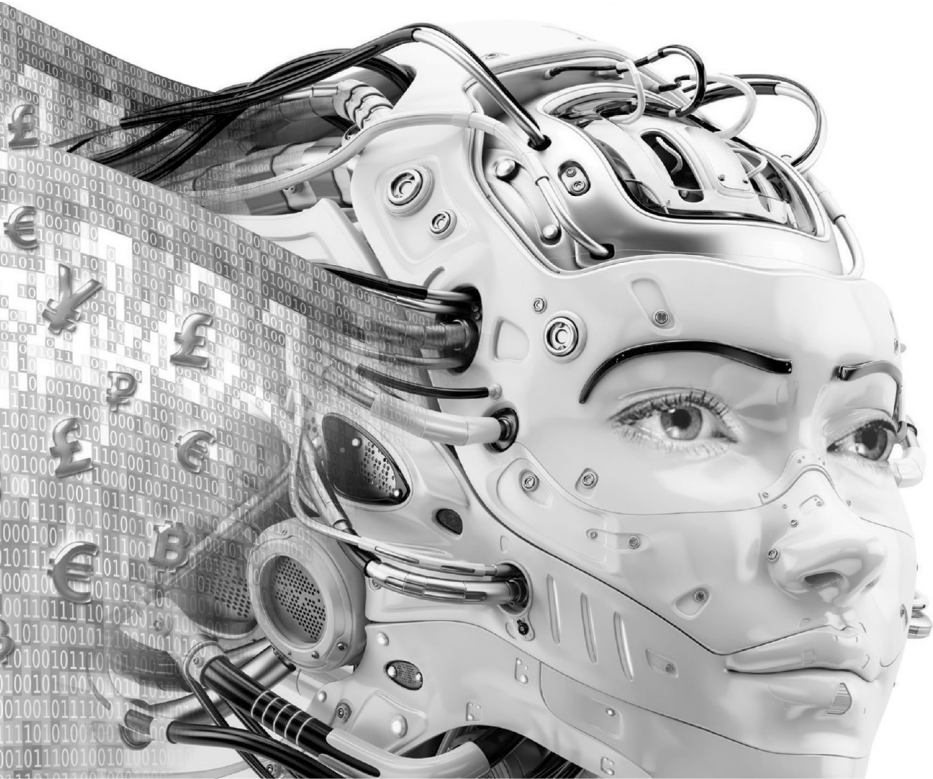


CHAPTER 1



THE REVOLUTIONS OF HUMANITY: DIGITAL HUMANS

The history of money is wrapped up in sex, religion and politics, the things we are told not to talk about. Yet these are the themes that rule our lives, and money is at the heart of all three. The origins of money reflect the origins of humans. As you will see, there have been three great revolutions in human history: we first formed communities, next civilisations and then industry. We are currently living through a fourth great revolution in humankind, with a fifth in the not-so-distant future. And each revolution in humankind, in turn, creates a revolution in monetary and value exchange. That is why it is important to reflect on the past to understand the present as well as forecast the future. To put all of this into context, we need to begin at the beginning and talk about the origins of humans.

THE FIRST AGE: THE CREATION OF SHARED BELIEFS

Seven million years ago, the first ancestors of mankind appeared in Africa. Fast-forward seven million years and mankind's existence is being traced by archaeologists in South Africa where they believe they will find several

missing links in our history. A history traced back to the first hominid forms. What's a hominid, I hear you say?

Well way back when, scientists believe that the Eurasian and American tectonic plates collided and then settled, creating a massive flat area in Africa, after the Ice Age. This new massive field was flat for hundreds of miles and the apes that inhabited this land suddenly found there were no trees to climb. Instead, just flat land and berries and grasses. This meant that the apes found it hard to thunder over hundreds of miles on their hands and feet, so they started to stand up to make it easier to move over land. This resulted in a change in the wiring of the brain which, over thousands of years, led to the early forms of what is now recognised as human.

