Journalism, revolutionary technologies and preventing future harm:

Proposing the Flaming Torch Media Ethics Theory and the Ten Tenets Field Guide for responsible and ethical communication on science and technology's cutting edge

by

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DECLARATION

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ABSTRACT

Revolutionary emerging technologies and new scientific discoveries can radically enhance human lives and capabilities, but can also disrupt and harm society – especially if they challenge prevailing world views, established ways of doing things or core human beliefs. And yet, no simple, practical field guide exists for how people, especially science journalists and communicators, ought to talk about technologies and discoveries responsibly so as to limit fear, misinformation and harmful disruption. This study proposes the novel Flaming Torch Media Ethics Theory and its underlying Ten Tenets as the basis for a useful field guide for more responsible, ethical communication of revolutionary technologies and discoveries in the public sphere. A literature review, on key lessons taken from three historical case studies of mass communication efforts relating to the *theory of evolution*, *climate change* and *nuclear energy*, informed the draft version of the theory and its tenets. The theory was then presented, in a set of in-depth interviews, to nine experts from three current emerging technologies – *Bitcoin/blockchain*, *artificial intelligence* and *human gene editing* – to refine the theory and to assess its usefulness. The resulting theory, and the simplified field guide, are presented here. A chief aim was to create a field guide simple enough to be fit for the era of social media, where there is very little control over who communicates what new science or technology to which audience.

Keywords: emerging technology, science journalism, science communication, media ethics, social media, hive mind, climate change, nuclear energy, evolution, artificial intelligence, human gene editing, Bitcoin, blockchain, cryptocurrencies

OPSOMMING

Revolusionêre ontluikende tegnologieë en nuwe wetenskaplike ontdekkings kan menselewens en menslike vermoëns dramaties verbeter en verbreed, maar dit kan ook uiters ontwrigtende en skadelike gevolge op die samelewing hê – veral as dit aanvaarde wêreldperspektiewe, handelswyses of kern-geloofsoortuigings uitdaag. Tog bestaan daar tans geen eenvoudige, praktiese veldgids vir hoe mense, en veral wetenskapjoernaliste en -kommunikeerders, verantwoordelik oor tegnologieë en ontdekkings behoort te praat sodat vrees, wanpersepsies en skadelike ontwrigting verhoed word. Hierdie studie stel bekend die Vlammende Fakkel Media Etiese Teorie en onderliggende Tien Beginsels as die basis vir ’n bruikbare veldgids vir meer verantwoordelike, etiese kommunikasie van revolusionêre tegnologieë en ontdekkings in die publieke sfeer. ’n Literatuurstudie, oor sleutel lesse uit drie historiese gevallestudies van die massakommunikasiepogings rondom ewolusie, klimaatsverandering en kernkrag, het die konsep van die teorie en sy beginsels ingelig. Die teorie is hierna, in ’n stel in-diepte onderhoude, aan nege kundiges vanuit drie huidige ontluikende tegnologievelde – Bitcoin/blockchain, kunsmatige intelligensie (AI) en mensegeen-redigering – voorgelê om die teorie te verfyn en die nuttigheid daarvan te toets. Die gevolglike teorie, en die vereenvoudigde veldgids as ’n uitkoms, word hier voorgelê vir oorweging. ’n Sleutel-doelwit was om ’n veldgids te skep wat eenvoudig genoeg is om toepaslik te wees in die era van sosiale media, waar daar bitter min beheer is oor wie watter wetenskap of tegnologie aan watter gehoor kommunikeer.

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CHAPTER 1

1. Introduction: The media, mass hysteria and mushroom clouds

"One ring to rule them all."

Possibly one of the most famous lines in fiction, taken from J.R.R. Tolkien's *The Lord of the Rings*, might also be the most famous warning about the potential danger associated with the rise of a new technology.

For what is the One Ring other than a device forged with the purpose of greatly increasing the user's abilities and power?

Take away the magic of the rings in Tolkien's Middle Earth, and you're left with a concise, accurate description of technology and its purpose: *knowledge precisely applied to increase ability*. And, of course, those with increased ability have increased power that can either be used, misused in ignorance, or purposely abused.

Following from that, *The Lord of the Rings* can be read as a warning about the perils of technology in the hands of those who misuse and abuse it. Tolkien himself stated as much in a 1956 letter to Joanna de Bortadano, wherein he compares the power of the One Ring with the atomic power made possible by nuclear physics (Carpenter, 1995: 246):

> My story [*The Lord of the Rings*] is not an allegory of Atomic power, but of *Power* (exerted for Domination). Nuclear physics can be used for that purpose. But they need not be. They need not be used at all. If there is any contemporary reference in my story at all it is to what seems to me the most widespread assumption of our time: that if a thing can be done, it must be done. This seems to me wholly false.

This study is concerned with the same peril.

For the purpose of the study, when referring to emerging technologies and new science, what is meant is simply those technologies or scientific discoveries that are still in earlier stages of development or discovery, that have only started to enter mainstream application and public thought, but that have the potential to greatly disrupt human societies (with unknown effects), either by potentially supplanting a widely used existing technology or by providing humanity with brand new abilities or knowledge that often have deeper (and unpredictable) cultural, political, economic, moral or ethical implications.

Emerging technologies and new scientific discoveries can be revolutionary and immensely powerful, and how they could be used ought to be carefully considered, debated and communicated in the public domain in order to decide, with some degree of wisdom, whether a thing that *can* be done, *should* be done.

New technologies and discoveries have, after all, led not only to great human progress, but also great human suffering. Think of the sword and the spear, of gunpowder, the AK-47 and the atomic bomb. Not to mention the massive cultural, political, psychological and social effects that new technologies and scientific advances have had on the world's peoples, empires and history itself. The wheel, the compass, concrete and steel, the mechanised clock, the printing press, the steam engine, antibiotics, antivirals, vaccines, electricity, computing and the internet have all shaped what it means to be human – often through periods of

massively disruptive upheaval from when the technology first appears to when it becomes commonplace.

This study posits that much of the human divisions and conflict surrounding (and due to) such scientific advances have, to a significant degree, often been the result of a *failure of communication* about the scope and limits of a new technology or discovery, how it might have unintended impacts and consequences, and how such knowledge ought to be used.

In this regard, the media, which inevitably is tasked with educating the general public about new science and technologies, and increasingly social media, in which any individual becomes a mass communicator, have a crucial role to play.

In the past, the media has too often (as is shown in the literature review in Chapter 2) failed to prevent the spread of misinformation borne from fear or ignorance or influenced by some hidden agenda. The news and popular media have also often betrayed a 'utopia or apocalypse' relationship with emerging technologies, skewing either toward unrealistic hype about the capabilities of a new technology, or toward conspiratorial, unproven fears about the risks involved.

Think, for example. of the myriad of sci-fi films in pop culture that have had at their thematic core either the amazing utopian possibilities or the apocalyptic horrors that futuristic technologies might present to humanity – *The Matrix* (1999), *Jurassic Park* (1993), *The Terminator* (1984), *2001: A Space Odyssey* (1968), *Gattaca* (1997), *Minority Report* (2002), *Iron Man* (2008), *Avatar* (2009) and many others. Not to mention the smorgasbord of similarly themed novels, comics and television series.

Famous thinkers throughout history, from Albert Einstein ("It has become appallingly obvious that our technology has exceeded our humanity" – Makovsky, 2012) to Elon Musk ("AI is a fundamental risk to the existence of human civilization" – Clifford, 2017) have bemoaned the dangers of unchecked technological progress.

And yet, at the time of writing, there does not seem to be any dedicated theoretical framework or practical guide for science journalists, educators or interested individuals on how to report, write or talk about potentially disruptive emerging technologies in an effective, accurate, responsible and ethical manner so as to limit harm and to ensure technology enhances human progress without causing human suffering. This study is an attempt at such a theoretical basis and a draft version of such a field guide.

The YouTube channel, Lessons from the Screenplay (2018), in discussing *Jurassic Park* (1993) as an example of a film that uses its theme to properly tackle both the good and bad aspects of technological advancement, perhaps explains this goal most succinctly:

> It celebrates the marvels that technology can provide, while also warning of the dangers of irresponsible progress.

That should arguably also be the aim of the media when reporting on potentially disruptive emerging technologies or revolutionary scientific discoveries. To put it in simple terms, this study attempts to answer the question:

How should we, as a society and as a species, talk about new emerging technologies and scientific discoveries in an ethically responsible way, right from the start, in order to prevent harmful consequences to humanity?

Another way to say it is precisely how Prof. Hank Greely, a law professor working on legislation that will influence policy on the controversial topic of human gene editing, has said in a documentary on the issue (Designer DNA, 2019):

> I do the work I do in the hopes that if we think about these things,
> if we worry about them, if we talk about them enough in advance,
> we're a little bit less likely to screw up.

This study presents a new media ethics theory, called the Flaming Torch Media Ethics Theory, and an accompanying field guide so that science communicators of all kinds can – when promising and risky new emerging technologies enter the public sphere – help steer the conversation towards human advancement, and compassion, and away from mass hysteria and mushroom clouds.

1.1 Disruption: From a flat earth to a round earth – and back again

New scientific knowledge and technological advances can have a vast array of disruptive consequences.

Sometimes, especially when a technology is weaponisable, the consequences are obvious and often violent, like nuclear bombs, napalm, sarin or Agent Orange.

Other consequences might be less obvious but no less influential. These include social divisions surrounding the proper use or morality of a new technology (like social media and privacy); costly political conflict due to the shift of power thanks to a new technology (e.g. the space race); similar economic shifts due to technological power (e.g. the Cold war); time wasted on agenda-driven, unscientific public debates (e.g. on climate change); or perhaps, on the smallest personal scale, the persecution of individual activists who are against a certain technology, or the persecution of scientists behind new science and technologies who are often challenging what is thought at the time to be *normal*.

One of the earliest and most famous examples is of Galileo Galilei, a pioneer of modern science, who, after his revelatory assertion proclaiming heliocentrism (that the Earth revolves around the sun, and not the sun around the Earth), was sentenced by the church to house arrest for the rest of his life (Hilliam, 2005:96). Galileo was not by any means the last scientist or technologist to cause a public uproar due to publicising new ideas.

The ongoing open hostility between climate scientists, so-called climate-deniers and the fossil fuel industry is well documented (Bolin, 2007; Hansen, 2009; Oreskes & Conway, 2012). This public debate has at times turned fatal. Environmental defenders, motivated by efforts to stop pollution, hazardous mining, deforestation and other climate-unfriendly, unsustainable practices, have been documented as "dying violently at the rate of about four per week" (Watts & Vidal, 2017).

Conflict between evolutionary biologists and extremist religious groups, especially creationists, is equally well documented (Larsen, 1997; Humes, 2007; Coyne, 2009; Dawkins, 2009; Chappell, 2014). The Darwinian theory of biological evolution (or, at least, the complete misappropriation of the theory of natural selection) also played a role in the rise of Hitler's Nazism, resulting in the Holocaust and the killing of millions of Jews (Bergman, 1999).

More recently, the 2013 intelligence leaks by former NSA analyst Edward Snowden, which exposed several previously secret mass surveillance systems used by the NSA and CIA, is a

powerful example of the disruptive effect of cutting-edge technologies (Gallagher, 2018). In this case, the disruptive value is twofold. First, the surveillance systems in question made it possible for these agencies to spy on and monitor anyone's online activity without their consent or knowledge (Gallagher, 2018). This invasion of privacy could potentially be disruptive to individuals, groups or nations (through the exploitation of sensitive information), and yet the public was unaware of even the existence of such technologies. Second, a global media outcry followed after Snowden had leaked the documents to prove the extent of the surveillance, and this has since caused a re-evaluation and acute awareness of the need for and protection of online privacy (*The Economist*, 2017; Gallagher, 2018).

The negative consequences of technological advancement are of course demonstrated most frighteningly by the aftermath of the discovery of nuclear fission, resulting in the Chernobyl meltdown, Project Manhattan and the bombs dropped on Hiroshima and Nagasaki (Schull, 1995; Bird & Sherwin, 2005) – directly resulting in the deaths of hundreds of thousands.

What is most troubling is that these persecutions, conflicts and atrocities often occur regardless of the veracity of the available scientific evidence, as is the case with anthropogenic climate change and the theory of evolution. The vast majority of scientists have reached consensus that anthropogenic climate change is an indisputable fact (Bolin, 2007; Hansen, 2009; Oreskes & Conway, 2012; Ritchie, 2016), and that the theory of evolution adequately explains the human and animal fossil record (Coyne, 2009; Dawkins, 2009) – and yet, for some, these facts remain unconvincing (Pappas, 2017). This might always be the case, but more responsible communication might limit the influence of misinformed outliers, activists or conspiracy theorists.

In the present era, science – how its resulting technological developments ought to be used, and even the objective facts that result from rigorous, scientific inquiry – is often under attack. As Boon (2018) puts it:

> We live in a 'post-truth' era in which the US President [Donald Trump] tells on average 5.5 lies per day, and attacks the media for publishing 'fake news' – usually news that is critical of him or his government. At the same time, actual false news stories are spreading like a virus via social media and fringe media publications.

Most recently, fake news, pseudo-science and fear-mongering have allowed for the manifestation of pseudo-scientific movements like the so-called "flat-earthers" (Pappas, 2018), who believe the earth is flat, and "anti-vaxxers" (Belluz, 2018), who believe that life-saving vaccines for infants may cause autism, both of which are movements completely based on pseudo-science and which actively reject accepted, evidence-based science. Inevitably, communities in which the anti-vaccine movement has taken hold strongly have been linked with recent (and in some cases fatal) measles outbreaks (Offit, 2008, 2011; Molteni, 2017).

The global COVID-19 pandemic of 2019/2020, perhaps more obviously than any other event so far, has highlighted how viral online misinformation and fake news can damage the effective communication of life-saving science to the public. The World Health Organization (WHO), in a media release issued on 25 August 2020, detailed its efforts at "immunizing the public against misinformation", coining the term "infodemic" to describe an overabundance of information and the rapid spread of misleading or fabricated news, images and videos (World Health Organization, 2020):

> Like the virus, it is highly contagious and grows exponentially. It also complicates COVID-19 pandemic response efforts … Proliferating misinformation – even when the content is, in a best-

> case scenario, harmless – can have serious and even social and lethal health ramifications in the context of a global pandemic. In some countries, rumours about impending food scarcity prompted people to stockpile supplies early on in the epidemic and caused actual shortages. In the United States, a person passed away from ingesting a fish tank cleaning product containing chloroquine after reports mentioned hydroxychloroquine as a possible – yet unproven – remedy for treatment of COVID-19. In Iran, hundreds died after drinking methanol alcohol that social media messages said had cured others of the coronavirus … Even as the world is laser-focused on the search for a safe, effective vaccine, misinformation continues to spread about immunization as well. Health experts in Germany are concerned that the country's anti-vaccination movement may deter many people from getting immunized when a safe vaccine becomes available …

This is all to say that, even as science and technology often advance our knowledge and understanding of, capabilities over and mastery of the natural world – and even though modern technologies like the internet and social media have made possible the proliferation of incredible amounts of useful information – the miscommunication, abuse or misunderstanding of new science and emerging technologies, as well as the proliferation of pseudo-science and fake news, can still be disruptive and dangerous for humanity in a grand variety of ways.

1.2 Rationale: The need for responsible disruption

The implication, when looking retrospectively at the disruptions that have occurred in the past due to new science and technologies, is that the scientists, technologists, engineers, organisations and companies that are actively engaged in the development of *current* emerging technologies should be mindful of the fact that revolutionary technological breakthroughs that seemingly possess great promise for the enhancement of human life might well cause unintended (and perhaps violent) sociocultural, political or economic upheaval if these technologies and their effects are not considered carefully and communicated properly in the public sphere. To this end, the crucial role of science journalists and science communicators becomes obvious.

