Emerging technologies 01

The world is certainly a smaller, more intricately connected place because of the digital revolution and one also still very much in flux as technologies continue to collide with one another, forming new ones. A recent example of this is the use of machine learning and instant messaging to create 'chat bots', in essence an 'ask and answer' mechanic using instant messaging but also now being used to deliver search results, book tickets and perform other functions in the social and work environments. Many businesses (and technologies) are acting like balloons under pressure – sometimes the balloon bursts and other times (depending on the location and other forces acting on it) it morphs into a new shape. Data is driving a lot of this change – data needs input and input comes from recording what is happening, which requires sensors. With billions more sensors flooding the market over the next five years in devices like smartwatches, phones, cars and household items (commonly known as 'the Internet of Things'), we are about to see entirely new emerging technologies and economies springing up and altering those that already exist. Some of these new technologies will change industries and others will add to existing economies – but not all will disrupt.

Is it emerging or disruptive?

Both emerging and disruptive technologies can be confusing at times. Emerging technologies are referred to as such because they are not yet fully formed and usually never fully develop a final state of being. Social scientists Rotolo, Hicks and Martin (2015) point this out in their description:

> [an emerging technology is] a radically novel and relatively fast-growing technology characterized by a certain degree of coherence persisting over time and with the potential to exert a considerable impact on the socio-economic domain(s) which is observed in terms of the composition of actors, institutions

> and patterns of interactions among those, along with the associated knowledge production processes. Its most prominent impact, however, lies in the future and so in the emergence phase is still somewhat uncertain and ambiguous.

Disruptive technology is a contentious theory with several critics. The main arguments are around when the term should be applied, although as more and more technologies arrive that appear to disrupt, two things become clear – speed and totality are key for true disruption to occur. The speed of the disruption, or rather if the disruption is expected, is key for many; for example, while they are transformative, electric cars have not been truly disruptive because of the way gas companies and other organizations have slowed their progress. In other words, there must be some element of speedy bypassing, upgrading or replacement of the outdated way of doing something. Personally, I feel disruption is disruption whether it happens quickly or slowly but there is merit in the criteria so let's let the nerds have this one.

The second argument surrounds a technology's transformative ability or how much of an old thing a new thing changes and the value this creates. Rather than speed, this, to me, feels like the key criterion for disruptive technology, as Christensen (considered the Godfather of the term 'disruptive technology') puts it:

> The technological changes that damage established companies are usually not radically new or difficult from a *technological* point of view. They do, however, have two important characteristics: first, they typically present a different package of performance attributes – ones that, at least at the outset, are not valued by existing customers. Second, the performance attributes that existing customers do value improve at such a rapid rate that the new technology can later invade those established markets (Bower and Christensen, 1995).

Put another way, disruptive technologies (or at least the ones that iterate on an existing market or company) often discard what people don't like about a business and ramp up what people do like, such as saving money, saving time, being happier, making better choices, being extravagant... the list goes on. Additionally, companies producing the disruptive technology may add in extra desirable elements to further add value to the end user.

A great way of seeing how disruption works and affects established businesses can be seen in a great quote from Tom Goodwin of Havas Media:

> Uber, the world's largest taxi company, owns no vehicles. Facebook, the world's most popular media owner, creates no content. Alibaba, the most

> valuable retailer, has no inventory. And Airbnb, the world's largest accommodation provider, owns no real estate. Something interesting is happening (Goodwin, 2015).

The perfect case study is, of course, Uber. Except it isn't when you look at it deeply. While it has displaced multiple entrenched taxi services around the world, it did not create anything new; it just changed the rules of the existing system. While Uber is now building on its network and pushing into new areas such as delivery of parcels, food and gifts, these are all areas traditionally owned by other massive companies. The days of Uber not meeting significant resistance may soon be over thanks to various new laws and readings of old laws affecting their business model. New services like Uber may provide more validity for applying the disruptive innovation criteria, but currently Uber is simply mislabelled in the eyes of many academics.