The first link to understanding this chain was the discovery of Lucy. Lucy, named after the Beatles' song "Lucy in the Sky with Diamonds", is the first skeleton that could be pieced together to show how these early human forms appeared on the African plains in the post-Ice Age world. The skeleton was found in the early 1970s in Ethiopia by paleoanthropologist Donald Johanson and is an early example of the hominid australopithecine, dating back to about 3.2 million years ago. The skeleton presents a small skull akin to that of most apes, plus evidence of a walking gait that was bipedal and upright, akin to that of humans and other hominids. This combination supports the view of human evolution that bipedalism preceded increase in brain size.

Since Lucy was found, there have been many other astonishing discoveries in what is now called the Cradle of Humankind in South Africa, a UNESCO World Heritage site. It gained this status after the discovery of a near-complete *Australopithecus* skeleton called "Little Foot", dating to more than three million years ago, by Ron Clarke between 1994 and 1997. Why was Little Foot so important? Because it's almost unheard of to find fossilised hominin remains intact. The reason is that the bones are scattered across Earth as soil sank into the ground and remains were distributed amongst the porous caves underneath. An intact skeleton is therefore as likely to be found as a decent record by Jedward.

All in all, the human tree of life that falls into the catch-all of the *Homo* species, of which we are *Homo sapiens*, has several other tributaries including *Homo erectus*, *Homo floresiensis*, *Homo habilis*, *Homo heidelbergensis*, *Homo naledi* and *Homo neanderthalensis*. The question then arises: if there were several forms of human, how come we are the only ones left?

Some of that may have been due to changing times. After all, there aren't any mammoths or sabre-toothed tigers around today, but there are several forms of their ancestors still on Earth. Yet what is interesting in the order of hominids, according to Yuval Noah Harari, author of *Sapiens* and a leading authority on the history of humankind, is that *Homo sapiens* defeated all other forms of hominid because we could work together in groups of hundreds. According to his theory, all other human forms peaked in tribes with a maximum of 150 members, about the maximum size of any ape colony, because with this sized group, too many alpha males existed and the order of the group would fall apart. One part of the group would then follow one alpha male and another part the other.

Homo sapiens developed beyond this because we could talk to each other. We could create a rich landscape of information, not just grunts and signs, and began to build stories. By building stories, we could share beliefs and, by sharing beliefs, hundreds of us could work together in tribes, not just one hundred. This meant that when *Homo sapiens* villages were attacked by other *Homo* forms, we could repel them easily. We could also, in return, attack those human forms and annihilate them. And we did. Neanderthals, who share about 99.5 per cent of our DNA, died out 40,000 years ago and were the last *Homo* variation to survive. After that, it was just us human beings, or *Homo sapiens* if you prefer.

Now why is this important as a background to the five ages of man? Because this was the first age. This was the age of enlightenment. It was the age of Gods. It was an age of worshipping the Moon and the Sun, the Earth and the Seas, the Fire and the Wind. The natural resources of Earth were seen as important symbols while the birds of the sky, the big cats of the earth and the snakes of the below were seen as key symbols for early humankind.

We shared these beliefs and stories and, by doing so, could work together and build civilisations. One of the oldest surviving religions of the world is Hinduism but there were other religions before Hinduism in Jericho, Mesopotamia and Egypt. Then the Sun God and the Moon God were the basic shared beliefs, and these shared beliefs were important because they kept order. We could work together in larger and larger groups because of these shared beliefs.

This is why there is a lot of commonality of Old Testament stories in the Bible with that of the Qur'an. Jews, Christians and Muslims all share beliefs in the stories of Adam and Eve, Moses, Noah and Sodom and Gomorrah, and even some of these beliefs originate from ancient Hindu beliefs of the world.

Shared beliefs is the core thing that brings humans together and binds them. It is what allows us to work together and get on with each other, or not, as the case may be. I will return to this theme as the creation of banking and money is all about a shared belief that these things are important and have value. Without that shared belief, banking, money, governments and religions would have no power. They would be meaningless.