The hypothesis central to this study is that, by looking at what went wrong regarding the public mass communication of past discoveries and emerging technologies, and by talking in depth to a range of experts and science communicators who are engaging with current, potentially disruptive emerging technologies, a practical field guide can be compiled (based on a novel media ethics theory) to help science journalists, scientists and all other communicators to communicate the promise, dangers and implications of potentially disruptive emerging technologies properly and ethically.

The historical case studies that are examined in the literature review involve the unfolding mass communication efforts surrounding:

i. the theory of biological evolution,
ii. man-made (anthropogenic) climate change, and
iii. nuclear energy.

Each of these discoveries and associated technologies had a profound and disruptive influence on history and humanity.

With regard to current emerging technologies that are showing potential for massive human disruption in the coming years and decades, this thesis specifically examines communication efforts surrounding Bitcoin and blockchain, artificial intelligence (AI) and human gene editing, and how science communicators and experts in these respective fields believe these topics – and emerging technologies in general – ought to be communicated responsibly to the public.

The three current technologies were chosen because humanity finds itself, in the first quarter of the 21st century, at the precipice once again of unprecedented scientific and technological disruption – the scale of which might never have been seen before. This is because these three emerging technologies, each with massively disruptive implications for modern human life, are arriving at just about the same historical moment.

1.3 Disruption guaranteed

1.3.1 Bitcoin, blockchain and cryptocurrencies

Although in many ways still in its infancy (in terms of mainstream adoption), Bitcoin might well be as significant a human development as the internet.

Explaining what Bitcoin is, and why the public should care, has already been difficult for Bitcoin developers, investors and journalists, but a good, cursory explanation was given by Peter van Valkenburgh, director of research at Coincenter, in his address to the Senate Banking Committee in 2018:

> What is Bitcoin? Bitcoin is the world's first cryptocurrency and it works because of the world's first public blockchain network. What does Bitcoin do? It's simple, it lets you send and receive value, to and from anyone in the world, using nothing more than a computer and an internet connection. Now, why is it revolutionary? Because unlike any other tool for sending money over the internet, it works without the need to trust a middleman. The lack of any corporation in between means that Bitcoin is the world's first public, digital, payments infrastructure. And by public I simply mean available to all, and not owned by any single entity. Now, we have public infrastructure for information, for websites, for email – it's called the internet. But the only public payments infrastructure that we have is cash, as in paper money. And it only works in face-to-face transactions. Before Bitcoin, if you wanted to pay someone remotely, over the phone or the internet, then you could not use public infrastructure. You would rely on a private bank to open their books and add a ledger entry that debits you and credits the person you're paying. And if you both don't use the same bank then there will be multiple banks and multiple ledger entries in between. With Bitcoin, the ledger is the public blockchain, and anyone can add an entry to that ledger, transferring their Bitcoin to someone else. And anyone, regardless of their nationality, race, religion, gender, sex or credit-worthiness, can for absolutely no cost create a Bitcoin address in order to receive payments digitally. Bitcoin is the world's first, globally accessible, public money. Is it perfect? No. Neither was email when it was invented in 1972. Bitcoin is not the best money on every margin.

> It's not yet accepted everywhere, it's not used often to quote prices, and it's not always a stable store of value. But it is working, and the mere fact that it works without trusted intermediaries, is amazing. It's a computer science breakthrough. And it will be as significant for freedom, prosperity and human flourishing as the birth of the internet (Finance and Crypto, 2018)

With Bitcoin's creation in 2009, by the pseudonymous Satoshi Nakamoto, anyone on the internet suddenly had access to "an electronic payment system based on cryptographic proof instead of trust, allowing any two willing parties to transact directly with each other without the need for a trusted third party" (Nakamoto, 2008). Ten years later Bitcoin was already widely hailed as "the biggest thing since the internet" (Splend, 2018) and "the decentralized alternative to central banking" (Ammous, 2018).

With the promise of trustless, immutable, secure and instant global transactions with no need for intermediaries, Bitcoin and its underlying blockchain technology has the potential to completely upend the world economy that is run by central banks (Boyapati, 2018).

However, Bitcoin's use as a new store of value and medium of exchange, or so-called 'digital gold', is not the underlying technology's only potential application. Blockchains, or blockchain-inspired technology such as distributed acyclic graphs (e.g. the Tangle system being developed by the IOTA Foundation), is what will most likely make the internet of things (IoT) – which requires automated microtransactions between machines and systems – a practical possibility (Marr, 2018):

> In principle, it makes a lot of sense. IoT is a term used to describe the ongoing proliferation of always-online, data-gathering devices into our work and personal lives. Blockchain is an encrypted, distributed computer filing system designed to allow the creation of tamper-proof, real-time records. Put them together and in theory, you have a verifiable, secure and permanent method of recording data processed by 'smart' machines in the Internet of Things.

Another way that blockchain technology (and Bitcoin itself) might create a technological revolution is through its potential to automate governance. One of the creators of the YouTube channel, ReadySetCrypto (2019), has explained this as follows:

> The way I see Bitcoin and the cryptocurrency space is as an investment in the future, because the technology of a distributed asset ledger combined with the incentive-producing currency is certain to remain with us for some time. These mechanisms allow for great gains and efficiency in many situations in which trust previously had to be delegated to a central arbiter. Although there's no question that governments and central authorities will continue to exist and play a meaningful role in the world's future, much of the current work performed by these governments and other authorities is also needlessly repetitive and mundane. Just as robots and automation are helping the world produce menial physical labour, so too is cryptocurrency helping us build the tools to automate the menial labour of bureaucracy. Optimistically, the entirety of humanity will benefit as a result and that I think is a worthy endgame for any technology.

This is of course the scenario everyone would hope for but, as has already been made clear, the rise of such a technology – which in this case could very well supplant central banks, the

existing fiat-based financial system and governments as we know them – could likely also result in negatively disruptive consequences for humanity (for instance, new emergent power struggles between the custodians and benefactors of the traditional economic systems, such as governments, and the new decentralised systems).

Some of the biggest risks and concerns often voiced in the public domain when Bitcoin and cryptocurrencies are discussed are:

- **Bitcoin's energy consumption:** Bitcoin mining, driven by a proof-of-work (PoW) system that requires competing computers to hash out ever more difficult cryptographic solutions in order to mine the next 'block' in the blockchain, relies on a global network of millions of ever-whirring hard drives that collectively require more electricity than small countries (digiconomist.net/bitcoin-energy-consumption). This has raised concerns over the effect of Bitcoin mining in exacerbating climate change, especially should Bitcoin adoption continue to increase (Huang, O'Neill & Tabuchi, 2021).
- **Bitcoin transparency:** Because it does not require any regulated intermediary, and because transactions can be done anonymously, many are concerned about Bitcoin's (and other cryptocurrencies') potential use for nefarious purposes like tax evasion, ransomware, money laundering, fraud, scams and the like (Iacurci, 2021).
- **Bitcoin's scalability and usefulness as money:** Doubts have been raised over the usefulness of cryptocurrencies as money on a societal scale, chiefly because transaction (settlement) times often can take upwards of 10 minutes, depending on various factors, and transaction fees (especially with Ethereum, currently the most-used cryptocurrency) are still at times exorbitantly high (current average confirmation times and fees available at ycharts.com).
- **Bitcoin's volatility:** The Bitcoin price has reached $20 000, fallen back to $3 000, risen to $65 000 and fallen back to less than $30 000 over five years, and has become known for periods of parabolic rises and steep downturns (Hajric & Greifeld, 2021).

These issues are discussed further in Chapters 6 and 7.

1.3.2 Artificial intelligence

For our purposes, artificial intelligence (AI) is used as an umbrella term for the increasingly 'smart', hyper-connected world of computers, mobile devices, apps, sensors, robots, electronic appliances and cloud servers that are enabling the Fourth Industrial Revolution, or Industry 4.0, and what has been dubbed Web3 (the third major evolution of the internet). Aside from the connectedness (through the internet, WiFi, 5G, Bluetooth, fibre optics, etc.) of the new Industry 4.0/Web3 world, it is the machine-learning capabilities of AI that are the driving force of this new era.

We find ourselves in a new, emerging world of mass automation, big data, and ever smarter machine-learning algorithms that are taking over an increasing number of human tasks, functions and systems.

A World Economic Forum (2016) report estimates that, by 2030, at least 20% of all current occupations will be automated (West, 2018). Millions of jobs will become obsolete as human labour gives way to advanced software algorithms and robotic automation, where all machines become connected to the internet and 'talk' to each other and run large-scale production systems with no human intervention. On the flip side, according to West (2018), many new industries (for instance automated public transport) and new careers (for instance automated taxi 'software mechanics') will also arise as a result.

Many of the world's largest corporations, such as Google, Facebook and Amazon, are furthermore making enormous investments in the development of advanced, human-like AI (Hern, 2016). AI will play a major role in the coming decades, both indirectly – as the enabler of Industry 4.0, and directly – through the development of new digital intellects such as Apple's Siri, Amazon's Alexa and Google's Assistant.

Some of the world's most prominent thought leaders, like Elon Musk and the late Stephen Hawking, have repeatedly issued warnings of what may befall humanity should AI reach the same levels as the modern human intellect (Shead, 2017). Even leaders in the AI space itself, such as DeepMind, have admitted there are significant "risks" with human-like AI projects (Phys.org, 2018). The ethical implications of humanity outsourcing much of its labour, and its thinking, to ever smarter machines present significant and unknown risks. Not to mention the potential use of AI to create autonomous weapons systems, for which there are already a multitude of use-cases, prototypes and working products (Al Jazeera English, 2022).

AI also has a more direct effect on mass communication through the media, with news reports (including fake news) increasingly being 'written' by AI algorithms or 'bots' (Tatalovic, 2018). The use of AI for tailored, user-specific social media posts and online targeted marketing is already ubiquitous.

Science communication is not exempt from the effect of disruptive, emerging AI on the media. Tatalovic (2018) cautions that most science journalists are "woefully unaware" that AI bots (software algorithms) already exist that are able to write and edit the science stories from which they make a living, including turning complex research papers into popular news stories, and that science journalists ought to pay attention to help shape how such bots are used to enhance, rather than hinder, science communication. As a counterpoint, the World Health Organization made use of AI and big data during the COVID-19 pandemic to help dispel fake news and misinformation online (World Health Organization, 2020).

AI will no doubt have a tremendous effect on how humanity develops in the next century.

1.3.3 Human gene editing

At the same time, the emergence of the CRISPR-Cas9 gene-editing technique has made possible the cheap, easy and fast editing of human (and any) genetic material (Thanasis, 2018). This has heralded the dawn of so-called 'designer babies'. Rich parents can now choose the gender, hair and eye colour of their children and will soon be able to edit many other genetic traits (Bennett, 2016). So-called 'bio-hackers' like Josiah Zayner have begun distributing do-it-yourself CRISPR kits for as little as $30 and have made videos instructing people on how to use the technology – even going so far as to inject themselves with CRISPR-Cas9 to alter their own genetics (Quartz, 2019).

The world's first genetically modified babies, two Chinese girls whose DNA was altered before birth by Dr He Jiankui to hypothetically protect them from the AIDS virus, have already been born (Stein, 2019). The announcement was met with enormous criticism from the scientific community, especially after it emerged that the modification may put the two girls at a higher risk of premature death because the mutation might potentially have been linked to an increased vulnerability to the flu (Stein, 2019).

According to Prof. Jennifer Doudna, one of the inventors of CRISPR-Cas9, the gene-editing revolution "is already here", with CRISPR-Cas9 having been discussed in over 15 000 scientific papers (by the end of 2019) and resulting in a "rapidly growing CRISPR economy" (Doudna, 2019). On the potential benefits and pitfalls of CRISPR in the future, Doudna (2019) says:

> There's a possible future where genetic disease is a thing of the past, where we routinely sequence DNA and treat harmful mutations as an outpatient procedure. But we must ensure that in this future, everyone will have access to these new technologies and there's a consensus on rules to regulate whether and how this technology is applied to the human germline. This must come from a collaborative effort that includes increased private and public investment, more commercial partnerships to reduce financial risk and scale the technology, and the political and regulatory nuance to allow widespread affordable access to safe, effective cures without stifling a technology that will underpin the health of future generations.

Even all of this, however, is just the start. The debate about where the ethical line should be drawn, for instance whether or not it would be ethical to create 'superhumans' with increased strength and intelligence, has long since begun (Hiltzik, 2017). The use of genetic editing to 'improve' organisms like crops or livestock, or to end malaria with CRISPR-edited mosquitoes (Molteni, 2018), has given rise to similar debates.

For the first time, humanity has the technology to *completely and permanently alter the human genome*, as well as the genetic makeup of the entire biosphere. This moment might in the future well be called the First Biological Revolution.

The fact that some studies have found that, when CRISPR-Cas9 is used to edit genomes, off-target DNA damage is more common than previously appreciated (*The Economist*, 2018a) is just another example of why the importance of accurate, ethical communication around such a sensitive technology will be increasingly important in years to come.

There is good reason why the YouTube channel, Kurzgesagt – In a nutshell, titled their video on this subject, "Genetic engineering will change everything *forever*" (Kurzgesagt, 2016).

1.3.4 Technology[2]

Each of these technologies on their own could have an enormous effect on humanity. Put them together and the resulting combination might well shape a human reality that is yet quite unfathomable.

Historian Prof. Yuval Harari, for instance, has stated (*The Economist*, 2018b) that the combination of biotechnology and AI may enable some people to become "digitally enhanced", transforming what it means to be human, and that concepts of life, consciousness, society, laws and morality consequently will need to be revised. Whether these and as yet unknown emergent technologies will lead us to a kind of utopia or an apocalypse will be the result of our own choices. And our choices, as a species, will depend on how we talk about such issues in the media and in public.

None of this is meant to paint a picture of doom and gloom of the future of humanity. After all, the mentioned technologies have massive potential to enhance the quality of human life, abilities and health, and hold a lot of promise for a more equal, free and cohesive global society.

But the fact is – as is clear from history – that such advancements are often divisive and can cause great harm among people. That is why it will be of great importance *how* these disruptive technologies are communicated to the public. Scientists, developers, engineers, science communicators and science journalists all have to weigh the probabilities of

advancement versus harm on behalf of society in order to help steer politicians, policy and the public away from one toward the other.

1.4 Objectives: How to communicate disruption

Technological and scientific disruption will inevitably occur as science advances, but how harmful or constructive that disruption becomes depends to a large extent on how we as a society communicate about it.

This study aims to answer the question of what the role of responsible science communicators, of all kinds – from experts to laypersons with huge social media followings – can be and should be in the ethical public communication of potentially disruptive emerging technologies and discoveries in order to limit unnecessary future harm to society and the environment. This has to be done by helping to foster healthy public discourse on such issues.

To answer this question, this study proposes a new media ethics theory and resulting field guide for emerging science and technology communicators. A chief aim of the theory, and especially of the field guide, is to be *as simple as possible*. Firstly, because the literature review (Chapter 2) and the theoretical background (Chapter 3) determined that no such guide currently exists and, secondly (as discussed in detail later), the era of social media has made it possible for anyone to instantly become a science communicator with a potentially massive audience. As such, the theory and field guide cannot rely on potential communicators to have prior knowledge or a scientific or journalistic background. If it should, it would likely not be practically useful or relevant in the social media era.

The exact research methodology is set out in Chapter 4, although in brief: A literature review was done to derive key lessons from historical case studies about the mass communication of three past disruptive technologies and discoveries, namely the theory of evolution, anthropogenic climate change and nuclear energy. These key lessons informed the core principle and tenets for a new media ethics theory – the Flaming Torch Media Ethics Theory – as well as a shorter, more practical field guide for science communicators.

To test this theory, nine experts from the fields of three current emerging technologies, namely Bitcoin and blockchain-technology, artificial intelligence (AI) and human gene editing, were interviewed to comment on the theory in order to improve it and to determine its practical applicability to different science and technology fields. The resulting, improved theory and field guide are presented here as an attempt to enhance public communication efforts to help mitigate the potential harmful effects of new science and technology.

