Google have been buying roughly one company per week since 2010, largely in the areas of search, autonomous devices, robotics, and artificial intelligence. In 2013 alone, Google purchased eight robotics start-ups. Perhaps they are buying these companies to acquire the minds behind them. Or maybe we'll get these technologies for free, but the price we'll pay could be Google knowing everything about us inside and out.

Death as software error

But what of the fortunes resulting from such clever ideas?

One idea is to do away with death. There's a tendency found in high-tech hot spots of people, mainly financially successful men, trying to avoid what's been called the death problem. PayPal co-founder Peter Thiel, for example, says, 'Basically, I'm against it.' Personally, I think death is a good idea. Death has advantages, ranging from generational renewal and wealth transfer to avoiding boredom. If life were unlimited, it would become meaningless.

However, this seems to be a point lost on many digital dreamers. Their longing for the disappearance of death appears to grow from the same philosophy that favours radical transparency and the total removal of regulatory frameworks. A way of achieving the latter could be building floating countries out of reach of legal jurisdictions — what Andrew Keen calls the 'fantasy of secession from the real world'.

One possible future is therefore a world where, if you can afford the payments, your life will be extended even to the point of not dying at all. Aubrey de Grey, a gerontologist who is partly funded by Peter Thiel, thinks this is possible and has even suggested that the first person to reach the ripe old age of 1,000 has already been born. Or maybe not: dying might eventually become a choice we all make, although, if not, we'd presumably have to instead choose not to have children, to avoid overcrowding and resource problems.

Brains in boxes

Yet silicon dreamers' minds stretch further than this. They would like not only to solve immortality, but also to have the chance to crack the most difficult coding problem in the world, namely human consciousness.

To put this into perspective — we cannot currently describe consciousness, so we are a long way off replicating it outside the human body. Some scientists think that consciousness is the drawing together of data: it kicks in when data is networked and becomes more than the sum of its parts.

At the moment, consciousness (the ability to reflect and to think deeply about our own thinking and existential condition) is one way in which humans are different from machines. Consciousness, along with intuition, is not computable.

On the other hand, it may not be essential for consciousness to be located inside carbon-based biochemical neural networks. (God and aliens again?)

I suspect that consciousness is a spectrum and that all animals, even plants, have a level of awareness. However, whether matter is capable of having consciousness, or whether levels of self-awareness could ever be added to machines, is hugely unclear, although some human brains, desperate to turn creator, are trying to do the latter.

The Human Brain Project in Geneva is an attempt, with one billion euros of EU taxpayers' money, to build a silicon brain simulation deep inside a supercomputer. They haven't got very far so far, possibly because they're focused on how humans think as opposed to how humans feel.

Demis Hassabis, the founder of DeepMind, a company bought by Google for $400 million in 2014, is on a similar mission to create artificial-intelligence systems and general-purpose learning algorithms to make machines 'smart'. DeepMind isn't, as far as I'm aware, trying to replicate human consciousness, but is attempting to copy the human brain in a number of ways in order to solve many of the world's most serious problems, including disease.

Hassabis started life as a chess prodigy and became a computer-games designer and neuroscientist, studying parts of the brain associated with memory, navigation, and imagining future events. He is undoubtedly exceedingly smart, and genuinely seems motivated by the idea of making the world a better place. Nevertheless, he seems most at home with logic and efficiency, seeing consciousness and creativity as potential software programs. As he says, 'It's quite possible there are unique things about humans. But, in terms of intelligence, it doesn't seem likely.' In other words, the human mind is a computer.

Peter Thiel and Elon Musk have both put money into DeepMind's AI technologies, which Hassabis refers to as 'neutral in themselves'. This is true, but I'd argue that once any technology comes into contact with humans, they (that is, we) always become something else. Please don't get me wrong — I'm not suggesting that Hassabis is anything other than a nice person. It's just that anyone who's spent from the age of four playing chess, often against adults, might have missed out on something about the human condition. A telling comment he made is that eating, with the exception of eating out, is

wasted time and that he'd be happy if he could just swallow tubes of paste: 'It would be good if there was something more efficient.' (There's that word again.)