THE SECOND AGE: THE INVENTION OF MONEY

So man became civilised and dominant by being able to work in groups of hundreds. Eventually, as shared beliefs joined us, they joined us together in having leaders. This is a key differential between humans and monkeys. For example, the anthropologist Desmond Morris was asked whether apes believe in God, and he emphatically responded no. Morris, an atheist, wrote a seminal book in the 1960s called *The Naked Ape*, in which he states that humans, unlike apes, “believe in an after-life because part of the reward obtained from our creative works is the feeling that, through them, we will ‘live on’ after we are dead.”

This is part of our shared belief structure that enables us to work together, live together and bond together in our hundreds and thousands. Hence, religion became a key part of mankind's essence of order and structure, and our leaders were those closest to our beliefs: the priests in the temples. As man settled into communities and began to have organised structure however, it led to new issues. Historically, man had been nomadic, searching the lands for food and moving from place to place across the seasons to eat and forage. Where we were deficient in our stores of food, or where other communities had better things, we created a barter system to exchange value with each other. The barter trade worked well and allowed different communities to prosper and survive.

You have pineapples, I have maize, let's swap.

You have brightly coloured beads, I have strong stone and flint, let's trade.

Eventually, large cities began to emerge. Some claim the oldest-surviving city in the world is Jericho, dating back over 10,000 years. Others point to Eridu, a city formed in ancient Mesopotamia, near Basra in present-day Iraq, 7,500 years ago. Either way, both cities are seriously old. As these cities formed, thousands of people gathered and settled because the city could support complex, civilised life.

Using Eridu as the focal point, the city was formed because it drew together three ancient civilisations: the Samarra culture from the north; the Semitic culture, whose people had historically been nomads with herds of sheep and goats; and the Sumerian culture, the oldest civilisation in the world. It was the Sumerians who brought with them the earliest form of money.

The Sumerians invented money because their barter system had broken down. It broke down because humankind was settling into larger groups and farming. The farming and settlement structures introduced a revolution in how humankind operated. Before, people had foraged and hunted; now they settled and farmed together.

Farming resulted in abundance and abundance resulted in the trading system breaking down. Barter doesn't work when everyone has pineapples and maize. You cannot trade something that someone already has. So there was a need for a new system and the religious leaders of the time—the government if you prefer—responded by inventing money. From the outset, money has been the control mechanism of societies and economies. Countries that have money have respected economies; countries that don't, don't.

So how did the priests make this new belief viable? Sex. There were two gods in ancient Sumer: Baal, the god of war and the elements, and Ishtar, the goddess of fertility. Ishtar made the land and crops fertile, as well as provided pleasure and love.

This was the key to Sumerian culture: creating money so that the men could enjoy pleasure with Ishtar. Men would go to the temple and offer their abundant crops to the priests. The priests would place the crops in store for harder times, insurance against winter when food was short and against crop failure in seasons of blight and drought. In return for their abundance of goods, the priests would give the farmers money. A shared belief in a new form of value: a coin.

What could they do with this coin? Have sex, of course. The Greek historian Herodotus wrote about how this worked:

“Every woman of the land once in her life [had] to sit in the temple of love and have...intercourse with some stranger... the stranger men pass and make their choice.... It matters not what be the sum of money; the woman will never refuse, for that were a sin, the money being by this act made sacred. After their intercourse she has made herself holy in the sight of the goddess and goes away to her home; and thereafter there is no bribe however great that will get her. So then the women that are tall and fair are soon free to depart, but the uncomely have long to wait because they cannot fulfil the law; for some of them remain for three years, or four.”

So money was sacred and every woman had to accept that she would prostitute herself for money at least once in her life. This is why Ishtar was also known by other names such as Har and Hora, from which the words “harlot” and “whore” originate. It is why prostitution is the oldest profession in the world, and accountancy the second oldest. Money was created to support religion and governments by developing a new shared belief structure that allowed society to overproduce goods and crops, and still get on with each other after barter broke down.