The objective of this study will be to attempt to answer the following core questions:

- What key lessons can be learned from case studies from history – evolution, climate change and nuclear energy – about how the media, in the past, have communicated new scientific discoveries and technologies to the public?
- Can common factors be identified from these key lessons that might inform a media ethics framework on important communication pitfalls that ought to be avoided?
- What do science communicators and experts in the emerging fields of Bitcoin and blockchain, AI and human gene editing believe are the main risks in communicating these technologies to the public?
- Do the communication risks and problems identified by experts and science communicators in these emerging fields correlate with the key lessons identified in the historical case studies?

- What type of media ethics theoretical framework emerges from the lessons taken from the historical case studies, combined with the expertise of current technologists and science communicators in the mentioned emerging fields?
- How can such a theoretical framework inform a simple, practical field guide for the responsible and ethical communication of new scientific discoveries and emerging technologies to be used by science communicators of all kinds?

1.5 Pressing concern

Public confidence and trust in the scientific community as a whole has remained stable for decades, according to US surveys, yet there simultaneously also are wide public divides over science issues like evolution, climate change and nuclear power, according to a survey by the Pew Research Center (Funk & Kennedy, 2017) – and public trust in the *media* has been on a steady decline since 1975, and by 2019 was at an "all-time low" (Funk & Kennedy, 2017).

Tankelevitch (2016) cautions that, to counter poor or sensationalist journalism, science communicators need to focus on the *how* and *why* of science, and Byrd (2018) similarly holds that science is not "broken", but that it is the media's task to educate the public about how science works. It is a complex problem, with O'Malley (2018) warning that any attempt to lump together the doubters of science on the many important science issues and subjects will impair an effective response, because there is no single public that perceives science through a shared lens of experiences and values.

One possible solution might be better public engagement, where journalism is tasked with creating a platform for public debate on new science and technology issues.

Having examined communication on and public attitudes regarding various emerging technologies, Nisbet and Scheufele (2009) emphasise the need for science communication initiatives that are guided by careful, formative research; that span a diversity of media platforms and audiences; and that facilitate conversations with a public that recognises, respects and incorporates differences in knowledge, values, perspectives and goals. Rochman, Shukla, Williams and Hill (2018) argue that more researchers are realising that engagement is a crucial part of their job. Say Williams *et al*. (2018):

> If scientists had engaged more before now, we as a society might not be in the situation where 'alternative facts' exist.

An editorial in *Nature* (2018) states that effective engagement requires a nuanced approach and a willingness to accept uncomfortable truths, which suggests two ambitious models for public engagement (on genetic editing, for example): the first, a global forum whose members push the discussion beyond the technical abilities of genome editing and collect a wide diversity of views about its potential applications; and the second, a large consortium that would break down the idea of one, homogeneous public by investigating the distinctions that exist between different communities, such as farmers' unions and parent-and-toddler groups.

Another possible solution related to public engagement might be a form of civic or activist journalism, where science journalists actively try to steer public conversation away from harmful hyperbolic rhetoric and towards informed, insightful debate in order to create the best possible chance for emerging technologies to advance humanity, and to help smooth over periods of inevitable disruption in a responsible manner. This, of course, raises problems regarding objectivity, which will then also need to be addressed.

Science communicators and journalists are clearly in need of a clear, useful, practical field guide, based on sound media ethics theory as drawn from evidence in the literature and

practice, on how to report on potentially disruptive emerging technologies and new scientific discoveries from as early as possible after they become aware of them.

When fantastical future technologies currently unimagined become reality, the scientists and science journalists of the day should be able to look to this field guide and know what to avoid, and what to do, in order to convey the significance, risks and implications of the disruptive discovery or revolutionary technology properly and responsibly – without causing unnecessary fear, misinformation or harm.

Currently, no such guide exists.

CHAPTER 2

2. Literature review

2.1 Purpose of the literature review

For the sake of clarity, and because the topic in question demands to be examined from several different perspectives, this literature review is divided into two sections.

The first section deals directly with existing literature on the communication of emerging technologies in the mass media and the effects of these communications, and highlights gaps in the research.

The second section deals with the literature on the three chosen case studies, discussing the role of the media, scientists, governments and public figures in communication efforts at the time of the emergence of the theory of evolution, as popularised by Charles Darwin, the emergence of data supporting anthropogenic climate change, and the discovery of nuclear fission, which resulted in nuclear energy and the atomic bomb.

The goal is to arrive at a set of key lessons on how each of the new technologies and discoveries were communicated in the media in the years after discovery or publication, the factors that were involved in how these ideas were communicated, and the effect that such communications had on society as a consequence.

In the review of the literature below, and in the subsequent chapters, there inevitably are many references to the "media", which has become a confounding collective noun. The media is massively diverse. "Media" can mean many different things to different people and covers an endless scope of journalists, editors, content creators and content in an ever-growing multitude of formats, aimed at ever-changing audiences. For the purpose here, the term "media" can be defined and interpreted simply as 'mainstream attempts at mass public communication across the various popular media of the era concerned'.

The three examples were chosen as they illustrate well the potential ills and societal disruption that can result from the framed messages about emerging technologies and scientific ideas in the mainstream narrative. This section therefore serves to provide proper historical context to, and precedent for, the study and the emergent theoretical hypothesis and field guide.

2.2 The effects of communicating emerging technologies in the mass media

Existing research on the mass communication of emerging technologies focuses mostly on the societal effects of such communication, or on how these effects ought to be measured.

Some studies, such as Bauer (1995), MacKenzie and Wajcman (1999), Lee, Scheufele and Lewenstein (2005) and Macnaghten, Davies and Kearnes (2015), have examined the effects of emerging technologies on the public and society, albeit each with a different sociological, cultural or behavioural focus.

Bauer (1995) deftly unpacks a range of causes and effects of social resistance to technology, using a multitude of case studies regarding such resistance across different time periods, nationalities and technologies. Bauer (1995:35-36) concludes that social resistance to new technologies can be seen as "the 'acute pain' of the technological process", and that social systems theory can provide a framework to elaborate the "self-monitoring functions of

resistance", namely that it allocates attention to, evaluates and alters the technological progress in question.

Resistance, according to Bauer (1995:35-36), is primarily "a functional process that is constituted in communication about it; dysfunctions are likely, but are secondary". In this sense, public resistance to new technology might be seen as a natural form of course correction for how technology ought to progress, but Bauer (1995), although making mention of the role of the media in communicating information about new technologies, does not attempt to address how scientists and journalists ought to go about communicating emerging technologies in order to prevent such dysfunctions.

MacKenzie and Wacjman (1999) argue that technology does not only have an effect on society, but is affected at a fundamental level by the social context in which it is developed. This suggests that science communicators who are in tune with the ethical and moral weight of the responsibility associated with conveying information on technologies could, in fact, influence the direction in which the technology develops and help ensure ethical outcomes.

From studying public attitudes to emerging technologies, Lee *et al*. (2005) caution that cognitive and affective influences on public opinion regarding technologies are not distinct and often work in tandem, and that emotional heuristics moderate the effect that knowledge has on people's attitudes about a technology. In other words, knowledge about an emerging technology, no matter how accurate and rooted in evidence, has a weaker effect on the attitudes of people who have a strong emotional reaction to the technology, usually informed by their perceptions of past scientific controversies and their view on science in general (Lee *et al*., 2005).

People who have made up their minds that AI or gene editing or humanoid robotics is inherently 'bad' are therefore not easily swayed – even when presented with sound knowledge. This has obvious implications for science communication and suggests that, in some cases, there is a strong need for the public to be engaged on a deeper emotional level in order to instil rational attitudes to, and informed decision-making on, potentially disruptive technologies. Lee *et al.* (2005:263) state: "Effective public communication and outreach on the part of scientists and governmental agencies, therefore, are more important than ever."

Macnaghten *et al*. (2015:1) examine how public attitudes are formed in relation to the interplay of wider cultural narratives about science and technology:

> A core argument of science and technology studies (STS) is that emerging technologies have potentially far-reaching social consequences and that a certain degree of work (political, cultural and institutional) may be required to ensure their alignment with broader societal values … However, the principle approaches to thinking about public perceptions of new technology – and specifically cognitive social psychological theory on attitude formation – represent a deeply inadequate model of the way in which laypeople make sense of novel technologies.

Going further, Macnaghten *et al.* (2015) identify five recurring narratives (emerging from focus group discussions) that help to explain attitude formation regarding novel technologies, namely "Be careful what you wish for", "Pandora's box", "Messing with nature", "Kept in the dark" and "The rich get richer".

Some of these narratives reveal an ancient fear of "the ills and harms as the product of the transgression of norms and orders" (Macnaghten *et al*., 2015:12). Although this narrative approach is of great value to understand public attitude formation and to guide policy

formulation, it again does not address how science journalists ought to best make use of these narratives in telling new science stories.

Some journalists and researchers have looked specifically at the role of the media and mass communication in the public understanding of emerging technologies. Writing on the research of Binder, Hillback and Brossard (2015), Shipman (2015) discusses how, when news stories highlight conflict in the scientific community on an emerging technology, people who accept the authority of scientists on scientific subjects are more likely to view the emerging technology as risky. Shipman (2015) highlights the risk to scientists (and science) when journalists fail to properly convey the necessary nuance and caveats to research, or purposefully focus on conflicting scientific opinions:

> Previous surveys have found that many people are deferent to scientific authority – they trust scientists – so a reporter's decision to cut nuance or highlight conflict could make a very real impact on how the public perceives emerging technologies.

Binder, Cacciatore, Scheufele and Corley (2010) examine appropriate methods of survey measurement when evaluating public attitudes to science, concluding that researchers in this area must prioritise and revisit notions of measurement in order to accurately inform the general public, policymakers, scientists and journalists about trends in public opinion toward emerging technologies; for instance, that researchers should avoid using single-item measures of complicated judgements when respondents are unlikely to be able to categorise their views correctly (when they perhaps have a limited understanding of the technology in question). In other words, there needs to be room for nuanced views and ambiguity.

Nisbet, Scheufele, Shanahan, Moy, Brossard and Lewenstein (2002) propose a media effects model for public perceptions of science and technology, drawing several conclusions:

- that society's best educated are the least likely to hold reservations about science and new technologies;
- that some forms of media content, like sensationalised television programmes, can do damage to the public perception of science and technology;
- that scientific expertise leads to greater public trust;
- that general television viewing seems to cultivate reservations about science and technology, but that it may also directly promote belief in the promise of science and technology;
- that newspaper use (and other print media) and science television use decrease reservations directly; and
- that policy efforts for public outreach should focus on print media rather than on television.

In the two decades since this study, the nature of media has changed – with a decline in print media consumption in favour of digital media and social media – and it is unclear to what extent these findings still hold.

Studies like that of Donk, Metag, Kohring and Marcinkowski (2011) look at the way that the media frame communications surrounding specific emerging technologies. Focusing on reporting on nanotechnology (as an example of a technology that cannot be directly seen or experienced and on which public opinion is based almost exclusively on information from the mass media) in the German press, Donk *et al.* (2011) conclude that media framing of nanotechnology is overwhelmingly positive, emphasising the medical and economic benefits of the technology, and that there is a lack of critical coverage of this one-sided perspective – which is in line with media coverage observed internationally. This conclusion highlights the

danger of the media focusing too much on the (potentially sensationalised) future benefits of emerging technologies.

All of these mentioned studies are mostly concerned with the effects that emerging technologies, and the communication thereof, have on society, and all seem to confirm that emerging technologies can have a disruptive effect; that the communication and framing of such technologies in the media is important in determining social, political or cultural effects; and that there are different ways of measuring these media effects.

Very little research seems to have been done up to the current writing on exactly *how* science journalists and science communicators practically ought to go about the communication of potentially disruptive emerging technologies and novel science in an ethically responsible manner so as to limit social unease, harm and conflict.

Ethical communication is especially important in the current 'hyper-connected, always-online' era, and most especially at the dawn of the Fourth Industrial Revolution and the inevitably disruptive technologies that will define it.

Kukaswadia (2014), in response to a public television debate between Bill Nye 'the Science Guy' and creationist Ken Ham, states that science communication is "doomed" when it is framed in the form of extreme viewpoints, as is sometimes the case in the media. This is because it causes an 'us vs. them' mentality in terms of which criticism simply results in the consolidation of extreme perspectives, rather than taking in new information on its merit.

Talking about technologies and discoveries in a nuanced, accurate, context-rich, evidence-based, ethically responsible way logically becomes important to avoid fear, misinformation, hype or extreme polarising viewpoints. As the late Stephen Hawking said:

> For millions of years, [hu]mankind lived just like the animals. Then something happened which unleashed the power of our imagination. We learned to talk and we learned to listen. Speech has allowed the communication of ideas, enabling human beings to work together to build the impossible. Mankind's greatest achievements have come about by talking, and its greatest failures by not talking. It doesn't have to be like this. Our greatest hopes could become reality in the future. With the technology at our disposal, the possibilities are unbounded. All we need to do is make sure we keep talking (Associated Press, 2018).

Let us now examine three cases in history where humankind failed, for various reasons, in how it talked about new scientific discoveries and technologies to expose the massive scale of societal disruption that followed, and the lessons to be learned from it.

2.3 Lessons in disruption: Evolution, climate change and nuclear energy

If you want to liven up the conversation in any gathering, perhaps one of the easiest ways to do so would be to ask everyone's opinion on either evolution, climate change or nuclear energy.

All three these scientific concepts continue to fuel intense public debate and, in some cases, even violent activism – even though scientists themselves have mostly reached consensus on the issues. These three topics were chosen precisely because of the strong societal impact that

they have had ever since they first entered the public sphere – impacts that can often be traced back to a breakdown of truthful, transparent, nuanced and responsible communication.

Could some of these harmful societal effects have been prevented if scientists and journalists were better at how they talked about and communicated the science and technology in question? According to the evidence, likely yes.

2.3.1 The evolution of evolutionary thought, in the press and in public

Few books have made as deep an impact on Western civilisation as Charles Darwin's (1859) *On the Origin of Species*. The introduction of the concepts of the transmutation of species and its driver, natural selection, was in many ways a watershed moment in history.

In examining the first public reactions to and communications on Darwin's theories, it becomes clear that many different factors influenced how public discourse and opinion on the subject were shaped, such as the ideas, beliefs, agendas and ideologies of certain prominent individuals, the nature of the press (and its audience) at the time, the nature of news itself, and also the role played by language.

Allen (2014) writes the initial reaction to the publication of Darwin's book was as varied as the sources from which it emanated:

> Responses ranged from those of naturalists, physical scientists, and religious leaders and theologians to social scientists, political activists, historians, and even artists from George Eliot and Fyodor Dostoyevsky to Richard Wagner … The initial reaction, dating between the years 1860 and 1882 (Darwin's death), included numerous scientific critiques, some of which were highly favourable, even if not agreeing with Darwin in all details. Others, however, attacked virtually every aspect of Darwin's theory from his concept of heredity to his insistence on gradualism and including his vagueness about how speciation would actually come about … The general period in the history of Darwinism from 1860 to 1925, then, is one marked by numerous controversies, even as many, at least in the scientific realm, began to reach some sort of resolution by the time of the so-called evolutionary synthesis of the later 1920s and 1930s.

The mainstream press of the time played a major role in steering public opinion away from the radical upheaval just after publication to general acceptance (at least by scientific consensus) from the 1920s onwards (Allen, 2014).

Caudill (1987) conducted a telling content analysis of press views (in the *New York Times* and the *American Journal of Science*, from 1860 to 1925) of Darwin's theory of evolution, and found that interest gradually shifted from "Darwin the man", with him being either championed or lambasted by peers, depending on their scientific and religious stance, to "Darwinism, the theory", when the significance of the theory of evolution eventually came to the fore.

Caudill's research highlights key factors that defined public communication on Darwin's ideas in those early years that are of significance to the communication of any potentially disruptive emerging technology or novel scientific idea, namely the conflict between science and religion; the challenging of the pervasive world view of the time; the events-oriented nature of media coverage; and the fact that the news media favour conflict.