Clearly Hassabis has a laser-like focus. Like many in Silicon Valley, he has missionary zeal. But I fear that his key interest concerns efficiency rather than humanity. This seems cold and calculating — I prefer the term 'effectiveness', which can be highly illogical. 'Efficiency' reminds me of a primary-school teacher in Norfolk, England, who closed classroom blinds so that the small children wouldn't be distracted by snowflakes falling outside. As the poet W.H. Davies wrote:

What is this life if, full of care,

We have no time to stop and stare.

Teaching a machine to deal with a logical problem such as playing chess is relatively easy. Teaching a robot kung-fu could be a maths problem. But getting a machine to think about snow slowly falling or wind on the Welsh hills, or to be moved by poetry, is different.

Humans have always adapted. In fact, adaptation is what our species does best. As Susan Greenfield points out, we inhabit more environmental niches than any other species. We have survived ice ages, pandemics, revolutions, wars, and Paris Hilton. We've also augmented our bodies and tools in the face of change. We've created clothing, glasses, guns, and some semblance of security. Our survival will depend on us continuing to do all this and more, and we shouldn't assume that human evolution is over. It isn't. We will continue to evolve, most probably by merging with our machines using bio-electronics. As John Rogers, a materials scientist at the University of Illinois says, 'Bit by bit, our cells and tissues are becoming just another brand of hardware to be upgraded.'

Gaining digital immortality by putting our brains inside boxes may indeed negate the need to eat and would bypass the awkward and inconvenient need to deal directly with other human beings or to inhabit a physical body. Floating digital minds would be free to blast off toward distant galaxies, far beyond any government red tape, where they might spend eternity inventing new forms of Facebook. Given a long enough timeframe, this is a very real risk, so we should focus now on where we're heading as humans and whether or not this is the road we wish to follow.

A thoroughly modern malady

Allow me to end this chapter with a brief discussion of what I see as an emerging epidemic. This epidemic has many causes — demographic, technological, and cultural among them. How we choose to treat it will likely involve technology, although I suspect that using people might be more appropriate.

My fear for healthcare is that we may be going down a slippery slope where we are forgetting the human touch. But this is not the epidemic of which I speak.

The National Health Service in Britain paid for seven million tranquilliser prescriptions in a single year recently to meet growing demand for drugs to ease the debilitating effects of anxiety. Over one five-year period, the number of outpatients treated in hospitals for anxiety quadrupled. This is a tragic state of affairs for a wealthy country.

The clinical psychologist Linda Blair says that technology is exacerbating economic worries because it causes people to be on a permanent state of alert. Digital media especially means that we are constantly threatened by an endless procession of risks ranging from terrorism and automation to impending economic collapse.

Furthermore, rather than technology allowing us to escape into a world of leisure and relaxation, as was widely predicted in the 1960s, it has done the opposite. The idea of the idle rich has been flipped on its head. Nowadays, it tends to be the moderately wealthy that work all hours. Too much leisure now symbolises idleness and unemployment. This is partly because of something called the substitution effect, whereby high wages make leisure expensive.

Digital communications in particular rob us of the opportunity to switch off. When we are always available and constantly sent messages from the time we wake to the time we fall asleep we cannot relax or switch off. This can lead to chronic anxiety about what might happen next. Being constantly bombarded with images of what we ought to achieve also creates constant low-level exhaustion. We fear losing control, especially after we wake up one day to discover that the ideal life we once thought we'd lead won't come true.

We also seem to have become less tolerant of adversity, real or imagined, and need a little something to help us deal with our worries. Thus the use of alcohol, food, or

recreational drugs to enforce or compress relaxation.

Frank Furedi, a sociologist, takes a contrary view. He says that our culture feeds anxiety and encourages sufferers to wear it with pride. It has become fashionable to discuss anxiety at dinner parties. If you are not anxious then there is something wrong with you. He says even children 'medicalise the everyday' and learn how to speak the jargon of anxiety.

Anxiety is a modern problem, a medical definition of which only appeared in 1980, when the authors of the *Diagnostic and Statistical Manual* (DSM) suggested that between 2 per cent and 4 per cent of a population would typically suffer from an anxiety-related condition. Thirty years on and a US report called *America's State of Mind* said that this number had risen to one in six of the population. A more recent study puts the number of people who are severely anxious or deeply insecure at 20 per cent.