THE THIRD AGE: THE INDUSTRIAL REVOLUTION

The Industrial Revolution can more or less be aligned with the emergence of steam power. While the steam age created lots of new innovations, the one that transformed the world was the invention of the steam engine. Moving from horse power to steam power allowed ships to steam across oceans, and trains across countries. It led to factories that could be heated and powered. The range of transformational moments that emerged during this time culminated in the late nineteenth-century innovations of electricity and telecommunications. With the move from steam to electricity, there was a shift from heavy-duty machinery to far lighter and easier communication and power structures. This shift from factories to offices ultimately heralded the end of the Industrial Revolution.

The use of money as a means of value exchange, alongside barter, has been commonplace for centuries or, to be more exact, about 4,700 years. During this time, beads, tokens, silver, gold and other commodities were used as money. Perhaps the weirdest money is that of the Yap Islands in the Pacific where stone is still used as currency.

The trouble is that stone, gold and silver are pretty heavy as mediums of exchange and vulnerable to attack and theft. Thus, as the Industrial Revolution powered full steam ahead, a new form of value exchange was needed. There had already been several innovations—the Medici bankers created trade finance and the Chinese had already been using paper money

since the seventh century—but none of these went mainstream until the Industrial Revolution demanded it.

To address this need for a new form of value exchange, the governments of the world started to mandate and license banks to enable economic exchange. These banks appeared from the 1600s, and were organised as government-backed entities that could be trusted to store value on behalf of depositors. It is for this reason that banks are the oldest registered companies in most economies. The oldest surviving British financial institution is C. Hoares & Co., created by Richard Hoare in 1672. The oldest British bank of size is Barclays Bank, first listed in 1690. Most UK banks are over 200 years old which is unusual as, according to a survey by the Bank of Korea in 2008, there are only 5,586 companies older than 200 years, and most of these are in Japan.

Banks and insurance companies have survived so long as large entities because they are government instruments of trade. They are backed and licensed by governments to act as financial oil in the economy, and the major innovation that took place was the creation of paper money, backed by government, as the means of exchange.

Paper bank notes and paper cheques were created as part of this new ecosystem in order to make it easier to allow industry to operate. At the time, this must have caused quite a stir. A piece of paper instead of gold as a payment? But it wasn't so outrageous. Perhaps this excerpt from the Committee of Scottish Bankers provides useful insight on why it took off:

The first Scottish bank to issue banknotes was Bank of Scotland. When the bank was founded on 17th July 1695, through an Act of the Scottish Parliament, Scots coinage was in short supply and of uncertain value compared with the English, Dutch, Flemish or French coin, which were preferred by the majority of Scots. The growth of trade was severely hampered by this lack of an adequate

currency and the merchants of the day, seeking a more convenient way of settling accounts, were amongst the strongest supporters of an alternative.

Bank of Scotland was granted a monopoly over banking within Scotland for 21 years. Immediately after opening in 1695 the Bank expanded on the coinage system by introducing paper currency.

This idea was first viewed with some suspicion. However, once it became apparent that the Bank of Scotland could honour its “promise to pay”, and that the paper was more convenient than coin, acceptance spread rapidly and the circulation of notes increased. As this spread from the merchants to the rest of the population, Scotland became one of the first countries to use a paper currency through choice.

And the cheque book? The UK's Cheque & Clearing Company provides a useful history:

By the 17th century, bills of exchange were being used for domestic payments as well as international trades. Cheques, a type of bill of exchange, then began to evolve. They were initially known as ‘drawn notes’ as they enabled a customer to draw on the funds they held on account with their banker and required immediate payment ... the Bank of England pioneered the use of printed forms, the first of which were produced in 1717 at Grocers' Hall, London. The customer had to attend the Bank of England in person and obtain a numbered form from the cashier. Once completed, the form had to be authorised by the cashier before being taken to a teller for payment. These forms were printed on ‘cheque’ paper to prevent fraud. Only customers with a credit balance could get the special paper and the printed forms served as a check that the drawer was a bona fide customer of the Bank of England.

In other words, in the late seventeenth century, three major innovations appeared at the same time: governments giving banks licences to issue bank notes and drawn notes, cheques and the replacement of coins and valued commodities with paper. The banking system then fuelled the Industrial Revolution, not only enabling the easy trading of value exchange through these paper-based systems, but also allowing trade and structure finance through systems that are similar to the ones we still have today.