In one of the first American reviews of Darwin's seminal work, *The New York Times* warned in 1860 that Darwin's theory "threatened war" on established religion (Caudill, 1987:782), of which the most prominent battle, according to Caudill (1987:782), would be fought a full 65 years later in Dayton, Tennessee, when John Thomas Scopes was put on trial for teaching evolution in public schools. Caudill (1987:783) notes that, because Darwin's theory was an argument based on observation rather than faith, it initially threatened traditional religious views of the world. Caudill (1987:786) further notes, however, that as time passed, Darwin's ideas were reconciled, by some at least, with Christian principles and that, by 1882, evolution was widely accepted over the idea of the special creation of separate species, even by theologians who once opposed it. As discussed in the introductory chapter, however, this battle is as yet unresolved – due largely to a resurgence of creationism in recent decades.

The about-turn nature of the press coverage of evolution was even more prominent when discussing the changing of the public's world view from 1860 to 1925. Darwin's inductive method of science had a "profound" effect on Western thinking (Caudill, 1987:782) because, when first published, the theory of evolution was "the antithesis to the mainstream way of thinking about species as unchanged and constant across time" (the absolutist, theistic view) (Caudill, 1987:785). Over the next 65 years, the attitude of the press and the public gradually changed – so much so that, by 1925, the year of the Scopes trial, the *Chicago Tribune* decried opposition to scientific discovery, and articles in *The New York Times* were "in complete opposition to the scepticism expressed 65 years earlier" (including, therefore, its own scepticism) (Caudill, 1987:786). Evolution had gone from a "radical idea" to valid scientific theory (Caudill, 1987:786).

Caudill (1987:782) argues that newspapers and magazines are important in assessing the impact of novel ideas and theories on society, because the press [and the mainstream media] is a "major force in disseminating ideas to society". He notes, however, that once in the hands of the press, an idea is subject to a variety of forces, such as institutional norms and definitions of news that affect the form in which the idea is offered to the public:

> Any idea, however noble or humble, intelligent or inane, provincial or universal, is subjected to essentially the same process while the press aims at general readers (Caudill, 1987:782).

To illustrate this, Caudill (1987:783) refers to the "events oriented" coverage patterns exposed by his content analysis of the press of that time, noting that coverage was closely related to specific newsworthy events, such as actual publication in 1860, a visit to America in 1876 by Darwin-defender Thomas Huxley, Darwin's death in 1882, the centennial of Darwin's birth in 1909, state laws against the teaching of evolution in the 1920s, and the Scopes trial in 1925. Although Darwin's theory did not simply disappear from the intellectual landscape in the years in between, higher frequencies of coverage were without doubt correlated to some event that could be used as a news peg (Caudill, 1987:783), suggesting that even the most prominent scientific and technological discoveries are subject to the "news net" that seeks out prominent, headline-friendly events.

Finally, Caudill (1987:946) notes that the press's love of conflict inevitably plays a major role in how novel scientific ideas are communicated to the public:

> … the evolution conflict may have been magnified by the nature of the press with its reliance on action and reaction, whether in events or ideas, especially in the first years after 1859 … Ideas perhaps, cannot be reported well within the framework of typical news standards such as timeliness, proximity and human interest. But one element of news – conflict – emerged as a 'hook' for the news

> stories about evolution and Darwin. In such a way did the public learn about theory. In this case the conflict was science and religion. Even though press opinions about the theory changed in our sample from 1860 to 1925, the press' orientation to conflict did not. Only the conflict changed – from the challenge of evolution to religion, to the challenge of religion to scientific fact. Some battles cannot be finished, at least in the press.

This reaffirms the assertions by Kukaswadia (2014), namely that the media sometimes tends to gravitate toward extreme viewpoints (either for or against), which can pit those of differing opinions against each other when reporting on novel science and technology.

The most exhaustive study on the reception of Darwin's theory in the press was done by Ellegård (1990), who conducted a highly detailed analysis of 115 British newspapers, magazines and journals in the first dozen years after the publication of Darwin's book. Like Caudill (1987), Ellegård (1990) concluded that the conflict between science and religion was the main driver of public debate surrounding the theory of evolution, and that this conflict was sparked when the implications of natural selection for theology and the nature of man became apparent. Indeed, even those authors favourably disposed to the evolution of species were much less enthusiastic about natural selection (Ellegård, 1990:2).

Interesting, too, is Ellegård's (1990) finding that scientific journals were initially much less inclined to cover the theory than was the popular press, probably because scientists "had to overcome a stronger resistance" (Ellegård, 1990:38) before being able to incorporate these ideas into their view of the natural world. Ellegård (1990:6) notes that scientists are also members of the public, influenced like everyone else by political, religious and ideological beliefs, and that these factors influenced their attitudes towards Darwin's theory.

Ellegård (1990:7) posits that the two main effects of Darwin's theory were, firstly, the fact that to the general public Darwinism was "at least as much a religious as a scientific question", which challenged traditional religious and ideological views concerning the history of humankind and the nature of man [and woman]. This colouring of views along religious and ideological persuasions, according to Ellegård (1990:335), meant one did not on the whole disagree with the facts; one disagreed with the *interpretation* of the facts.

A second major effect was on the philosophical basis of scientific inquiry, which was "a necessary preliminary to the emergence of science in our own day" (Ellegård, 1990:7). In his conclusion, Ellegård (1990:332) illustrates that the different levels of knowledge of the different strata of society played a role in how each perceived the theory, but that, in the end, the theory even changed how scientists view the scientific process – the gathering of new knowledge and evidence – itself.

Ellegård (1990:332) notes that only a small portion of those who made public their opinions even had a rudimentary knowledge of the facts on which evolution was based, that attitudes were mostly determined by the established prejudices of the different social groups rather than by factual evidence, that to the uneducated majority the question was simply whether man was descended from Adam or from apes, and that only on the very highest intellectual level was the debate centred on the fundamental problems the theory raised.

At the highest intellectual level, however, there gradually emerged a vigorous debate on the problem of the philosophy of science, wherein natural selection acted as a watershed, separating empiricist Darwinians, on the one hand, from idealistic anti-Darwinians on the other (Ellegård, 1990:334). Because the idealistic position was much more strongly represented amongst the general public (Ellegård, 1990:335), it was not until well into the 20th century that biology, and especially genetics, could establish the theory of natural selection on

a more solid basis and that it became accepted. So, although Darwin's theory had an immediate influence on the general populace's beliefs and ideologies, the full scientific implications took *decades* to be (mostly) accepted. Says Ellegård (1990:337):

> The establishment of an evolutionary view had been virtually achieved among the educated classes before the end of the first decade after the publication of *Origin of Species*. That was the first and most palpable change that the Darwinian theory worked in our outlook on man and the world. But it was not necessarily the most important. Some contemporaries felt keenly, others obscurely, that the extension of purely scientific methods of reasoning to subjects which had hitherto lain outside the scope of science, was the most explosive and revolutionary element in the new doctrine.

The key point of relevance in this regard is the fact that novel scientific knowledge can change the way science itself is perceived and conducted, even if it takes decades for such effects to become clear.

More recently, Lightman (2009) studied not the press views of the time, but the various books published and public lectures given in the USA and Britain from 1860 to 1900 by those (chiefly among the intellectual elite) who wished to popularise evolution. Lightman (2009:6) concludes that Darwin must have been constantly disappointed by the way in which prominent popularisers, even his friends, presented his theory, because evolution was rarely popularised in ways that reflected Darwin's major contribution to biology, namely his theory of natural selection.

This, according to Lightman (2009:6), meant that the reading audience more often encountered an alternative to Darwin's naturalistic, non-directional and non-progressive evolutionary perspective:

> There were at least four different versions of evolution circulating in the period from 1860 to 1900, and only one conformed to Darwin's vision. The results of this study … mirror the conclusion that Ellegård reached in his analysis of the general periodical press from 1859 to 1872. Ellegård found that most journalists were willing to accept evolution, at least for the organic world below humans, but they rejected Darwin's explanation of it.

This serves as further evidence that multiple competing narratives may arise in the media and public discourse following the discovery or announcement of novel scientific ideas or technologies. Given that many of these narratives will inevitably be flawed, biased, warped or inaccurate, it again highlights the potential role of the media and intellectuals to steer public discourse away from misconceptions.

Lightman (2009:20) also acknowledges, however, that these popularisers of Darwinian evolution played a crucial role in making his theory accessible to audiences with different views and beliefs:

> What difference did the popularizations of evolution make? Books written before 1900 by popularizers who were not Darwinians allowed the reader to imagine alternative interpretations of evolution before a scientific consensus started to form around a specific mechanism for the evolutionary process. American and British readers who could not accept the Darwinian version of evolution, with its non-progressive and secular characteristics,

> could turn to Fiske, Wallace, Kidd or Drummond and find in their works an evolutionary vision that satisfied their yearning for meaning. Books by these authors permitted many members of the public to accept evolution, because popularizers linked it to some form of theism, whether written by a Spencerian, by a spiritualist or religious evolutionist or by a Christian evolutionist. Each of these interpretations appealed to a different community of readers.

So, competing narratives in the mass media about emerging technologies or scientific ideas might at once increase both confusion and accessibility.

Although not immediately apparent in the first years after publication of *On the Origin of Species*, mention must also be made of the influence of Darwin's (biological) evolutionary theory on the rise of Social Darwinism, or rather the misuse of Darwin's theories by Social Darwinists – who contend that natural selection must also apply to human social structure.

This misappropriation gave rise to the movements of eugenics, imperialism (as justification for colonialism), a new kind of racism and Nazism, which caused incredible human suffering and has been well documented by Bergman (1999, 2014), Hodge and Radick (2003), Rogers (1972) and Weikart (2004, 2013).

Most of the trouble, according to some, was a consequence of the fact that 'survival of the fittest' – a phrase coined by English biologist and philosopher Herbert Spencer (in *Principles of Biology*, 1864) and not by Darwin himself – erroneously became synonymous with Darwin's concept of natural selection (Rogers, 1972).

Rogers (1972:278) contends that even Thomas Huxley, the fearless defender of Darwinism, believed that the use of Spencer's phrase was most unfortunate:

> The unlucky substitution of 'survival of the fittest' for 'natural selection' had done much harm in consequence of the ambiguity of 'fittest' – which many take to mean 'best' or 'highest' – whereas natural selection may work toward degradation … We commonly use 'fittest' in a good sense, with the understood connotation of 'best'; and 'best' we are apt to take in its ethical sense. But the 'fittest' which survives in the struggle for existence may be, and often is, the ethically worst.

Spencer had used the phrase to describe the beneficial effect of population pressure on human society, whereas Darwin used the term only to describe biological progress (Rogers, 1972:278). Nevertheless, the apparent misappropriation stuck, leading many to legitimise their own ideas about society and what (or rather who) constituted 'more evolved' humans:

> The term, Social Darwinism, was extremely unfortunate because it linked Darwin's theory of natural selection with various theories of human social evolution for which Darwin was in no way responsible. Moreover, the so-called Social Darwinists were not even consistent Darwinists. They combined Darwin's theory of biological progress among animals and plants with [Thomas] Malthus' concept of a struggle for existence in human society. Although their resulting doctrine of inevitable human social progress (Spencer's 'survival of the fittest') contradicted both Malthus' and Darwin's views on human society, the Social Darwinists preferred to see their doctrine as a necessary consequence of Darwin's scientific theory. For those who could

> not distinguish between biological and social evolution, Darwin's theory offered the public authority of science by which they could attempt to legitimatize their private vision of human progress (Rogers, 1972:280).

It is worth noting, however, that others do not feel Darwin was necessarily as innocent or misunderstood in this regard. Milam and Seth (2021) argue that Darwin explicitly drew upon the social mores of his age, naturalising Victorian assumptions concerning class, race and sex. Rose (2009) feels even stronger:

> Any attempt to separate a 'good' Darwin from a 'bad' Social Darwinist cannot be sustained against a careful reading of Darwin's own writing (Rose, 2009:298).

Nevertheless, this appropriation, whether intended or unintended, had severe consequences for humanity. In its most extreme form, the Social Darwinist conception contributed directly to the rise of Nazism, as studied by Weikart (2013:552), who concludes that:

> Nazi racial ideology – and the many policies based on it – were profoundly shaped by a Darwinian understanding of humanity. Certainly many non-Darwinian elements were synthesized with Darwinism: Aryan supremacy, anti-miscegenation, antisemitism, and many more. Nonetheless, Nazi racial ideology integrated all these factors into a worldview that stressed the transmutation of species, the evolutionary formation of the human races, the need for advancing human evolution, the inevitability of the human struggle for existence, and the need to gain *Lebensraum* to succeed in the evolutionary struggle.

According to Weikart (2013:552), the Nazi regime's policies were aimed at one supreme goal: "improving the human species biologically, i.e., advancing human evolution."

The development, therefore, of Darwin's theory of natural selection into the Social Darwinist conception of what is meant by 'survival of the fittest' contributed directly to the Holocaust, one of the worst ever incidents in human history. This plainly highlights the role of language (intended or unintended) in mass communication, and the role of scientists, journalists and any communicators of fame and authority, to ensure that new science and new technologies are conveyed with ethical sensitivity in the public sphere.

At the end of this literature review (2.4), Table 1 compares the key lessons – supported by the evidence presented here – from how evolution, and also climate change and nuclear energy, were historically communicated to the public by the mass media of the time, and the relevant consequences thereof on society.

To arrive at such a comparison, we next turn to the mass media's gradual conceptualisation of anthropogenic climate change.

2.3.2 When the climate changes faster than minds (or science) can

The idea that humanity's continuous burning of fossil fuels (and the subsequent release of carbon dioxide) could warm the atmosphere to such an extent that it affects our global climate was first proposed by Swedish scientist Svante Arrhenius in 1896 (Weart, 2012). And yet it was only in 2017, a full 121 years later, that scientists reach a claimed "100% consensus"

(Powell, 2017:183) that anthropogenic climate change is indeed occurring at a rate that poses an existential risk to humanity.

Over the last century (and more), a veritable tsunami of scientific evidence in support of man-made global warming has gradually emerged to vindicate Arrhenius and the many climate scientists who followed in his footsteps (Le Treut *et al*., 2007; NASA, 2020; The Royal Society, 2020). The veracity of daunting climate predictions are also drawn into question less and less (Simon, 2018), to the extent that prominent world leaders who still seem in doubt, such as former US president Donald Trump (Leber, 2020), have become increasingly maligned.

Says Powell (2017:184):

> Denialists have long run out of excuses for inaction and humanity has almost run out of time.

So, why did it take such a long time for such an important scientific discovery – with potentially massive, planetary repercussions – to be accepted? In a word, complexity.

What most confounded effective communication on climate change was the extreme complexity of climate science (Weart, 2012):

> [Even by the 1970s and 80s] the only thing most scientists agreed on was that they scarcely understood the climate system, and much more research was needed … Earlier scientists had sought a single master key to climate, but now they were coming to understand that climate is an intricate system responding to a great many influences … Apparently the climate was so delicately balanced that almost any small perturbation might set off a great shift.

To understand this complexity it is necessary to look briefly at the history of climate science.

Without a complete recounting of the exhaustive historical events surrounding the field of climate science, which others have already done in admirable detail (Weart, 2012; Mason, 2013; Mann, 2018), a very brief (and vastly incomplete) summarised timeline of the evolution of the climate debate already shows the myriads of complex issues that had to be overcome to get to a point of general acceptance:

1896: Svante Arrhenius figures out that an increase in the amount of carbon dioxide in the atmosphere would result in a certain amount of warming, but because the warming was calculated as 5°C to 6°C over the span of many centuries, it was mostly seen as a scientific curiosity.

Early 1900s: A poor understanding of the absorption of heat and light by carbon dioxide and water vapour in the atmosphere, and faulty experiments, leads to scepticism and the general scientific dismissal of Arrhenius' work.