A better example of disruptive innovation is Netflix. Initially a DVD (remember those?) mail-only company, Netflix helped dislodge Blockbuster and flipped the video rental business forever. Netflix identified issues that Blockbuster (a physical product-based company) simply weren't handling well; the service took a lot of time, and availability and choice were an issue. Fast-forward a few years and Netflix responded with an online service that offered fast access, affordable service and bandwidth to serve more customers than Blockbuster ever could.

All may not be well in the Netflix camp, as others are now looking to disrupt their business model by creating similar and different models based on the success Netflix continues to see. This highlights the old idiom that seeing and fixing others' problems is easier than seeing and fixing one's own – a valuable insight for many businesses and no doubt for most people reading this book. Looking at someone else's business and 'fixing' it to create something new that enough people want is a core skill in tomorrow's economy. Beyond simply creating new businesses and products, the TBD framework explained later in this book will also help you to identify areas of improvement (or weakness) in your own business before disruptive forces affect the business negatively.

Disruptive technology is not necessarily about killing off old or 'bad' businesses; as we saw earlier, Blockbuster was not a bad business – the company simply failed to move fully with the times and technologies that encroached upon it. Joseph Bower (2002) explains how companies miss this happening:

> When the technology that has the potential for revolutionizing an industry emerges, established companies typically see it as unattractive: it's not something their mainstream customers want, and its projected profit margins aren't

sufficient to cover big-company cost structure. As a result, the new technology tends to get ignored for what's currently popular with the best customers. But then another company steps in to bring the innovation to a new market. Once the disruptive technology becomes established there, smaller-scale innovation rapidly raises the technology's performance on attributes that mainstream customers value.

How do disruptive technologies happen?

We've seen a glimpse into how disruptive technologies come to light but an alternative way to answer this question is to look at creativity and how new things get created. There are three basic ways to create something: copy the thing you want, combine multiple things, or transform something to become the thing you want (you can then apply the other techniques multiple times). As Kirby Ferguson puts it in the excellent 'Everything is a Remix' series (Everythingisaremix, 2015):

> Remix. To combine or edit existing materials to produce something new. These techniques – collecting material, combining it, transforming it – are the same ones used at any level of creation. You could say that everything is a remix.

Disruptive technology can get overly complex, with a lot of detail needing to be ploughed through. However, the technology can also be radically reduced to help us understand it and move forward in a smart and effective way. This reductionist philosophy can be applied proactively or reactively and the theme of clarity through simplicity is one carried throughout this book.

So what disruptive technologies are going to be big deals?

Writing about every technology that will 'blow up', while possible, isn't realistic or necessarily helpful for business leaders. Instead, this book will help you do two things: know more about the big areas and discover a framework that will aid you in evaluating any technology and change to be made to make more strategic bets about the future. However, there are five big bets for disruptive technologies that are important for every business owner and department head to understand beyond simple surface knowledge. Some are

in their infancy (artificial intelligence, nanotechnology), and others are still on the periphery of mainstream culture (blockchain); some remain misunderstood (3D printing) and some, while highly desired, are not quite ready to take any giant leaps forward (holography).

Why were these technologies chosen?

Some of the technologies are software based, others are materials, and some are virtual. Some names will no doubt be familiar to you and others will not be, but none of them are difficult to understand when you reduce the basic elements down. Each of the technologies has been chosen because of its potential likely impact on business and culture at large. Additionally, the technologies explored offer the biggest potential for businesses when it comes to cost savings, product innovation and future-proofing business functionality.

To aid comprehension and the use of the information, each emerging technology has:

- a clear and simple description;
- a brief discussion of why the technology will impact different businesses;
- a predictive timeline of when they will impact different businesses;
- pros and cons;
- an impact score (out of 10) regarding how big an impact it will have on mainstream culture (or life).

The technologies covered include:

- blockchain (the computation behind Bitcoin) and Bitcoin;
- artificial intelligence (and machine learning);
- holography (including virtual reality and augmented reality);
- 3D printing;
- nanotechnology (including graphene).

Impact scores have been assigned to all technologies based on several factors including likelihood of happening, time to disruption, the potential severity of the impact and the length of disruption (amongst other elements).

The timeline to impact is a guide for businesses to use as markers to create changes needed to survive and thrive. 'Consumer' relates to when the average consumer will have greater than surface knowledge of the technology and will probably use it – in some form – in their daily lives. 'Enterprise' refers to the other end of the scale, when businesses will be using (or benefiting most from) the technology.