THE FOURTH AGE: THE NETWORK AGE

The reason for talking about the history of money in depth is to serve as a backdrop to what is happening today. Money originated as a control mechanism for governments of Ancient Sumer to control farmers, based on shared beliefs. It was then structured during the Industrial Revolution into government-backed institutions—namely, banks—that could issue paper notes and cheques that would be as acceptable as gold or coinage, based on these shared beliefs. We share a belief in banks because governments say they can be trusted and governments use the banks as a control mechanism to manage the economy.

So now we come to bitcoin and the internet age, where some of these fundamentals are being challenged by the internet. Let's first take a step back and see how the internet age came about. Some might claim it dates back to Alan Turing, the Enigma machine and the Turing Test, or even further back to the 1930s when the Polish Cipher Bureau were the first to decode German military texts on the Enigma machine. Enigma then led to the invention of modern computing, as British cryptographers created a programmable, electronic, digital computer called Colossus to crack the codes held in the German messages, alongside developments in the United States.

Colossus was designed by engineer Tommy Flowers and was operational at Bletchley Park by February 1944, two years before the American computer ENIAC appeared. ENIAC, short for Electronic Numerical Integrator and Computer, was the first general-purpose electronic computer. It had been

designed by the U.S. Military for meteorological purposes and was delivered in 1946.

When ENIAC launched, the media called it “the Giant Brain”, with a speed a thousand times faster than any electro mechanical machines of its time. ENIAC weighted over 30 tons, took up 1,800 square feet of space and could process about 385 instructions per second. Compared to an iPhone 6 that can process around 3.5 billion instructions per second, this was rudimentary technology. However, we are talking about seventy years ago, and Moore's Law hadn't kicked in yet.

The key is that Colossus and ENIAC laid the groundwork for all modern computing, with this becoming a boom industry in the 1950s. You may think that surprising when, back in 1943, the then president of IBM, Thomas J. Watson, predicted that there would be a worldwide market for maybe five computers. Bearing in mind the size and weight of these darned machines, you could see why he thought that way but, my, how things have changed today.

However, we are still in the early days of the network revolution and I'm not going to linger over the history of computers here. The reason for talking about ENIAC and Colossus was more to put our current state of change in perspective. We are seventy years into the transformations that computing is giving to our world. Considering it took 330 years from the emergence of steam power to the last steam power patent, this implies that there's a long way to go in our transformation.

The main difference between the fourth age and those that have gone before is the collapse of time and space. Einstein would no doubt have a giggle at this, but it is now a fact that we no longer are separated by time and space as we were before. Distance is collapsing every day, thanks to our global connectivity. We can talk, socialise, communicate and trade globally, in real time for almost free. Today, we have almost unlimited storage and connectivity, thanks to the rapidly diminishing costs of technology. As a result, there are \$1 phones out there today, and the cheapest smartphone in the world is currently the Freedom 251, an Android phone with a 4-inch

screen that costs just 251 rupees, around \$3.75, in India. In other words, what is happening in this revolution is that we can provide a computer far more powerful than anything that's come before and put it in the hands of everyone on the planet so that everyone on the planet is on the network. Once on the network, you have the network effect, which creates exponential possibilities as everyone can now trade, transact, talk and target one-to-one, peer-to-peer (P2P).

This is why I think of the network as the fourth age of humanity, as we went from disparate, nomadic communities in the first age; to settlements, farming and cities in the second; to travel across countries and continents thanks to steam power in the third age; and to a world that is connected globally, one-to-one, today. This is a huge transformation and shows that man is moving from single tribes to communities to connected communities to a single platform—the internet.

The importance of this is that each of these changes has seen a rethinking of how we do commerce, trade and, therefore, finance. Our shared belief system allowed barter to work until abundance undermined bartering, so we created money. Our monetary system was based on coinage, which was unworkable in a rapidly expanding industrial age, so we created banking to issue paper money. Now, we are in the fourth age, and banking is no longer working as it should. Banks are domestic but the network is global. Banks are structured around paper but the network is structured around data. Banks distribute through buildings and humans but the network distributes through software and servers.