1938: The English steam engineer and amateur meteorologist, Guy Callendar, discovers a warming trend in the early 20th century and ascribes it to the levels of carbon dioxide in the air, which had increased by some 10%. Most scientists, however, discount the research, believing that warming would simply increase cloudiness, and the extra carbon dioxide would be absorbed by the increased water vapour over time.

Post-1945: Cold War research, due to the importance of atmospheric processes in military terms, leads to an upsurge in climate science research, and more sensitive modern equipment determines that earlier experiments on carbon dioxide and the absorption of infrared light (heat) in water vapour had been wrong.

Mid-1950s: The advantage of the calculating power of computers finally makes it possible to dissect each layer of the Earth's atmosphere and work out how it might absorb infrared radiation. Physicist Gilbert Plass determines that, at 1950s' emission rates, a warming of 1.1°C per century could be expected. Again, it is falsely assumed by many scientists that, over time, clouds and oceans would absorb the extra carbon dioxide.

The era of nuclear testing and its by-products, unstable carbon isotopes, leads chemist Hans Seuss and oceanographer Roger Revelle to determine that the buffering effects of certain chemicals in seawater would place a strict limit on the amount of carbon dioxide the oceans could actually absorb – a crucial discovery. With new models, Swedish meteorologists Bert Bolin and Erik Eriksson project a 25% increase in atmospheric CO_2 by 2000.

1957: Revelle's colleague, David Keeling, sets up the first continuous monitoring of CO_2 levels in the atmosphere. Keeling soon finds a regular year-on-year rise.

1967: The first computer model that simulates the entire planet's climate is developed by Syukuro Manabe in collaboration with Richard Wetherald. Though basic, it found that, if the amount of CO_2 doubled, global temperatures would rise by some 2°C. Their model is also the first to take into account the important role of convective updraughts, which were largely ignored before.

1970s: S. Ichtiaque Rasool and Stephen Schneider of NASA model the effects of pollution in the form of aerosols and sulphur emissions in the atmosphere and discover that a significant increase in such pollution could – possibly – lead to a cooling episode. The findings lead a small minority of scientists and a larger number of commentators to muse over a new ice age. The dramatic nature of the claim receives a lot of media attention – causing much confusion over previous claims of global warming.

Computer models keep improving, and the drilling of ice cores (containing ancient atmospheric bubbles) in the Greenland and Antarctic ice caps becomes an important branch of research into the climate of the past. Ice cores put the focus on feedback, such as melting permafrost.

1980s: Scientists finally gain an understanding of the global carbon cycle: the realisation was that, throughout geological time, the levels of carbon dioxide and other non-condensing greenhouse gases had exerted major controls on the planetary temperature. Carbon dioxide had sources and sinks, but every now and then there were major upward or downward swings as unusually powerful sources or sinks dominated the picture.

Reconstructions of ancient hothouse periods reveal that the rate of fluctuations in atmospheric carbon dioxide levels in the past in many cases appeared to have been at a snail's pace compared to recent increases – and present levels continue to go up exponentially.

1988: The realisation that rapid environmental changes (over tens of thousands of years) were often accompanied by mass extinctions helps lead to the first Intergovernmental Panel on Climate Change (IPCC) – a century after the 'discovery' of global warming. It is also the hottest year since records began.

1990s–present: Models and data keep improving, and evidence mounts for potentially catastrophic anthropogenic global warming. But also, well-funded politically backed bodies promoting opposition to climate science, such as the Information Council on the Environment in 1991 and others (funded, for instance, by the American Petroleum Institute), emerge. Hereafter, into the 21st century, global warming and climate change become political "trench-warfare" (Mason, 2013), with the media playing a major role in the dissemination of climate-related information – and misinformation.

Because climate science is so complex, involving aspects from various scientific fields – meteorology, geology, oceanography, marine biology, chemistry, botany, astronomy, etc. – and because in many cases the science had to wait for technology to catch up (to produce accurate enough data and measurements), it took a very long time for the concept of climate change to properly enter the arena of public discourse. Says Weart (2012):

> It is an epic story: the struggle of thousands of men and women over the course of a century for very high stakes. For some, the work required actual physical courage, a risk to life and limb in icy wastes or on the high seas. The rest needed more subtle forms of courage. They gambled decades of arduous effort on the chance of a useful discovery, and staked their reputations on what they claimed to have found. Even as they stretched their minds to the limit on intellectual problems that often proved insoluble, their attention was diverted into grueling administrative struggles to win minimal support for the great work. A few took the battle into the public arena, often getting more blame than praise; most labored to the end of their lives in obscurity. In the end they did win their goal, which was simply knowledge.

Also, due to the complexity and (for a long time) obscurity of climate science, the mainstream media took a very long time before any significant attention was paid to the issue. When it did, the media were often out of their depth, erring on the side of sensation:

> The mass media (to the limited extent they covered the issue) were confused, sometimes predicting a balmy globe with coastal areas flooded as the ice caps melted, sometimes warning of the prospect of a catastrophic new ice age (Weart, 2012).

Another aspect to consider is the fact that, before science was able to sufficiently prove global warming, the vast majority of people (including the media) had a very hard time believing that mere human beings could ever have an impact on something as vast as nature, the weather and, indeed, the planet. "The idea," says Mann (2018) "seemed absurd on its face."

Climate change only became mainstream on 23 June 1988 (the year of the first IPCC and the hottest year up to that point), when NASA researcher James Hansen testified before the US Senate about its potential effects (Mann, 2018):

> Hansen's stark words sparked headlines across the world. *The New York Times* put his charts on page one, and he appeared on a dozen

> television shows. Suddenly the parched fields, forest fires, and sweltering cities added up to a coherent pattern – harbingers of a dystopian future. Adding to the furore, journalist Bill McKibben published in 1989 the first popular account of climate change, *The End of Nature*, a worldwide best-seller despite its ominous title. More importantly, scientific research took off. Before 1988 peer-reviewed journals had never published more than a score of articles in a given year that contained the terms 'climate change' or 'global warming.' After 1988 the figure climbed: 55 in 1989; 138 in 1990; 348 in 1991. By 2000: 1,340. In 2015 it was 16,576.

Ever since then, the media have played an increasingly important and often controversial role in how the issue of global warming is viewed, discussed and used (politically) in the public sphere.

The 2007/2008 Human Development Report of the United Nations Development Programme (UNDP) included a comprehensive survey of the role of the media in informing and communicating climate change, and how media coverage shaped discourse and action "in complex, dynamic and non-linear ways" at the interface of climate science and policy (Boykoff & Roberts, 2007). The report is based in part on explorations of newspaper coverage in 40 English-language newspapers in 17 countries across five continents. It details the gradual increase in media coverage during the 20th century into the early 21st century, and the various factors that influence discourses on climate change in the media. It serves as a useful basis for an exploration of the historical communication of climate change in the mass media.

Boykoff and Roberts (2007) confirm there were only "rare instances" of media coverage of climate science in the 1930s to 1950s, and "scant newspaper, radio and television news coverage" of anthropogenic climate change and global warming in the 1960s and 1970s, with international and domestic climate policy only taking shape in the mid-1980s – after which media coverage of climate change science and policy increased dramatically. They reiterate that James Hansen's testimony in 1988, in the hottest year on record – felt by the person in the street – was "pivotal" in shaping media coverage going forward, along with other important events that would see increases in media coverage. These included the release of Intergovernmental Panel on Climate Change (IPCC) assessment reports in 1990, 1995 and 2001, the 1992 UN Framework Convention on Climate Change (UN FCCC), and the 1997 Kyoto Protocol, which saw a large increase in coverage in Western Europe, North America, Australia, New Zealand, the Middle East, Asia, Eastern Europe and South Africa. At the meetings in Kyoto, Japan, registrants included 3 500 journalists from over 400 media organisations in 160 countries (Boykoff & Roberts, 2007).

Various case studies examined by Boykoff and Roberts (2007) support the idea that increases in media coverage of climate change (as with evolution in the previous chapter) are often linked to major news events, such as the huge uptick in media reports during September to November of 2006, during which time Al Gore's film on global warming, *An Inconvenient Truth*, was released; Richard Branson made a much-publicised donation of three billion dollars towards renewable energy initiatives and biofuel research; and the Twelfth Conference of Parties (COP12) took place in Nairobi, Kenya. Such events, according to Boykoff and Roberts (2007), provide the media with "news hooks" that conform to traditional news values like prominence, impact, conflict and timeliness. These can make climate science stories not only seem more sellable to news editors, but also more palatable for mass audiences.

The influence of prominent events, however, is only one of a myriad of factors that influence public discourse on climate change via the media. This is especially true because the nature of

climate science is so complex. Journalists often also have to become educators and need to get the public's attention before they can educate them. Say Boykoff and Roberts (2007):

> Interactions between climate science, policy, media and the public are complex and dynamic. It is clear that science and policy shape media reporting and public understanding, however, it is also true that journalism and public concern shape ongoing climate science and policy decisions and activities. While journalists have consistently viewed their role as one of information dissemination rather than education, the distinction between these roles becomes blurred in practice.

Boykoff and Roberts (2007) make use of the "circuits of communication" model proposed by Carvalho and Burgess (2005) to distinguish three phases of communication between the media and the public, namely news production (and framing), news consumption (public discourse), and personal engagement.

When discussing the first phase – news production – Boykoff and Roberts (2007) refer to the fact that media professionals inevitably produce news within a political, economic, institutional, social and cultural landscape. In other words, media content, including content on novel science such as climate change, is always framed by both large-scale economic and political factors and pressures, and small-scale pressures at the level of the individual journalist and story (such as the norms and values of a particular journalist or editor). As such, Boykoff and Roberts (2007) make several key observations relevant to this discussion pertaining to media framing at the macro- and micro-scale:

Macro-scale pressures

- Media ownership and control play a major role, because media owners can dictate climate change coverage based on which type of messaging they find most lucrative (that will attract advertising), which type they identify with (editorial preference), or with which type they are politically aligned.
- The short-term nature of news deadlines, and the space allocated by editors to science and environmental issues, often constrain reporting on climate change.
- Worldwide there has been great reliance on climate change coverage from major media organisations based in developed countries, because smaller countries have difficulties in funding and accessing climate science and therefore often cannot report on it adequately (causing a lack of localised reporting).
- The media overwhelmingly frames climate change as a 'global' issue, without distinguishing between 'luxury' greenhouse gas emissions (such as cars, restaurants, airlines, etc.), and 'survival' emissions (wood burning, brick baking, subsistence agriculture, etc.).
- Journalistic training varies widely between developed and developing regions. Consequently, journalists in less developed countries are often not qualified or equipped to report on the complex issue of climate change.

Micro-scale pressures

- There are always time and space pressures for individual journalists, such as allocated column length (explicit) or time pressure in covering multiple stories or beats (implicit).
- To a large extent, the mass media play an important role as translator of climate science. In this role, the individual journalist's proclivity for objectivity, fairness and accuracy becomes very important.
- Scientists often discuss the implications of their research in terms of *probabilities* and tend to qualify their findings in the light of *uncertainties* that lurk in their research.

For journalists and policy actors, these issues of caution, probability and uncertainty are difficult to translate smoothly into the crisp, unequivocal commentary often valued in communications and decision-making. The media "tend to translate hypotheses into certainties" (Weingart, Engels & Pansegrau, 2000:274)

- First-order journalistic norms play a role, such as personalisation (news focuses on the tribulations of individuals for emotional leverage, often neglecting deeper social or systemic analysis of an issue), dramatisation (such as the coverage of a hurricane that often downplays comprehensive analyses of enduring problems such as climate change in favour of dramatic 'surface events'), and novelty (the preference for coverage of crises rather than chronic social problems).
- Second-order journalistic norms play a role, such as authority order (the bias where journalists tend to primarily, and sometimes solely, consult authority figures – government officials, business leaders and others) and balance (consulting sources with conflicting views and opinions, useful when reporters lack the requisite scientific background or knowledge of an issue such as climate change). The complex issue of public trust in authority figures may also feed back into and influence climate policy decision-making.

In a related study on climate change and journalistic norms, Boykoff and Boykoff (2007) find (in analysing US newspaper and television coverage from 1988 to 2004) that adherence to first-order journalistic norms – personalisation, dramatisation and novelty – significantly influence the employment of second-order norms – authority order and balance – and that this has led to "informationally deficient mass-media coverage" of a crucial issue.

In the second phase, regarding news consumption and public discourse, Boykoff and Roberts (2007) describe how climate news stories compete (often weakly) with other, more immediate issues for public attention, and how this leads to their marginality in national budgets, as public officials face voters concerned with more immediate local issues like crime, unemployment, service delivery, etc. This phase is therefore concerned with the relative legitimacy and urgency of climate discourse in the public sphere and with how framed media messages on climate change have to compete with other news stories and issues in the public arena. Boykoff and Roberts's (2007) main takeaway regarding this phase of communication as it pertains to climate change is that media coverage has been considerably lower in developing countries. Editors and journalists here seem to be less interested in covering climate mitigation or adaptation issues due to three factors:

1. Low levels of knowledge on the issue.
2. Insufficient funds for environmental journalism.
3. Incongruent priorities (a preference for more immediate issues).

The third phase examined citizen knowledge and personal engagement with the issue and understanding of climate change, and the influential role of climate 'sceptics' in paralysing action. Boykoff and Roberts (2007) found that even without uncertainty about the human causes of climate change, people are often demobilised by feelings of isolation, hopelessness, powerlessness and a lack of public trust in government to effectively address the issues.

A salient focus in previous research on the public understanding of climate change has been on public representations of *uncertainty*. Boykoff and Roberts (2007) point out that scientists often have difficulty placing the uncertainty associated with their research into a familiar context and, in practice, the mass media have often served to amplify uncertainty through coverage of climate contrarians' counter-claims regarding anthropogenic climate change, without providing the context that these claims have been marginalised in the climate science community.

Research by Corbett and Durfee (2004) examined coverage of climate change with a focus on uncertainty. Through an experimental design of three newspaper story treatments – one with controversy, one with context and a control (with neither context nor controversy), they found that greater contextualisation within climate science stories helps to mitigate against controversy stirred up through uncertainty (Corbett & Durfee, 2004).

Other prominent studies found that an increased understanding of climate science also increases people's stated intentions to do something about it (Bord, O'Conner & Fisher, 2000) and that counterclaims by climate contrarians and dissenters (whose agendas are most often aligned with conservative think tanks and the carbon-based industries) are often successful in developing compelling competing discourses to disempower top climate science and gaining a foothold in national and international discourse on the causes of climate change, even in major newspapers such as the *Los Angeles Times*, the *New York Times*, the *Wall Street Journal*, the *Washington Post*, *USA Today*, the *Chicago Tribune* and *Newsday* (McCright & Dunlap, 2000, 2003).

Boykoff and Roberts (2007) warn that the material covered by their research on personal engagement has been contested and debated in a number of ways, complicating efforts to be able to clearly and specifically recommend how media can better frame climate change issues in order to increase public understanding and action. A story on the plight of polar bears in the Arctic, for instance, could inspire some people who value biodiversity, yet could be off-putting to others who value humanitarian issues (poverty, inequality etc.) more.

However, they do make some straightforward recommendations (Boykoff & Roberts, 2007):

- Journalists can work to place stories in greater 'thematic' context, instead of moving from story to story in an 'episodic' manner (focusing only on prominent events).
- Journalists can work to label those quoted so as to make it clear to readers which statements could be influenced by special interests.
- For scientists, more consistent interactions with journalists and policy actors can improve the background understanding of each of the groups about others.
- Scientists can think more deeply about accurate metaphors and analogies that they can use in order to more effectively communicate their findings (and thus translate their work more effectively for the public, including any inherent uncertainties).