Blockchain and Bitcoin

Often misattributed as Bitcoin itself, the blockchain is like a public ledger of transactions and is the basic element that underpins (or powers) virtual currency technologies like Bitcoin. Often referred to as 'crypto-currencies' or 'decentralized digital currency' Bitcoin can be used in the real world to buy goods but is primarily used for online transactions in both the light and darker areas of the Web. While the potential for blockchain technology is far from limited to virtual currencies, it is most famous for driving the idea of virtual currencies and is what we'll focus on here.

The simplest element of a blockchain is a 'block'. Blocks are essentially a permanent record of files that hold data about digital transactions. Each time a block is 'full' it gives way to the next block in the blockchain. No one can alter the contents of a block (part of what makes the technology secure) and every block has a highly complex mathematical problem attached to it. Once these equations and calculations are solved (a process called 'mining') using an individual computer's processing power (or series of networked ones) the miner accrues a Bitcoin he or she must keep in a wallet (think bank account). Every time this is done, a new Bitcoin enters circulation. The harder the mathematical problem, the longer it takes to solve, and so the creation of new Bitcoins is somewhat regulated but not in the way the outside world regulates currency.

The blockchain is stored in networks of distributed nodes across the Internet. Each node has a copy of the entire blockchain and as new nodes come and go this secures the chain against issues like poor connectivity, hardware failure or outside forces looking to disrupt the process. In other words, there is no single point of vulnerability, which makes blockchain harder to attack (and less likely to fail) than, say, a centralized banking system owned by one person.

Bitcoin has had a chequered past and, as with a lot of technologies, it saw some darkness before it saw the light, notably being used by unsavoury types on the Deep Web (content that is not indexed on the Web) to buy and sell drugs, guns and other illegal services. Despite there already being pizza shops in New York that have Bitcoin ATMs and coffee shops that accept Bitcoin as payment, the idea of the blockchain is a very technical one that many people and businesses simply do not want to trouble themselves with.

Quick snapshot: Blockchain

What: The underpinning technology of virtual currencies that uses a block to form chains as mathematical problems that are solved by computers across the Internet.

Pros:

- *Flexibility*. Due to their digital nature, it is easy to distribute and transfer money or Bitcoins anywhere in the world at any time.
- *Global*. You don't have to worry about crossing borders, rescheduling for bank holidays, or any other limitations one might think will occur when transferring money.
- *Control*. There is no central authority that controls Bitcoin, so you are totally in control.
- *Secure*. Created to ensure personal information is kept private, blockchain technology activity protects against things like identity theft.
- *Lack of fees*. Both a pro and con – while there are no or very low fees, new services can be created to charge extra (for example, faster processing).
- *Fewer risks for merchants*. Bitcoin transactions cannot be reversed and do not contain personal information, so merchants are protected from fraud.
- *Business in troubled areas*. Due to the blockchain, it could be possible to expand into otherwise dicey areas where it would have been easy to mislead people, because of the way the blockchain is set up. Due to this, Bitcoin could be said to have the potential to transform whole industries – from finance to retail – as dependence on old money hierarchies drops.

Cons:

- *Level of consumer understanding is low*. This is a key area of concern for many – while more money for education will likely in effect benefit everyone, no one wants to spend their own budget educating other people's customers.
- *Level of consumer trust is low*. A key concern to users and creators alike, significant resources can be misspent if companies fail to meet needs of consumers early.
- *Scale*. Growth will likely be slow and hard unless it is adopted by large-scale organizations.
- *Issue resolution*. No system is perfect but since there is no owner, who is at fault if issues arise? Who will sort the problem out? Key considerations for customer service, training and brand reputation management.
- *Volatility*. Blockchain technology, while secure, often means there are limited amounts of coins because of the way it was created. This volatility causes fluctuations and uncertainty and while as time goes on this issue is likely to decrease, businesses will still have to deal with the repercussions.

- *Uniqueness*. Unlike some technologies, Bitcoin and blockchain are hard to grapple with (despite being relatable to currency) and therefore have a higher bar than other technologies like contactless payments and in-app purchases.