One explanation for this is that the pharmaceutical industry is inventing problems to which only it can supply an answer. Another is that, in countries such as the US, anxious people need to be diagnosed with a disease so that insurance companies can pick up the bill for any treatment.

On many levels, anxiety is perfectly normal. Back in the 17th and 18th centuries, anxiety — or 'nervous disorder', as it was known then — was seen as a badge of upper-class sensitivity. Thus poets were allowed to be anxious whereas coalminers were not. There are certainly links between severe anxiety and high levels of creativity. Equally, some people think that some level of anxiety is good because it means that people are more sensitive to the needs of others.

One thing we should be clear about is that anxiety and depression are often assumed to be the same thing, when they are not. Anxiety is usually linked with worry, whereas depression is linked with loss of interest and pleasure. Both could be linked with low moods, especially loneliness, or they could both be caused, one way or another, by uncertainly.

All forms of anxiety can also be linked to wealth, yet not in the way you might expect. For example, a World Health Organisation study in 2002 suggested that 18.2 per cent of US citizens report anxiety in a typical year, but in Mexico the figure is less than half this. The pattern continues with some of the poorest countries reporting the lowest

levels of incidence.

Nigeria, where almost 85 per cent of people lived on less than US$2 per day in 2002, reported anxiety levels of 3.3 per cent. This suggests that anxiety disorders might be the curse of wealth, freedom, and security, or that we worry when we don't have anything to worry about. Some observers, the psychiatrist Vikram Patel for example, dispute this, suggesting instead that anxiety levels are much the same the world over. Nevertheless, I imagine that there is some correlation between anxiety and a world that feels overwhelming or out of control.

Stop the world, I want to get off

One small story I can't forget, and one that I almost started this book with, concerns a retired 89-year-old art teacher and former Royal Navy engineer called Anne, from Sussex in England. A keen environmentalist, Anne decided to end her life in 2014 because she felt that computers had taken the humanity out of human interaction.

People, she thought, were becoming 'robots' addicted to their gadgets, and she couldn't understand why so many people spent so many hours sitting in front of screens. As she put it, 'They say adapt or die. At my age, I feel I can't adapt, because the new age is not an age that I grew up to understand. I see everything as cutting corners.'

Suicide, alongside anxiety, is reaching epidemic proportions.

In the developed world, self-harm has become the main cause of death for people aged 15 to 49. It surpasses heart disease and cancer. In 2010, self-harm killed more people than war, murder, and natural disasters combined and, for middle-aged Americans, rose in incidence by 30 per cent during the first decade of this century.

According to the World Health Organisation, suicide rates have risen by 60 per cent since World War II. Any simple explanation for this will be wrong. It is likely to be caused by a combination of economic, social, and cultural factors. But this epidemic is still not the one I've got in mind.

As I stated earlier: many years ago, Theodore Zeldin told me that loneliness would be the single biggest problem facing humanity in the 21st century. I think he's right.

Forgotten, but not yet gone

If feelings of anxiety can sometimes be normal, what then of loneliness? I suppose the answer to this depends on whether or not you feel human beings are born social or whether you think being social is thrust upon us. Historically, sociability has been the norm, but perhaps this was because there wasn't much alternative. Nowadays, in contrast, it's relatively easy to be alone, either due to demographics or technology.

Declining fertility, shrinking households, and smaller direct and extended families mean that more people will be living alone in the future. Older people, in particular, can expect to live for extended periods without a partner, and even where there is family, it's either becoming more difficult to physically stay in touch or families are choosing not to. Work, too, is fragmenting, with more people working from home or away from shared office spaces. This means less meaningful contact with colleagues. And with medicine and elderly care, as we've seen, the shift seems to be away from human contact.

What the question here really boils down to, and it is a question that is at the heart of this book, is whether or not humans need to be around other people to be happy and healthy. To what degree do humans need physical connection? Some people say that it's non-negotiable, a must-have; it's in our nature, and human nature is invariable. I'm not so sure. I think that human nature has been fixed for a long time, but this could be changing due to changes in our external environment, especially technology. I hope I'm wrong.

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