Boykoff and Roberts (2007:34) conclude that the studies and analyses outlined in their research make it clear that climate science communication is a complex issue, where the media has in some cases played a significant role in hampering accurate communications about climate science, and in other cases has played a more positive role in communicating about climate science and the needed mitigation and adaptation actions recommended by scientists:

> One could summarize from this review that the media has at times kept the issue of climate change alive, but has also limited the extent to which real change in the organization of society and foreign assistance have been called for. To put it plainly, the press has been quite reformist in its portrayal of the needed action on climate change, when the scientific projections suggest the issue may call for truly revolutionary changes. The difficult position of the media in capitalist society is that commercial news outlets require huge amounts of advertising to pay their salaries and other expenses, and the greatest advertisers are for automobiles, real estate, airlines, fast food, and home furnishings. To create demand for real mitigation of climate change emissions would require the

> media to repeatedly and insistently call for truly revolutionary changes in society, precisely away from consumption of the products of their advertisers. By comparison, creating pressure for the allocation of significant resources for adaptation to climate change will be relatively less threatening to the system that supports these media outlets … The question is whether this new understanding of the need for adaptation will result in sustained and effective media coverage of the issue, increases in citizen action, NGO activity, national policymaker initiatives, and international agreement.

A possible solution, according to Boykoff and Roberts (2007), therefore is to focus reporting on adaptation actions, rather than mitigation (which necessarily requires governments and private industry to lose money).

Boykoff and Roberts (2007:35) state that, due to internal and external pressures on the mass media, it remains "a challenging task" to effectively cover the complex issue of climate change, and that, while reporting on the physical science and technical aspects has improved, it has been more difficult to effectively cover the associated moral, ethical and cultural issues.

Similarly, Stamm, Clark and Eblacas (2000) stated, at the turn of the millennium, that public understanding of global warming and climate change is "an example of a mass communication problem that has yet to be adequately solved", with a survey finding that "although people are aware of this problem in a general sense, understanding of particular causes, possible consequences, and solutions is more limited". In their conclusion, they acknowledge, however, that despite shortcomings, the results suggest that the media "are already making some contribution to public understanding of global warming" (Stamm *et al*., 2000).

Apart from simply ensuring accuracy in media coverage of climate change, Stamm *et al.* (2000) suggest the media should also be concerned about the content of public dialogue, and that evidence suggests that providing (and properly communicating and conveying) waste- or emission-reduction targets for a community might be effective in helping stimulate public engagement. But then, says Stamm *et al.* (2000), the media also ought to actively address potential points of confusion – for instance making clear the distinction between ozone depletion (caused by chlorofluorocarbons or CFCs) and global climate change (caused in part by CO_2).

Much of the public confusion surrounding climate science, global warming and anthropogenic climate change is a direct result of the fact that, in the United States (US), climate science has been "uniquely politicized" since 1988, thanks to right-wing politicians and think tanks that "have used the legacy of climate research strategically to deny the current crisis by falsely depicting greenhouse science as uncertain and contradictory" (Armitage, 2005:417).

Because corporate media has often accepted (or at least entertained) this narrative largely explains, according to Armitage (2005), the lack of political action against global warming in the United States. Key tactics for right-wing propagandists (often with interests in fossil-fuel enterprises) have been to emphasise a 'commitment to sound science', to claim that the 'scientific debate' around man-made global warming 'remains open' (thus sowing uncertainty) and, most effectively, to play into the journalistic norm of 'balance':

> As shown in a carefully researched study by Boykoff and Boykoff (2004), in order to achieve 'balanced' reporting,

> the 'prestige' newspapers in the United States – specifically the *New York Times, Washington Post, Los Angeles Times* and the *Wall Street Journal* – all offered roughly equal space to peer-reviewed science and those who claim global warming is not scientifically credible. In this way a superficial adherence to 'balance' – that is, reporting 'both sides' of a debate – distorted evidence and the overall understanding of the issue. Though many in the media accurately reported the story, overall the media provided 'balanced coverage of a very unbalanced issue' (Boykoff & Boykoff, 2004:133). Hence, 'when it comes to coverage of global warming, balanced reporting can actually be a form of informational bias' (Boykoff & Boykoff, 2004:126). In this respect, then, the journalistic norm of evenhandedness helped create a false impression about a lack of scientific consensus on global warming. Balanced coverage is not always accurate coverage. This kind of false journalistic balance unwittingly supported right-wing propaganda. (Armitage, 2005:425)

Hiles and Hinnant (2014:428) find evidence that this phenomenon ('balance as bias') has, over time, even caused highly experienced environmental journalists to "radically redefine" their understanding of objectivity and of what makes a story "balanced", to rather advocate for a "weight-of-evidence" approach, where stories reflect scientific consensus.

The increased politicisation of climate change, especially in the US, has continued into the second decade of the 21st century. Chinn, Hart and Soroka (2020:112), using computer-assisted content analyses of all articles on climate change in major newspapers in the US between 1985 and 2017, found that media representations of climate change "have become (a) increasingly politicized, whereby political actors are increasingly featured and scientific actors less so and (b) increasingly polarized, in that Democratic and Republican discourses are markedly different". These findings parallel trends in US public opinion, according to Chinn *et al.* (2020:112), pointing to these features of news coverage as polarising influences on climate attitudes.

This fact – that public confusion around climate change can to a large extent be blamed on politicisation and polarisation as a result of the public being guided away from scientific consensus through "a professional public relations effort, motivated by industrial and ideological concerns … where deniers of the scientific consensus avoided normal scientific discourse and resorted to *ad hominem* attacks that cast doubt on the entire scientific community" (Weart, 2016:41) – has been researched and documented well.

Nissani (1999:27) concludes at the end of the 20th century that media coverage of environmental issues suffers from "both shallowness and pro-corporate bias". Some other noteworthy studies in this regard are those by Brulle, Carmichael and Jenkins (2012:169), who find that "information-based science advocacy has had only a minor effect on public concern, while political mobilization by elites and advocacy groups is critical in influencing climate change concern"; by Boykoff (2007:486), who states that "US media have portrayed conflict and contentions rather than coherence regarding scientific explanations of anthropogenic climate change"; and by Schmid-Petri, Adam, Schmucki and Häussler (2015), who find that outright denial of anthropogenic climate change has gradually waned as evidence has mounted, that political scepticism has turned away from 'balance as bias' (as a weapon) toward rather attacking 'binding regulations' that are deemed harmful to the economy or individual freedoms, and that "the political divide between Democrats and Republicans regarding climate change and the changing majorities in Congress might be key

for understanding the strength and form of climate change skepticism in the mass media" (Schmid-Petri *et al*., 2015:509).

Monbiot (2019) writes that the "masterstroke" of big polluters and fossil-fuel interests who had known about the environmental harm they were doing "for decades" was to absolve themselves with an ideological campaign blaming the crisis on "you and me" (the consumers choosing to use their products).

Other studies have explored how this politicisation and polarisation has played out in the medium of US cable television news. Feldman, Maibach, Roser-Renouf and Leiserowitz (2012) find that the more often people watched (the right-leaning) Fox News, the less accepting they were of global warming, whereas frequent viewing of CNN (which claims a nonpartisan stance) and MSNBC (which has in the past been accused of liberal bias) is associated with greater acceptance of global warming – even despite "robust controls for demographics, other media use, political partisanship, and values and predispositions related to science and the environment". Feldman *et al*. (2012) conclude that their findings add to a growing body of work demonstrating the power of cable news to shape public knowledge and attitudes:

> To the extent that Fox News presents a different view of reality than does CNN or MSNBC, the knowledge and opinions of the networks' respective audiences will likewise tend to polarize (Feldman *et al*., 2012:25).

Hart and Feldman (2014) studied how US network television news has conveyed threat and efficacy information about climate change through its framing of the discussion, and their results show that, while impacts (the threats of climate change) and actions (the efficacy of proposed interventions) are discussed independently in major broadcasts, they are rarely discussed in the same broadcast; efficacy cues are often inconsistent; impacts are framed primarily in terms of environmental consequences; and actions are framed in terms of political conflict. According to Hart and Feldman (2014), journalists can remain objective and simultaneously educate the public by simply discussing climate change impacts and actions "in the same story" to provide better context, which could trigger a more productive response.

Ahern and Formentin (2016) conclude that Fox News is generally more dismissive of global warming than other news outlets (which are more likely to cover actual causes and effects of climate change), covers global warming more frequently, and often co-opts the issue as an exemplar of "political correctness" and the excess of political progressivism. Furthermore, Ahern and Formentin (2016:60) confirm that "the issue is covered primarily in a political context, with little exploration of impacts and outcomes … Political elites drive coverage, with virtually no focus on the human interest aspect".

Similar studies have been done in other countries.

Weingart *et al*. (2000:280) analysed changes and differences in communication about global warming in the spheres of science, politics and the media in Germany between 1975 and 1995, and found that, in the German discourse on climate change "scientists politicized the issue, politicians reduced the scientific complexities and uncertainties to CO_2 emissions reduction targets, and the media ignored the uncertainties and transformed them into a sequence of events leading to catastrophe and requiring immediate action". Following on this, Weingart *et al*. (2000:80) highlight certain *risks of communication* that result from the uncertainty inherent in issues as complex as climate change, stating:

> For science, its credibility as an institution producing reliable knowledge is jeopardized. In the case of politics, legitimacy is at

> stake. Finally, though they seem to be affected least, the media are threatened by the loss of market share.

The lesson from this, according to Weingart *et al.* (2000:80), is to acknowledge these risks of communication:

> … the patterns of communication disturbances must be brought into the open and acknowledged on all sides. An acknowledgement of the systematic nature of differences in perception and communication can introduce a much needed reflexivity into the closely coupled communication between science, politics, and the media.

Olausson (2009) presents results from studies of the communication of global climate change in three Swedish newspapers and discusses the media's attribution of responsibility for collective action to organisations ranging along an axis from local to national to transnational. The results highlight the media's reluctance to display any kind of scientific uncertainty that would undermine the demand for collective action, and underlines the media's responsiveness to the political setting in which it operates and the growing relevance of the transnational political realm of Europe for the construction of news frames of reference for global climate change in the European national media. According to Olausson (2009), the tight relationship between the political elite and the media implies that the media often do not offer alternative frames (failing in their role as a fourth estate or as a 'discursive bridge') in relation to those established in policy discourse on climate change. The research again highlights the fact that issues relating to the mitigation of climate change and adaptation to climate change are hardly ever covered in the same news item, even though they are two sides of the same coin – in other words, espousing proper *context* in reporting official political and policy narratives.

On the other hand, Shehata and Hopmann (2012), in analysing and comparing 1 785 news articles from both the US and Sweden over a 10-year period, as well as the 1992 Kyoto and 2007 Bali climate change summits in particular, find that media coverage in the two countries have been strikingly similar, indicating a *weak* influence of national political elites on how climate change is framed in the news. The researchers acknowledge, however, that their results may have been skewed by their primary focus on the two climate summits – possibly indicating that contextual factors can strongly influence framing in the news media, such that, where frames are institutionally defined (as with coverage of a prominent climate summit), counter-frames may be less likely to gain prominence, despite the presence of opposing voices (which otherwise might have voiced the scientific-uncertainty frame).

The results might also support findings in research mentioned earlier that points to the fact that, as scientific evidence for anthropogenic climate change grew, the scientific-uncertainty frame was increasingly abandoned by sceptics in favour of the counter-frame against 'binding regulations'.

As already mentioned, research shows that, for the most part, there has been considerably less media coverage of climate change in developing countries and the global South (Africa in particular), largely due to issues such as a lack of resources, funding, education, training and editorial prioritisation (Boykoff & Roberts, 2007; Tagbo, 2010). Scholarship, similarly, has been concentrated strongly on Western countries, and specifically on the print media (Schäfer & Schlichting, 2014).

Dayrell (2019), in examining discourses around climate change within the Brazilian press from 2003 to 2013 (analysing almost 20 000 newspaper texts from 12 broadsheets), finds that, due to their proximity to the Amazon rainforest and the known effects of deforestation, Brazilians have a striking level of climate change concern (nine out of 10 consider the

problem serious), and that the Brazilian press has played a key role in raising public awareness of the problem of climate change, as well as in encouraging engagement with the debate. However, even here there emerged a "lack of serious discussion about the significant rise in emissions from the energy, transport and farming sectors" (Dayrell, 2019:19). The press coverage appeared to "reflect, rather than steer, government priorities", exposing a "real challenge to the country's actual transition into a low-carbon economy" (Dayrell, 2019:19).

Similarly, Johannessen (2013), who investigated how the South African media constructed representations of climate change during coverage of the 17th United Nations Conference of the Parties (COP17) held in Durban in 2011, finds the selected media outlets in her study provided extensive news coverage of COP17, but failed to address socio-economic inequalities when responding to climate change and created limited opportunities for engagement due to the lack of a personalised, localised narrative. Dayrell (2019) and Johannessen (2013) seem to expose a trend of media in developing countries 'toeing the line' of Western countries' policies, concerns and actions around climate change, without providing serious discussion and debate at a local level with the appropriate socio-economic context, which could be very different in developing countries. Developing countries could also be affected worse by the effects of climate change:

> The historical responsibility for today's climate crisis rests in the hands of rich, industrialised countries, while developing countries in many cases face its most devastating effects (Johannessen, 2013:13)

Johannessen (2015) also compared South African (developing) and Norwegian (developed) media coverage of COP17, finding that the South African media coverage did in fact portray climate change as a holistic, sustainable development challenge, linking it to societal transformation, including the need to balance mitigation with energy security, employment creation and poverty alleviation.

By contrast, according to Johannessen (2015), the Norwegian coverage mainly defined climate change as a global political issue in which Norway took the role as a benefactor, obscuring the question of how Norway should transform its own economy, industry and infrastructure to become a low-emission society. The study also highlighted how COP17 represented a shift away from an 'old world view', in which only the Western, industrialised countries contribute with legal commitments to cut their emissions. Johannessen (2015:48) warns that this causes the danger of ignoring the "common but differentiated responsibilities and capabilities" principle (for developing and industrialised nations), which may be an attempt to excuse rich, industrialised countries from their responsibility "after 150 years of benefitting from fossil-fuel-driven development". In this regard, Johannessen (2015:48) again points to the importance of national context in communicating climate change mitigation and adaptation:

> … the large difference seen between South African and Norwegian coverage of society transformation suggests the importance of further investigation of drivers toward, and barriers against, engaging constructively with climate transformation in different contexts and how this debate is promoted or restricted in the media.

Wasserman (2012) underscores research showing how the South African media, even leading up to and during COP17, did not pay sufficient attention to climate change, that journalists did not fully understand the science behind climate change or were unable to communicate it effectively, and that the media often fail to keep climate change on the news agenda long enough to inform opinion. Systemic challenges to news production, such as complicated and uncertain science, the influence of the political, and the need to interpret complex effects on

society, are exacerbated by under-resourced newsrooms and a news agenda "ill equipped" to properly deal with such complexities (Wasserman, 2012:1).

Bosch (2012) points to a shortage of literature on journalism and climate change in the global South, suggesting online and social media might be more effective than print media in reaching audiences in developing countries to inform them about climate change (due to the aforementioned constraints of traditional newsrooms and the huge growth in mobile internet in Africa).

Jones (2012) stresses that "more concerted, better organised and researched information and communication efforts are essential if African citizens are to have the capacity and opportunity to respond effectively to the impact of climate change", placing emphasis on the need for sound ethics.

The fact that South African environmental journalism often tends toward advocacy (due, in part, to the aforementioned systemic problems and journalistic norms in newsrooms) need not necessarily be a problem, according to Jones (2012:39), as long as it is "genuinely balanced, fair and critical", that it takes into account the specific context and all players and points of view, and that it clearly distinguishes fact and opinion without misrepresentation, suppression or omission of facts.

The problem, as pointed out by Boykoff and Roberts (2007) and Hiles and Hinnant (2014), is that 'balance' might in some cases itself cause bias, and that experienced environmental journalists have found that 'fairness' requires a weight-of-evidence approach that might even supersede the traditional concept of objectivity.

On the one hand, therefore, the communication of climate change requires a straightforward reliance on scientific accuracy, proven facts and solid evidence:

> Science and journalism are not alien cultures. They are built on the same foundation: the belief that conclusions require evidence (Tagbo, 2010:37).