Why important? It is not hyperbolic to say that blockchain and the technologies it enables have the potential power to disrupt entire countries. Big banks and corporations have billions invested in maintaining the current state of the financial system but it is when the friction of using Bitcoin and the other technologies reduces that we will really see consumer adoption and larger disruptions occur.

Impact score: Likely = 7. Potential = 10.

(Note: This score is for mainstream life and the average business – naturally (as mentioned above) some businesses will be (or could be) affected more than others.)

Timeline to impact: Consumer = five years, enterprise = two to four years. Adoption may be slow due to the level of education required, the closeness to something of value (people really avoid messing with money) and finally the protection the current system has from multiple powerful (and interconnected) entities.

Artificial intelligence (and machine learning)

If we look at film history – *Chappie*, *Her*, *I, Robot*, *A.I.*, *The Matrix*, *Transcendence*, *Blade Runner*, *Ex-Machina* and of course the dreaded HAL from *2001, A Space Odyssey* – things are not going to end well for humans according to Hollywood. To fully understand the realities of AI you need to do one thing and that is erase everything that Hollywood has taught you or everything you have read about AI. The reality, as you'll see below, is much less advanced than we are being led to believe by the news and the movie studios.

At its simplest, AI is any technology (not just robotics) that aims to emulate intelligent human behaviour by appearing to understand complex content, engaging in natural conversation with people, learning and making 'its' own judgments. The applications of such technology are as far-reaching as they can be unnerving, from cars that drive themselves (autonomous vehicles) and speech recognition (customer service bots) to risk detection and consideration. Besides these useful elements, there is also the ability to process much more information – and create useful outcomes from it – than the human brain is currently able to. The processing element enables

systems to run millions, possibly billions of scenarios and choose the best outcome based on rules we give them. However, it is the sentient nature of such systems that concerns Hollywood producers it seems – rather than being a robot slave, true AI seeks betterment and a focus on awareness beyond simple scenario planning.

Often AI is simply attributed to the loner genius in his basement who stumbles upon sentient intelligence or robots that for some reason develop a glitch in their programming that suddenly gives them human-like awareness. Sadly, the reality is far duller – research is slow, highly technical, siloed and incredibly secretive at the top end of the spectrum as scientists and researchers are often unable to share or learn from other experts because of non-disclosure agreements. Progress is slow and, despite the sensationalist appetite for the technology from some (Hollywood), the reality of a world with sentient robots – barring a breakthrough – is some way into the distance.

However, it would be foolish to ignore AI as being too far in the future to be useful. Facebook has successfully piloted 'M', the helpful service within Messenger that helps book tickets and hotel rooms and answers simple questions but with human oversight. In essence, it is not true AI but a learning algorithm that can then predict things based on this data – this is known as 'machine learning' and evolved from attempts to create AI.

The main goal of the AI field remains firmly general intelligence (which is fairly universally accepted as a long-term goal) over some of the subfields like computational intelligence and machine learning that have goals that are easier to achieve.

Quick snapshot: Artificial intelligence

What: The field of science – not limited to robotics – that handles technology aiming to emulate human behaviour.

Pros:

- *Accuracy*. Due to increased processing capabilities, better decisions can be weighed and then chosen.
- *Human limitations*. Creating smart robots does make sense when we think about the human body and its fragility. In particular, the areas of space and underwater exploration have a lot to gain from the use of AI.
- *Freedom*. Intelligent machines can free us from boring jobs and indeed manage the process. While this scenario may scare some, it will equally excite others as new jobs and opportunities emerge.

- *Smart use of time*. Time is something we as a species can never get back. Thus, creating or utilizing tools that can help us do things more efficiently (GPS, predictive text, virtual personal assistants like Apple's Siri) should be the priority to maximize our time here and the impact we have on the planet.
- *Always on*. Robots and AI do not need sleep as humans do, which could lead to significant productivity gains through maximizing the workable hours in a day.
- *Safer*. AI and robots can complete tasks without feelings, eliminating human error due to boredom or tiredness.