This is why so much excitement is hitting mainstream as we are now on the cusp of the change from money and banking to something else. However, as in each previous age, the “something else” doesn't replace what was there before. It's added to it. Money didn't replace bartering; it diminished it. Banking didn't replace money; it diminished it. Something in the network age isn't going to replace banking but it will diminish it.

Let's put diminish into context. Barter is still at the highest levels that it has ever been—about 15 per cent of world trade is in a bartering form—but

it is small compared to the monetary flows. Money in its physical form is also trading at the highest levels it has ever seen—cash usage is still rising in most economies—but it is not high compared to the alternative forms of monetary flow digitally and in foreign exchange (FX) markets and exchanges. In other words, the historical systems of value exchange are still huge but they are becoming a smaller percentage of trade compared with the newest structure we have implemented to allow value to flow.

This is why I'm particular excited about what the network age will do, as we connect one-to-one in real time, because it will create massive new flows of trade for markets that were underserved or overlooked. Just look at Africa. African mobile subscribers take to mobile wallets like ducks to water. A quarter of all Africans who have a mobile phone have a mobile wallet, rising to pretty much every citizen in more economically vibrant communities like Kenya, Uganda and Nigeria. This is because these citizens never had access to a network before; they had no value exchange mechanism, except a physical one that was open to fraud and crime. Africa is leapfrogging other markets by delivering mobile financial inclusion almost overnight. The same is true in China, India, Indonesia, the Philippines, Brazil and many other underserved markets. So the first major change in the network effect of financial inclusion is that the billions of people who previously had zero access to digital services are now on the network.

A second big change is the nature of digital currencies, cryptocurrencies, bitcoin and shared ledgers. This is the part that is building the new rails and pipes for the fourth generation of finance, and we are yet to see how this rebuilding works out. Will all the banks be based on an R3 blockchain? Will all clearing and settlement be via Hyperledger? What role will bitcoin play in the new financial ecosystem? We don't know the answers to those questions yet, but what we will see is a new ecosystem that diminishes the role of historical banks. Thus, the challenge for historical banks is whether they can rise to the challenge of the new system.

The fourth age of humanity is a digital networked value structure that is real time, global, connected, digital and near free. It is based on everything

being connected, from the more than seven billion humans communicating and trading in real time globally to their billions of machines and devices, which all have intelligence inside. This new structure obviously cannot work on a system built for paper with buildings and humans, and is most likely to be a new layer on top of that old structure.

A new layer of digital inclusion that overcomes the deficiencies of the old structure. A new layer that will see billions of transactions and value transferred at light speed in tiny amounts. In other words, the fourth age is an age where everything can transfer value, immediately and for an amount that starts at a billionth of a dollar if necessary.

This new layer for the fourth age is therefore not like anything that we have seen before and, for what was there before, it will supplement the old system and diminish it. Give it half a century and we will probably look back at banking today as we currently look back at cash and barter. They are old methods of transacting for the previous ages of man and moneykind.

This fourth age is digitalising value. Banks, cash and barter will still be around but will play a much smaller part of the new value ecosystem. They may still be processing volumes greater than ever before but, in context of the total system of value exchange and trade, their role is smaller.

I don't expect banks to disappear, but I do expect a new system to evolve that may include some banks, but will also include new operators that are truly digital. Maybe it will be the Googles, Baidus, Alibabas and Facebooks or maybe it will be the Prosperers, Lending Clubs, Zopas and SoFis. We don't know yet but if I were a betting man, I would say it will be a hybrid mix of all, as all evolve to the fourth age of humanity.

The hybrid is one where banks are part of a new value system that incorporates digital currencies, financial inclusion, micropayments and peer-to-peer exchange, precisely because that is what the networked age needs. It needs the ability for everything with a chip inside to transact in real time for near free. We're not there yet but, as I said, this revolution is in its early days. It's just seventy years old. The last revolution took 330 years to play out. Give this one another few decades and then we will know exactly what we built.