On the other hand, the literature discussed here suggests that, due to the amount of uncertainty, complexity, denialism, developmental constraints, newsroom pressures and political interference regarding the issue of climate change, a higher journalistic responsibility – perhaps guided by an ethical standard – is perhaps needed in order to best communicate the proper context, the nuances, the weight of evidence and the social complexities of the issue.

Painter and Osaka (2019) suggest five tips for better coverage of the climate crisis, almost all of which involve providing the public with context, deeper understanding, personal relevance and engagement:

1. Focus on relevance to the everyday lives, experiences and passions of audiences.
2. Incorporate climate coverage across all news beats (not just environment).
3. Emphasise potential solutions (adaptation).
4. Highlight the visual (multimodality, to show impact and encourage mitigation).
5. Make it local, rather than global.

According to Painter and Osaka (2019), the sharp upward trend in climate change coverage has been encouraging, with over 400 media outlets worldwide having joined the Covering Climate Now Initiative (coveringclimatenow.org), and some media houses adopting forms of advocacy journalism, like *The Guardian*'s Keep it in the Ground Campaign. Covering Climate Now has the aim to encourage news media to 'break the climate silence' and to prioritise covering the 'defining story of our time', while the Keep it in the Ground Campaign

encourages fossil fuel divestment through journalism. But, warn Painter and Osaka (2019), 'more' coverage does not necessarily mean 'better' coverage – especially if it lacks proper context or leads to "more inaccurate reporting of climate science" (referring specifically to Fox News and the UK's *Daily Mail*).

Rögener and Wormer (2015) developed a set of defined criteria to try to assess the quality of coverage of environmental issues such as climate change. They find that a *lack of context* and the deficient elucidation of the evidence pose major problems to environmental reporting.

Salvesen (2018), in examining the pros and cons of the type of advocacy journalism adopted by *The Guardian* – which, apart from their Keep it in the Ground Campaign, also adapted their house style to use "climate emergency" over "climate change" and "denier" over "sceptic" – draws the following conclusion:

> … one can argue that the most critical question for journalism is no longer about solely informing about the problem of climate change, but about engaging in the how-to of transformative changes necessary to avoid catastrophic man-made climate change. *The Guardian*'s campaign is one way of tackling this challenge. Yet engagement can be done in several ways. While the campaign makes a powerful case for journalism to engage more in a reciprocal dialogue with the public, adhering to its core value of public trust, but also because a newspaper needs an engaged public to survive – it also makes the case for sticking to what journalism knows best: newsrooms are not set up to campaign like a campaigning organisation. Yet there should be room for experimentation and various ways of doing journalism.

Nisbet (2019:26) warns, however, that initiatives such as Keep it in the Ground and Covering Climate Now could easily become an "echo chamber for climate change activism" by reinforcing longstanding biases that eschew nuance, uncertainty and context in favour of "hot takes" that only highlight the most calamitous scientific studies that produce the most dramatic headlines such as "hottest days", "hottest years", "melting glaciers", "rising sea levels" and the like. What is needed, Nisbet (2019:26) suggests, is critical, independent thinking and integrity:

> The main challenge for a new generation of climate change journalists is not to turn up the threat level on behalf of the Green New Deal, but to identify for their audience the flaws in conventional narratives about climate change, holding all sides accountable for their claims and actions. We will not solve climate change; it is a chronic societal condition that we will do better or worse at managing over the century and beyond. Journalists have a vital role to play, contextualizing expert knowledge and competing claims, promoting consideration of a broader menu of policy options and technologies, and facilitating discussion that bridges entrenched tribal divisions. But to achieve this alternative vision for where journalism needs to go, the new Covering Climate Now initiative must strongly challenge longstanding biases in environmental reporting, rather than reinforcing them. The project is shaping up to become an echo chamber for climate change activism, just another symptom of today's bitter political culture. What if, instead, it focused on assuring the integrity and independence of journalists covering the most difficult and defining challenge of our generation?

These statements make it clear that, in covering complex, disruptive novel science and technologies, something more than traditional journalism might be required – if not a form of advocacy, then at least additional ethical guidance to ensure sufficient context, adequate engagement, level-headedness and integrity.

Palfreman (2006:38), who accepts that public policy on issues like climate change or nuclear power depends on public attitudes – which tend to be strongly affected by mass media coverage – posits that journalists should include not just the objective, accurate facts surrounding the complicated (and often emotional) risks of such issues, but also how audiences *feel* about those risks:

> Unlike advocates, journalists are not supposed to persuade but to report. It would be inappropriate for them to use these insights to manipulate their audience to, say, fear global warming more and nuclear power less. But, it can be argued that journalists should expand their narrative horizons: to include not just the facts about the risk in question but also how people *feel* about the risk and why. In essence, they should report two dimensions of the risk story – the physical narrative of nuclear power or global warming, and the psychological subtext that discusses how the public thinks about those risks.
>
> Journalists, of course, should strive to be accurate and avoid distorting the science, but getting to the heart of risk tales involves something more: in sum it requires not only understanding the objective facts of the danger, but also navigating the way their audience feels about the risk issue while telling a gripping, scientifically accurate story. It is to be hoped that with such insights journalists will discover new ways to tell important stories such as climate change … and nuclear energy.

Examples might be the concept of ‘legacy’ (protecting the environment for future generations), which has become popular in reporting on nuclear waste and climate change, and the trend of world monitoring (satellite imagery showing the effects of deforestation, pollution or glacial melt) to make the idea of environmental catastrophe more visual and tangible for audiences.

Palfreman (2006:39) maintains that, if Dorothy Nelkin (1995:2-3) is right that the public understands science “less through direct experience or past education than through the filter of journalistic language and imagery”, then public policy and the fortunes of the public are linked to the practice of journalism:

> We must hope that its practitioners are up to the challenge.

The key lessons learnt here about historical mass communication efforts surrounding climate change are listed in Table 1 in Section 2.4.

Next, we turn to the mass communication efforts surrounding nuclear energy.

2.3.3 Nuclear power: From fission miracle to Hibakusha hell

There is perhaps no better (or more obvious and famous) warning from history about the potential harm of a new technology than the example of nuclear energy.

It took only seven years from the discovery of splitting the atom (in 1938) for humans to successfully weaponise the technology and to use the first atomic bombs in warfare (in 1945) – killing around 200 000 people in Hiroshima and Nagasaki.

Following on from work done by Enrico Fermi in 1934 by bombarding uranium with neutrons, physicists Lise Meitner and Otto Hahn, along with chemist Fritz Strassman, had also been bombarding uranium and other elements with neutrons at the Kaiser Wilhelm Institute (KWI) in Berlin in order to identify the decay products (Tretkoff, 2007). In July 1938, Meitner, who had Jewish ancestry, was forced to flee from the Nazis and continued her work with Hahn through correspondence from her new position at the Nobel Institute for Physics in Stockholm, Sweden:

> In December 1938, Hahn and Strassmann, continuing their experiments … found what appeared to be isotopes of barium among the decay products. They couldn't explain it, since it was thought that a tiny neutron couldn't possibly cause the nucleus to crack in two to produce much lighter elements. Hahn sent a letter to Meitner describing the puzzling finding. Over the Christmas holiday, Meitner had a visit from her nephew, Otto Frisch, a physicist who worked in Copenhagen at Niels Bohr's institute. Meitner shared Hahn's letter with Frisch. They knew that Hahn was a good chemist and had not made a mistake, but the results didn't make sense. They went for a walk in the snow to talk about the matter … they stopped at a tree stump to do some calculations. Meitner suggested they view the nucleus like a liquid drop, following a model that had been proposed earlier by the Russian physicist George Gamow and then further promoted by Bohr. Frisch, who was better at visualizing things, drew diagrams showing how after being hit with a neutron, the uranium nucleus might, like a water drop, become elongated, then start to pinch in the middle, and finally split into two drops. After the split, the two drops would be driven apart by their mutual electric repulsion at high energy … Having made the initial breakthrough, he and Meitner collaborated by long-distance telephone. Frisch talked briefly with Bohr, who then carried the news of the discovery of fission to America, where it met with immediate interest. Meitner and Frisch sent their paper to *Nature* in January. Frisch named the new nuclear process 'fission' after learning that the term 'binary fission' was used by biologists to describe cell division. Hahn and Strassmann published their finding separately, and did not acknowledge Meitner's role in the discovery (Tretkoff, 2007).

Badash, Hodes and Tiddens (1986) document, in detail, the reaction to the discovery. Niels Bohr and Enrico Fermi announced it to the academic world at the Fifth Washington Conference on Theoretical Physics on 26 January 1939 and, within days, the experimental demonstration was repeated by several scientists in the US. The 'atomic age' had begun. Newspaper reports of fission provided those on the West Coast with their first information about the phenomenon:

> Luis Alvarez remembers coming across an article in the *San Francisco Chronicle* while having his hair cut and, before the barber finished his work, rushing out of the shop to tell his graduate student, Philip Abelson, who had been studying the bombardment of uranium by neutrons … When Robert

> Oppenheimer had seen the pulses, it took him only minutes to suggest that neutrons should accompany the fission, and he was soon talking of power-producing devices and bombs (Badash *et al*., 1986:211)

The *San Francisco Chronicle* was not the only newspaper to cover the discovery:

> Thomas R. Henry, one of the few science reporters in the country, reported for the *Evening Star* (Washington, D.C.) that it was just 'dumb luck' that he decided to drop in on the theoretical physics conference. He was rewarded with an extensive page-one story on 28 January, featuring the headlines 'Power of new atomic blast greatest achieved on Earth,' and 'Physicists here hail discovery greatest since Radium'. The sensational nature of fission, Henry emphasized, was in the understanding of matter and energy it provided; 'as a practical power source, the new finding has at present no significance.' Henry returned to page one on 30 January with another long story, this time on the confirmation of fission at Columbia, the Carnegie Institution, Johns Hopkins, and in Copenhagen. The Associated Press wire service picked up these accounts, and stories appeared in the *New York Times*, the *Los Angeles Times*, and in news magazines, such as *Newsweek* (Badash *et al*., 1986:212).

Overall, initial coverage focused mostly on the exciting possibilities of atomic power. The *New York Times* reported "the possibility of harnessing the energy of the atom crops up again", *The Los Angeles Times's* science editor, Waldemar Kaempffert, discussed the shielding that would be needed to protect workers at an atomic power plant, and the *Science News Letter* even cautioned readers to discount prophecies that the world might be 'blown to bits' by these experiments (Badash *et al*., 1986:212). This 11 February 1939 article would, ironically, appear to be the first connection made, in print, between fission and the possibility of explosives.

Excited shop talk about the possibility of 'useful nuclear energy' became common among scientists at various universities, and soon included the possibility of an atomic bomb. After receiving a letter from Robert Oppenheimer, George Pegram, a physicist from the University of Illinois, informed the technical assistant to the Chief of Naval Operations that Fermi would be happy to describe the recent experiments. Although he personally thought the likelihood was small, Pegram believed the possibility of liberating "a million times as much energy per pound as any known explosive" must be explored (Badash *et al*., 1986:213). Fermi did explain the status of investigations to naval officers and scientists from the Naval Research Laboratory, but their initial interest lay more in the potential of a power source for submarines.

For some scientists the idea of a bomb seemed preposterous. These included Bohr, as he deemed it too difficult to manufacture enough uranium-235 for an explosive device. Others, like Oppenheimer, felt the possibility remained strong, noting that "a 10 cm cube of uranium deuteride … might very well blow itself to hell" (Badash *et al*., 1986:214). Physicist Leo Szilard, who conceived of a fission chain reaction in 1933, wrote in a letter at the end of March 1939 that "it seems possible to devise engineering tricks for setting the reaction off in such a way as to cause an explosion the destructive power of which goes beyond imagination" (Badash *et al*., 1986:214).

On Easter Sunday of that year, young physicist Gael Young from Chicago was moved enough to pen a short story called "Road to Tomorrow", in which "the destruction of cities by nuclear

fission killed millions and condemned surviving generations to cancerous deaths" (Badash *et al*., 1986:214). Newspapers and magazines in March and April also kept returning to the idea of an explosive. Kaempffert of the *New York Times* speculated that a Martian observing earth's cataclysmic end might comment, "Some imbecile has been annihilating matter" (Badash *et al*., 1986:214).

Since the efficiency of the fission process was not yet well known, many scientists, such as Fermi, preferred to downplay the chance of a dramatic explosion, but the concept proved too enticing for reporters to overlook and, while they acknowledged many hurdles yet to be overcome, they seemed to delight in writing about "an explosion that would make the forces of T.N.T. or high-power bombs seem like firecrackers" (Badash *et al*., 1986:214). As the science of fission advanced quickly, scientists eagerly debated the practical possibility of a bomb, but without much consideration for the ethical and moral implications:

> If anyone raised any moral reservations about weapons of such destructive power, or ethical questions about turning one's professional goal from increasing knowledge about the universe to investigating military applications of science, it has gone unrecorded. Fission inspired awe and fear; doubt and revulsion would come much later. And even fear was not directed at the application itself. Rather, its origin lay in the expectation that German physicists also recognized the explosive possibilities of fission (Badash *et al*., 1986:214).

The Nazi threat would lead some scientists, like Szilard, to call for censorship, and also spurred US, UK and French scientists, the allied military and government to 'get there first', in fear of a Nazi atom bomb. These fears proved to be well-founded, as German scientific papers were published on the practical applications of nuclear energy. Several countries, including Germany, the US, the UK, France and the Soviet Union soon began to stockpile uranium compounds and to research nuclear fission for military application (Badash *et al*., 1986:215-216).

A breakthrough came in the spring of 1940, when Otto Frisch, by now at Birmingham, England, along with Rudolf Peierls, calculated that not tons but only a few kilograms of metallic U-235 would suffice to make a bomb. This not only gave new life to the British efforts, but similarly inspired a faltering American project. Eventually, the work done in England was transferred to the United States and Canada and became part of what would become the Manhattan Project (Badash *et al*., 1986:216).

News of fission received good press coverage throughout 1939. The British scientific magazine *Discovery* editorialised in May that "this result [of secondary neutron emission] is of great importance and, with a little imagination, one can easily regard this as the first real step towards the elusive goal of harnessing the vast store of nuclear energy which is released only very occasionally in processes so far investigated". The magazine later emphasised the serious choice between "a pinch of salt to power the *Queen Mary*" and "Wellsian chaos created by nations dropping bouquets of uranium bombs". *New York Times* science writer William L. Laurence referred to uranium-235 as the "philosopher's stone" that would enable one to tap "the vast stores of atomic energy" (Badash *et al*., 1986:216).

A thoughtful editorial in the July 1939 issue of *Scientific American* indicated that the dilemma physicists faced was becoming more apparent (Badash *et al*., 1986:216), because any time man found a new force, means were sought to turn it to destructive uses and, even when physicists decide to rather leave the subject, they would upon reflection realise that they would only be abandoning it "to the world conquerors". The physicist "cannot stop", in other words, nor can he be confident whether any discovery "will be a curse or a boon" (Badash *et*

al., 1986:216-217). In this sense, again, the Nazi threat and the background of World War II played a major role.

According to Badash *et al*. (1986:217), in 1939, the sense of social responsibility so widely acknowledged today and widely discussed even then, was weak:

> In that milieu, few scientists could, for moral or ethical reasons, renounce work on a weapon. Moreover, fission in 1939 is not the best yardstick of social responsibility, for the Nazi regime in Germany was considered the greatest evil.

Nevertheless, many scientists and journalists felt some ambivalence toward fission. Swiss physicist Auguste Piccard agreed that a slow chain reaction for use as an energy source would be a boon to humanity, but referred to fission as a "diabolical discovery" due to the possibility of fast, explosive chain reactions (Badash *et al*., 1986:217). *Discovery*'s editor, the British scientist C.P. Snow, was pessimistic should a bomb be made possible, but concluded:

> We have seen too much of human selfishness and frailty to pretend that men can be trusted with a new weapon of gigantic power … And yet, the bomb must be made if physically possible. There is no ethical problem, because there is no secret. Every large laboratory on earth will achieve the same results, and it must be done sooner in America than in Germany (Badash *et al*., 1986:217).