Cons:

- *Cost*. AI is incredibly expensive to create and while maintenance is small, updates and changes will be frequent.
- *Ownership*. Machines are programmable units; without consciousness, the robots do as they are programmed to do, so whoever owns the robots could, therefore, be said to choose – do I use them for good or bad? Hacking is also a real concern.
- *Ethics*. As mentioned briefly above, there is a raft of ethical and legal issues to contend with surrounding the giving of life, slavery principles and numerous other 'what if' scenarios. These are large and robust issues that cannot be ignored when thinking about any element of AI. Each has a book's worth of arguments for and against it and while it is always important to explore such things in detail before large decisions are made, this book's aim is to simplify as much as possible, so these will simply be listed here.
- *Data loss*. Due to the significant reliance on big data, the many possible issues faced by AI programs and robots will mean lengthy downtime and costly offline time to restore data and files.
- *Creativity*. Currently, a machine is a machine, but what if that machine is required to think outside of its programming? What about common sense?
- *Emotional intelligence*. Robots have no souls. Can empathy be programmed? This and more questions besides are considerations for when AI is inappropriate. For example, an AI surgeon may technically be a better doctor but would you want it to give you some life-altering news?
- *Degeneration*. What happens if we use our brains less as a species? What impact would this have on future generations?

Why important? AI is the next evolution of computing and potentially the next wave of humanity – imagine what the world could look like if every decision becomes optimized for the best possible outcome.

Impact score: Likely = 10. Potential = 10.

Timeline to impact: Consumer = three years for full public rollout but limited or low-level functionality; enterprise = two to four years for full rollout but limited functionality; +15 years for mid–full AI due to the level of investment required, the level of secrecy and siloed nature of the field. Additionally, new laws will be required regarding AI along with significant ethical guidelines for its use which will take time to create, agree on and sign into law.

Holography (including virtual reality and augmented reality)

Holography is simply the study or production of holograms. While often confused with tomography, Pepper's Ghost Illusion and volumetric displays, holograms are created using a technique that reads the light from an object and then presents it in a way that appears three-dimensional. It's important to note that the term 'hologram' can refer to both the encoded material and the resulting image – whether static or moving. While it is likely you've seen stickers, security features and images that appear holographic, it is unlikely you've had a jaunt in the Holodeck from Star Trek or a conversation with Princess Leia from Star Wars (although the ability to do both things is tantalizingly close, in laboratories at least).

Recently, holograms have come back into favour within multiple industries, especially music, although these utilize a technique known as Pepper's Ghost, based on an old trick that fools participants into thinking they see a ghost appear out of nowhere by using angled mirrors. This technique has been used recently with Michael Jackson, Tupac, Mariah Carey (and soon potentially Elvis Presley) and although this is not a 3D hologram, these examples are an interesting halfway step to what will one day likely be commonplace.

When you sit back and think about holograms, the issues are many. Beyond simple technical issues, there are multiple problems surrounding the legal use of likeness, distribution rights, fraud and the high costs involved in large-scale images without 3D glasses. In labs in Japan, the technology is being pushed even further with the use of haptic technologies (air pulses, ultrasound) that further extend our experience with holograms as they are not yet physical experiences you can interact with.

Most 3D holograms to date have been relatively primitive when it comes to design although this will change rapidly as more people gain access to the technology and begin experimenting with it.

Quick snapshot: Holography

What: Holograms and volumetric displays.

Pros:

- *Multiple applications*. Holography is a burgeoning field with lots of areas that can benefit from the insights and technology, including terrain modelling, scientific visualization, medical visualization and architectural modelling.

Cons:

- *Expensive*. Currently, the technology required to create holograms and 3D imagery is limited and expensive due to the technology and man hours required.
- *Limited need*. Currently, while there are benefits to using holograms, they are by no means essential. Beyond consumer desire to have Princess Leia-esque messaging, the use cases often do not match the cost or effort required.
- *Time-consuming*. Creating holographic images takes a lot of time due to the multiple processes required and the planning involved.
- *Technical issues*. Due to the physics involved, holograms will never work well in sunlight.
- *Lasers*. Current technology uses lasers to create holograms which, if viewed from incorrect angles, have the potential to damage retinas permanently.
- *Ethics and rights*. Currently, using people's likeness is covered by multiple laws and regulations – holography (especially) after death occurs causes another legal headache for creators and users of the technology.