THE FIFTH AGE: THE FUTURE

Above, I've talked about the main types of money used by people throughout the revolutions in humankind, namely:

- barter
- coins
- paper
- chips

What could possibly be the fifth? When we are just at the start of the Internet of Things (IoT), and building an Internet of Value (IoV), how can we imagine something beyond this next ten-year cycle?

Well, we can and we must. After all, people are already imagining a future beyond today. People like Elon Musk who see colonising Mars and supersmart high-speed transportation a realisable vision. People like the engineers at Shimizu Corporation, who imagine building city structures in the oceans. People like the guys at NASA, who are launching space probes capable of sending us HD photographs of Pluto when, just a hundred years ago, we only imagined that it existed.

A century ago, Einstein proposed a space-time continuum that a century later has been proven. What will we be discovering, proving and doing a century from now? No one knows, and most who predict usually get it terribly wrong. A century ago, people were predicting lots of ideas but the computer had not been imagined, so the network revolution was unimaginable. A century before this, people believed that the answer to the challenge of clearing horse manure off the streets was to have steam-powered horses, as the idea of the car had not been imagined. So who knows what we will be doing a century from now.

What will the world look like a century from now? Well, there are some clues. We know that we have imagined robots for decades, and robots will surely be pervasive and ubiquitous within the next hundred years as even IBM is demonstrating such things today. A century from now, we know

we will be travelling through space, as the Wright Brothers invented air travel a century ago and look at what we can do today. Emirates now offers the world's longest non-stop flight between Auckland and Dubai, lasting 17 hours and 15 minutes. We are already allowing reusable transport vehicles to reach the stars and, a century from now, we will be beyond the stars, I hope.

Probably the largest and most forecastable change is that we will be living for longer. Several scientists believe that most humans will live a century or more, with some even forecasting that a child has already been born who will live for 150 years. Just imagine what that child will see!

The reason why we will live so long is because a little bit of the machine will be inside the human and a little bit of the human inside the machine. The Robocop is already here, with hydraulic prosthetics linked to our brainwaves that are able to create the bionic human. Equally, the Cyborg will be arriving within 35 years, according to one leading futurist. Add to this smorgasbord of life-extending capabilities from nanobots to leaving our persona on the network after we die, and the world becomes a place of magic.

We will have smart cars, smart homes, smart systems and smart lives. Self-driving cars, biotechnologies, smart networking and more will bring all the ideas of *Minority Report* and *Star Trek* to a science that is no longer fiction, but reality. It might even be possible to continually monitor brain activity and alert health experts or the security services before an aggressive attack, such as in Philip K. Dick's dystopian novella *The Minority Report*.

So, in this fifth age of man where man and machine create superhumans, what will the value exchange system be? Well, it won't be money and it probably won't even be transactions of data but, instead, some other structure. Money may no longer be a meaningful system in the fifth age of man. Having digitalised money in the fourth age, it will just become a universal credit and debit system. Digits on the network recording our taking and giving; our living and earning; our work and pleasure.

After robots take over so many jobs, and man colonises space, do we really think man will focus on wealth management and value creation or will

we move beyond such things to philanthropic matters? This is the dream of Gene Roddenberry and other space visionaries, and maybe it could come true. After all, when you become a multibillionaire, your wealth becomes meaningless. This is why Bill Gates, Warren Buffett and Mark Zuckerberg focus on philanthropic structures because money and wealth have become meaningless to them.

So could the fifth age of man—the man who lives for centuries in space—be one where we forget about banking, money and wealth, and focus on the good of the planet and mankind in general? If everyone is on the network and everyone has a voice, and the power of the one voice can be as powerful as the many, will we move beyond self-interest?

I have no idea, but it makes for interesting questions around how and what we value when we become superhumans thanks to life-extending and body engineering technologies, when we move beyond Earth to other planets and when we reach a stage where our every physical and mental need can be satisfied by a robot.