Why important? Holography, because of its Hollywood portrayals, has been regarded as the holy grail of technology. Whether recorded or live, holography is one technology everyone wants but perhaps isn't sure what to do with it once they have it. True holograms (ie without the aid of a visor or another screen) are a technically challenging arena that can be extremely helpful for things like crime scene visualization or used for entertainment purposes. Both are valid but do not have equal value for society.

Impact score: Likely = 5. Potential = 8.

Timeline to impact: Consumer = +12 years, enterprise = +10 years. The long timelines are due to the technical nature of holography and the current state of the industry. While holograms do exist, current technology limits mean they are rarely seen outside of a laboratory. Beyond this, their practical applications, while not limited by any means, are equally not crucial to our existence – for example, dentists have X-rays and other imaging technologies to which a hologram wouldn't necessarily add more definition or understanding. Beyond these issues, the costs are simply too high currently for a speedy uptake in either the consumer or enterprise sector.

3D printing

3D printing is the process of using a digital file to create a three-dimensional solid. It is often referred to as 'additive manufacturing' as it involves adding layer after layer of material to create the final product. Currently, most 3D print manufacturing is at a somewhat low level, in most cases used for replacement equipment parts or prototyping new designs for trainers.

An easy way to understand the complex process is to imagine a piece of string being folded back and forth focusing on different areas sometimes more than others to create a model of Michelangelo's 'David' from toe to head. The process itself is pretty simple. First, take the design of the object you want to print after it has been digitally rendered by powerful computer programs or by scanning an object with a 3D scanner. The next step is to print the object using a 3D printer. There are several types of printer that use multiple processes but mainly vary the way each of the layers is added. For example, some methods use a melting process to create the 'thread' to create the layers (the most common method) but others use lasers to harden a pool of material instead. The materials that can be used in 3D printing include glass, nylon, wax, silver, titanium, steel, plastic, epoxy resins, wax, photopolymers and polycarbonate, with more announced from universities and laboratories around the world on a monthly basis.

Beyond simple trinkets and replacement parts, 3D printing gets incredibly interesting and cutting, nay bleeding edge, with a large number of fields experimenting with new materials and construction techniques:

- graphene – stronger than steel, graphene is giving a massive headache to the metal industry because of its lightness and strength;
- quick-drying cement is enabling construction firms to 3D print homes in disaster-stricken areas, enabling quicker recovery for communities;
- human cells are being used to create human organs and body parts using 3D printing techniques – a field called bio-printing;

- food has also been printed – fruit, pancakes, pizza, ice-cream, burgers, waffles and chocolate have all been piped into existence;
- drugs are one of the most recent items added to the list of things that can be 3D printed, with epilepsy medication already in circulation.

Quick snapshot: 3D printing

What: The process of creating a 3D physical object from digital blueprints that exist in databases and can be downloaded (if the author gives permission) by anyone, anywhere and anytime.

Pros:

- *Versatility*. As confirmed by the list of materials above and the ones being tested, 3D printing is without doubt one of the most versatile disruptive technologies out there.
- *Intricate*. 3D printing has already achieved standards on a par with traditional manufacturing methods in medical fields and has created prosthetics devices and dental accessories.
- *Prototyping*. The ability to rapidly create examples to be tested before mass production lowers costs and saves time in getting products to market.
- *Green*. Most components utilized by 3D printing offer the same (or superior) safety and stability capabilities as traditionally manufactured components but at a fraction of the weight. Now push this idea up a few levels when using metal in aircraft. The ability to save money and the environment due to requiring less fuel and you start to see why 3D printing is the disruptive force it is.
- *Logistics*. If there are 3D printers in LA and NY you don't need to transport goods between them; simply print one out where it is needed, again saving money and time.
- *Overproduction*. 3D printing is on-demand printing at its core, meaning that you print what you need, saving resources, time and waste. It also means you can print small batches when needed rather than shelving replacement parts in massive (and expensive) warehouses for many years.
- *Customization*. With free designs, low-level entry and increased access to high-level specifications and information, the ability to alter, remix and reimagine increases exponentially. The ability to redesign the latest lamp shape to their own specification is now within the grasp of every consumer.

Cons:

- *Mechanization*. The undertaking of more work by robots has massive implications for the labour industries. 3D printing enables the average consumer to create physical objects that can be used for a wide variety of purposes without the need for specialists, shops, delivery people and many more besides. Beyond this, 3D printing could also bring a fair amount of these jobs home and encourage increasing worker skill levels.
- *Copyright*. Intellectual property and copyright are massive issues in the area of 3D printing, and the law is being slow to catch up. How do designers and manufacturers maintain the value of their goods if a digital file cannot be secured? If a free design is modified and becomes a roaring success, does the original creator see any royalties?
- *New laws need to be created*. Guns have already been 3D printed and have quickly been banned in several states. With all new technologies, making sure people are safe is paramount, but often the law has to run to catch up to the potential (and threats) offered by new technologies.
- *Quality*. While some materials offer superior qualities, not all designs do. Currently, 3D printing designs are shared freely and openly – a great democratizing benefit of the technology – but often quality is simply lacking in the designs.
- *Liability*. What happens when something breaks? Who is liable if anyone can be a producer or manufacturer?
- *Speed*. The big issue with 3D printing is that it is not a quick process, with larger items taking double-digit hours to complete before the additional work – which most items require – can begin. Mass production is still a way off due to the cost of printers – especially the larger units.
- *Cost*. 3D printing is still expensive, and while costs are coming down (both of materials and machinery) it will be a significant number of years before the costs involved will be comparable to traditional manufacturing processes.
- *Control*. If items – especially drugs – can be 3D printed, what happens to the oversight and regulation? What happens to Customs departments when items are no longer transported across borders and oceans?
- *Shipping*. While many analysts predict lower transport costs because of 3D printing in the long term, many predict a rise in closer-to-home transport costs due to items requiring transport from printing hubs or stores.

Why important? The worldwide 3D printing industry is expected to grow to US $12.8 billion by 2018 and exceed $21 billion in worldwide revenue by 2020 (up from $3.07 billion in 2013) (Wohlers, 2015). Due to falling costs, 3D printing technology has the capability to transform almost every major industry (think everything but banking) and change the way we live, work, and play in the future. The most likely outcome is that 3D printing will take its place alongside traditional production technologies, rather than replace them.

Impact score: Likely = 10. Potential = 10.

3D printing is one of those technologies that seems harmless enough until you begin to think about the ramifications for big businesses of people printing replacement parts and making things last longer, let alone what this sort of technology does for developing economies based around manufacturing. 3D printing is unlike all other technologies previous generations have ever witnessed due to the lack of hierarchy required and distributional elements associated with the field.

Timeline to impact: Consumer = +seven years, enterprise = two to five years. 3D printing is already available in a limited format for both consumers and enterprise, but the technology is not mass market yet because of the costs involved, time of production and current materials available. Therefore, the disruption is truly set to come once this peak has been reached.

Nanotechnology

Nanotechnology is all about the small – the ridiculously small in fact. Often referred to simply as 'nanotech', the field derives its name from its scale and relates to the changing of matter at the atomic and molecular level to create new properties and applications.

Fields that are directly working with nanotechnology already include:

- aerospace (new materials, batteries, lighter materials);
- food (better preservatives);
- consumer electronics (scratch-resistant screens);
- energy (cheaper and cleaner sources);
- medicine (faster absorption).

The scale at which nanotech works at is staggering. A pin-head (1 mm diameter) could have a million nanometers laid end-to-end across it, a sheet of paper is about 100,000 nanometers thick and a single red blood cell could have 2,500 nanometers laying across it. The desired outcomes and properties that

result from breaking down and recombining different molecular and atomic elements are – as you might expect – strength (new metals), speed (electric conductivity) and weight (graphene – a super-light new metal) amongst others. Following these new properties is a raft of applications that are as desirable to the military as they are to scientific fields and the business world. Nanotech is already in use in numerous commercial products and processes when products require materials to be lightweight yet strong or with specific properties – think sunscreen, sporting goods and boat hulls for common applications.

Once the realm of science fiction, nanotechnology is about to revolutionize the medical field in particular. The ability to put sensors and diagnostic tools inside the body that send back data to the outside sounds a long way in the future but in fact Phillips recently introduced 'VitalSense', a pill-sized device that continuously monitors a person's core body and skin temperatures without touching the patient. In essence, it is an indigestible device rather than a wearable one. Dentists, opticians and pharmacists are all in some way, shape or form also using nanotechnology, be it to improve absorption, create scratch-resistant coatings or to promote bone growth from surrounding cells.

There is a global arms race (of sorts) happening when it comes to nano research. The United States is the leader, based on the National Nanotechnology Initiative, investing upwards of US $3.7 billion, with the EU investing a third of this and Japan trailing with US $750 million (*India Daily Star*, 2012). Nanotechnologies are estimated to have a global value that will reach US $4.4 trillion by 2018 (Lux Research, 2014).

Quick snapshot: Nanotechnology

Pros:

- *Better attributes*. While stronger, lighter and cheaper doesn't always mean better, it is likely that the flexibility of the nanotechnology properties will improve a wide variety of fields.
- *Impact*. If things last longer, we should be able to buy fewer of them
- *Recycling*. Advanced nanotechnology is currently being researched that will clean up landfills, in essence 'eating' (or molecularly destroying) rubbish – taking recycling to a whole new level.
- *Health*. Internal medicine will be massively affected by nanotechnology. Fields such as nutrition will also likely see benefits, with 'smart' foods that could potentially fight disease or stop ageing. In essence, the nanotechnology is programmed to seek and destroy various ailments.

- *Preemptive*. If nanobots can 'live' inside us, the ability to monitor and combat sickness early increases exponentially.

Cons:

- *Weaponization*. Nanotechnology has the potential to be lethal if turned inwards towards the human body. Issues surrounding the invisibility and programmability of the technology has many concerned in this regard.
- *Human costs*. With nanorobots and self-replicating technology on the horizon, human jobs are under risk as robots can work harder and longer under poor conditions.
- *Health issues*. Nanoparticles used in paint have been found to cause a severe lung disease in paint factory workers recently (Smith, 2009).
- *Environmental effects*. Despite being microscopic, the potential contribution to environmental destruction cannot be understated – especially if self-replication of nanobots (where one nanobot creates other nanobots) becomes a reality.
- *Economics*. Nanotechnology is not cheap and the research is not universally available, meaning intellectual property and skills become a rich area for disruption at a macro and market level.
- *Control*. Any country or business that forges ahead in this area will potentially have a significant advantage over others.

Why important? Despite the highly complex processes and costs involved when creating nanoproducts, the future is bright for nanotechnology. The possibilities when it comes to health and the human body are staggering and continue to drive massive amounts of research into prolonging and improving life. Academics predict the technology will evolve into new areas including being capable of self-replicating (collecting other particles it needs to create more 'nanites') – a theme already picked up on by Hollywood.

Impact score: Likely = 7.5. Potential = 10. The potential for nanotechnologies is impressive because of the versatility at the heart of the technology and the power it offers to business and humankind. While the technology has steep learning curves, costs and implications, it has the potential to revolutionize multiple industries.

Timeline to impact: Consumer = 5–10 years for advanced property consumer nanotechnologies; enterprise = five years. As with 3D printing, nanotechnology is available but has serious cost implications attached that are holding back larger breakthroughs and application in consumer settings. Disruption could occur at any time so make sure to keep an eye on research that is happening in your field.

Conclusion

Each of these technologies represents some of the biggest opportunities and major changes the world will see in the next few decades but none is without issue. Now that we have looked at each of the technologies to understand what they are, what they could become and when disruption will happen, we need to look at the larger landscape. These technologies are constantly changing and colliding into one another. In the next chapter, we will look at the brutal truths behind these technologies, why they are often misunderstood, the barriers to putting them into practice in corporate environments and why bad technology choices undermine customer relationships.

Beyond understanding how technology impacts the customer relationship, Chapter 2 discusses the need for a flexible approach and understanding of these and future technologies. This framework has become known as TBD and isn't set in stone; it is simply a pin to help navigate a route forward. The route will likely change but the key is to have a flexible system to enable you to move forward at all stages.