This fear led Szilard to pen a famous letter to President Roosevelt, signed by Albert Einstein, informing the White House of the possibility of a nuclear chain reaction, with radium-like elements and an explosive as conceivable products. This letter, delivered to the Oval Office by economist Alexander Sachs on 11 October 1939, during a briefing at which Army and Navy ordnance experts were also present, eventually led to the infamous Manhattan Project, the product of which was the conception and testing of a working nuclear bomb (Badash *et al*., 1986:218-219).

According to Badash *et al*. (1986:221), less was published about fission during the closing months of 1939 because of the war in Europe, but the possibility and threat of an atom bomb was widely discussed in public:

> … the possibility of constructing nuclear weapons continued to be discussed openly, in such places as a review article on fission in *Scientific American*, and in the *New York Times*'s annual roundup of science, where fission was called the year's greatest discovery … The year's end was also marked by a public address in Copenhagen by Bohr in which he discussed the destructive potential of the fission process. While the Allied effort to construct atomic bombs in World War II, popularly called the Manhattan Project, was cloaked in secrecy, it is clear that no literate scientist or layman in 1939 need have been unaware that such weapons were conceivable. Bombs and power plants were widely discussed; ethical and moral questions also were raised, but in the political climate of that year were regarded as inconsequential.

Badash *et al*. (1986:221-225) argue that, although many scientists did begin to voice moral and ethical concerns about working on such a potentially hazardous government-funded weapons programme (Joseph Platt called it a "perversion of a major intellectual accomplishment … to make the first practical application of that knowledge a huge bomb"),

these misgivings came later, from 1942 onwards. To condemn fission developments in the period from 1939 to 1942 would be to misinterpret the circumstances of the time and the prevailing feeling that a nuclear bomb developed in Germany would be a much more pressing concern than any moral-ethical hesitancy:

> There was the opportunity for personal choice, but it rarely presented itself clearly. Given the international conditions in 1939, there seemed little option but the pursuit of applications of science. When a bomb was discussed, it usually was done abstractly – *if*, not *when*, it were made – and the moral dimension ignored, or implied by common statements to the effect that civilization must be saved from Nazi domination. Note that the Einstein letter to President Roosevelt avoided moral or ethical matters, and most other comments by scientists in 1939 were similarly constructed. Although history has shown that they were overly impressed with German scientific and technological capabilities, they were fully justified at that time to fear Germany's threat to the world … For most, there was no self-consciousness about research for military purposes until the war ended in Europe, and before this time fission raised no more moral or ethical questions than did conventional weapons (Badash *et al*., 1986:222-223).

Only by 1945 did Oppenheimer's quotation – "We have made a thing, a most terrible weapon, that has altered abruptly and profoundly the nature of the world. We have made a thing that by all the standards of the world we grew up in is an evil thing" – become the prevailing sentiment (Badash *et al*., 1986:222).

Another point, according to Badash *et al*. (1986:223-224), concerns "the nature of scientific activity and the attitudes of scientists", adding that before World War II scientists generally felt that their work had little effect upon society, and their mobilisation for the development of weapons was not part of their normal activity. They were not professionally socialised to think about the implications of their work, and they certainly were no better at futurism than the rest of the population:

> Nor should they have been so. The vast majority of scientists are inherently non-speculative and non-philosophical; they prefer to stick closely to the data and extrapolate from them no more than prudence allows … Indeed, public remarks generally are carefully crafted, because professionally they engage in constant self-criticism. When they do speak, they usually limit themselves to statements of scientific fact and possibility. Rarely do they make statements of warning or of promise. Rarely do they engage in fantasy; that is better done by novelists. Cries of catastrophe more often come from those who do speculate beyond the data (Badash *et al*., 1986:223-224).

This, of course, also refers to the media, which are tasked with 'speculating beyond the data' in order to inform the public of the potential significance and consequences of new science. But although many media reports did mention the potential cataclysmic destruction of a nuclear bomb, many (if not most) scientists were yet unsure whether such a bomb was even physically possible. And, by the time it did become possible, their work, under the Manhattan Project, was classified. Even if it had not been, Badash *et al*. (1986:224-225) argue that the scientists of the time did not yet have the sense of social responsibility that is expected of scientists today (in large part due to the development of the atom bomb):

> To expect that in 1939 they should have focused quickly upon the significance of a new discovery, explored carefully its potential consequences, and weighed in the balance the question of their own involvement exaggerates the abilities and orientations of scientists. What was true individually seems also to be accurate collectively. There was time for group decision-making, as shown by the censorship attempt, but the opportunity for ethical, professional choice regarding work on a bomb was unperceived and the community drifted (or marched) into weapons development. There were no vocal protests from individual scientists and no organized opposition. That would have been unlikely in any case, since scientific societies, the basis of organized activity, regarded themselves far more as scholarly bodies than vehicles for activism …
>
> This was a period of adolescence, before the military found science too important to be left to the scientists, and before science found research too expensive to do without government funding. In 1939, if one were to define where social responsibility entered science, it would most likely have been where basic turned into applied science. There was no precedent of being held responsible for fundamental research that had been perverted for evil purposes. Certainly, in a subject still so opaque as fission physics, and with no concept that basic research would lead to harm of society, one could be unaware that ethical or moral questions existed.

Nevertheless, it is worth pointing out the "staunch refusal" of Hahn, Meitner and Strassman – the very pioneers of nuclear fission – to be involved in the development of nuclear weapons (Madsen, 2013). Perhaps their role in the technology gave them a more personal sense of responsibility for potential applications and consequences than was customary for the time.

Events over the decades since have sensitised scientists – and the media – to the role of social responsibility (Badash *et al*., 1986:224-225). Individuals have increasingly spoken out on various issues, leading to beneficial public debate, and scientific societies now feel comfortable in supporting some 'causes'. A "perfect early warning system might never be erected", says Badash *et al*. (1986:224-225), yet "we may expect ever more attention to be paid to the implications of scientific research".

After the secrecy of the Manhattan Project and the 16 July 1945 Trinity test (the first detonation of an atom bomb, in the Jornada del Muerto desert, New Mexico), the Japanese cities of Hiroshima (6 August) and Nagasaki (9 August) were decimated weeks later by the Little Boy and Fat Man bombs, revealing this "awesome new source of power to the world" (Palfreman, 2006). And yet, for a time, media coverage of nuclear power – even *after* the bombing of Hiroshima and Nagasaki – remained mostly positive, lasting until the late 1970s (Palfreman, 2006).

How could a weapon of such destructive force – resulting in hundreds of thousands of deaths and injuries and a full generation of the lingering effects of radiation fallout, and being condemned by many scientists – not result in negative sentiment and outcry in the public and the press? In a word – empathy, or rather the lack thereof.

The events of World War II and, in particular, the attack on Pearl Harbour (7 December 1941), had desensitised the public in the West to the plight of the Japanese 'enemy' and had dehumanised its people. The fact that the bombing of Nagasaki had effectively ended the war

was obviously also seen by most Western politicians, the media and the public to be a net positive effect.

Daly (2015) recounts the most prominent American journalists to cover the first use of the atomic bomb. In April of 1945, the US Army, in anticipation of the Trinity test and the bombings to follow, approached the editor of *The New York Times* in order to borrow science writer William Laurence to report on the Manhattan Project (including the false press release cover story for the Trinity test). On 9 August, Laurence was aboard one of the aircraft in the formation that dropped the bomb on Nagasaki, an experience he detailed in poetic narrative in the *Times* a month later (Laurence, 1945). As part of his coverage, he mused on the morality of the endeavour:

> In about four hours from now one of its [Japan's] cities, making weapons of war against us, will be wiped off the map by the greatest weapon ever made by man. In one tenth of a millionth of a second, a fraction of time immeasurable by any clock, a whirlwind from the skies will pulverize thousands of its buildings and tens of thousands of its inhabitants … Does one feel any pity or compassion for the poor devils about to die? Not when one thinks of Pearl Harbor and of the Death March on Bataan.

This, according to Daly (2015), was the prevailing sentiment – that the "Japs had it coming". In the UK, for example, the *Manchester Guardian* (later *The Guardian*) "showed no moral hesitation" (Nelsson, 2015) in its 6 August 1945 report, stating:

> In spite of the horror that must be kindled in all our hearts by the use of such a weapon against the human species, its use against the Japanese is entirely legitimate. It is illogical to judge the morality of bombing by the size of the bomb used … No race was ever more worth winning, and the wisdom of Mr Churchill and Mr Roosevelt … is something to be ever remembered with gratitude by this country and the United States, and, indeed, by the world.

Laurence, who went on to write a series of Pulitzer Prize-winning articles on the bombings for the *Times*, was later criticised for his attachment to the military, and for his downplaying of the effects of radiation. Daly (2015) also notes the inherent limits of Laurence's perspective, being from the point of view of the attackers. In contrast, Homer Bigart of the *New York Herald Tribune* was part of a group of journalists to be the first to report from the ground in Hiroshima in early September 1945. He estimated, fairly accurately, the loss of life at 53 000 dead and 30 000 missing and presumed dead, described the ruins, estimated that residents were still dying at a rate of 100 a day, and hinted at some of the problems eventually recognised as radiation sickness.

The most famous of these journalistic accounts is that of author John Hersey (Hersey, 1946), for the *New Yorker*. Hersey visited Hiroshima in 1946 and followed six survivors, documenting their accounts of what happened and the effect on their lives in meticulous detail to create "one of the masterpieces of war correspondence" (Daly, 2015). When his editor at the *New Yorker*, Harold Ross, got a look at the material, he decided to dispense with all the rest of the content scheduled to run and devoted the August 31 issue solely to Hersey's account:

> Hersey's story is a key document of 20th-century history as well as a touchstone for the human imagination in the nuclear age. His hyper-factual tale of immense suffering has become part of the worldview of most people on the planet. He said almost nothing in

> his own voice – no pontificating, no summarizing. Instead, he brought particular people to life by setting them in action and thereby showing the reader what had happened (Daly, 2015).

Hersey's account was soon published as a book, *Hiroshima*, which became a bestseller.

There existed then, fairly soon after the bombings, detailed journalistic accounts of the human cost and the immense suffering caused by the splitting of the atom, but because of the background of World War II, the focus seemed to have been on the awe and devastation itself, rather than the obliterated lives of the affected Japanese people.

President Harry Truman's televised announcement to the American public following the bombing of Hiroshima unsurprisingly put the focus on the bomb itself, with the destruction of Hiroshima and its people barely a footnote:

> A short time ago an American airplane dropped one bomb on Hiroshima and destroyed its usefulness to the enemy. That bomb has more power than 20 000 tons of TNT. The Japanese began the war from the air at Pearl Harbor. They have been repaid manyfold, and the end is not yet. With this bomb we have now added a new and revolutionary increase in destruction … These bombs are now in production, and even more powerful forms are in development. It is an atomic bomb. It is a harnessing of the basic power of the universe. The force from which the sun draws its power has been loosed against those who brought war to the Far East. We have spent more than $2 billion on the greatest scientific gamble in history, and we have won. But the greatest marvel is not the size of the enterprise, its secrecy or its cost, but the achievement of scientific brains in making it work (Truman, 1945).

Against the background of the war, this use of language makes sense, but also helps to explain how such a terrible human cost was justified and why nuclear power – and the promise of the atomic age – was viewed in a positive light in spite of Hiroshima and Nagasaki.

Hauger (2016) states that, if people are able to grasp the sheer magnitude and horror of the attack today, back in 1945 the bombings "were largely portrayed as the latest big battle victory and necessary evil to end World War II". In the US and UK there were "virtually no voices of dissent to the use of a revolutionary bomb to wipe out an entire city, with some papers choosing to focus on the scientific prowess and the technological possibilities the atomic bomb implied" (Hauger, 2016). Few American journalists and readers questioned the morality of Truman's decision, nor his government's choice of sharing few details of the operation, thus allowing "the cover-up and hiding away of US and Japanese newsreel footage of the blast for years, sometimes decades" (Hauger, 2016).

This secrecy by omission of course also played a major role in public perceptions, with the first photograph of Japanese victims only appearing in *Life* magazine about two months after the end of the war (Mohan, 2007). For the most part, photographs of the human cost of the bombings seldom appeared in the American media until the 1950s (Mohan, 2007). Truman's speech also made no mention of radiation, a key feature of the new weapon, and the White House repeatedly implied that Hiroshima had been targeted because it had an army base, but omitted that the bomb was aimed at the centre of a city of 300 000 civilians (of whom 140 000 would die). Mohan (2007) sees the Army-approved reports by William Laurence, "perhaps the first fully embedded journalist in history", as part of this propaganda effort, helping "to shape how we Americans came to think about nuclear weapons and energy … a

narrative that legitimized the use of nuclear weapons and absorbed the bomb into American life". Much of the early coverage after the Hiroshima bombing bore the stamp of Laurence's work. News reports noted (Mohan, 2007) that the bomb had obliterated an army base, that science had now harnessed the power of the universe, and that revenge had finally been visited on the Japanese.

Mohan (2007) compares the "tension between national security and press freedom" that existed during this time, with the limited critical press scrutiny that the Bush administration had enjoyed in its early years because of 9/11 and the threat of terrorism – making it much easier to go to war (with Iraq) despite a very weak case to do so. Yet Mohan (2007) feels the Truman administration could have chosen a different path – "many scientists recommended that the administration disclose the existence of the bomb and at least attempt to force Japanese surrender through a non-lethal demonstration of the bomb's power". But the bomb was dropped, and once they used it, the administration "had to justify its use, and this is where the American media came in" (Mohan, 2007). Against the background of the threat of war, media coverage of nuclear energy was undoubtedly coloured differently than it otherwise might have been.

On his retirement in 1953, *Washington Post* editor Herb Elliston told a reporter: "One thing I regret is our editorial support of the A-bombing of Japan. It didn't jibe with our expressed feeling [before the bomb was dropped] that Japan was already beaten" (Mohan, 2007).

Indeed, says Mohan (2007), despite occasional contrary opinion and information pieces (such as the reports by Hersey), there was "no concerted effort to investigate government claims and challenge the view of nuclear weapons that settled into place after the bombings of Hiroshima and Nagasaki".

The early media neglect of Japanese victims was reinforced, according to Mohan (2007), by the lack of emphasis on radiation in Hiroshima and Nagasaki, due partly to censorship:

> The first serious attempt at explaining what had happened in Japan came from an Australian journalist, Wilfred Burchett. Almost a month after Hiroshima had been bombed, Burchett arrived there and understood the horror of the bomb for the first time. Initially supportive of the bomb's use, Burchett ultimately rejected nuclear weapons because of what he had seen in Hiroshima. Reporting from the scene of the devastation, his account differed dramatically from that of other journalists: 'In Hiroshima, 30 days after the first atomic bomb destroyed the city and shook the world, people are still dying, mysteriously and horribly – people who were uninjured in the cataclysm – from an unknown something which I can only describe as the atomic plague. Hiroshima does not look like a bombed city. It looks as if a monster steamroller has passed over it and squashed it out of existence. I write these facts as dispassionately as I can in the hope that they will act as a warning to the world.'

After his reference to the atomic plague, Burchett was initially ordered by the War Department to leave Japan and his camera mysteriously disappeared (Mohan, 2007):

> The US occupation authorities claimed that Burchett had been taken in by Japanese propaganda about radiation. They decided to let him stay in Japan and opted instead to deal with his charges about atomic sickness by simply denying that radiation had caused any problems. As a result, a *New York Times* reporter who had a

> week earlier reported witnessing sickness and death due to the lingering effects of the atomic bomb simply reversed the truth. He now reported that according to the head of the US atomic mission to Japan the bomb had not produced any 'dangerous, lingering radioactivity'. *The Washington Post* uncritically noted that the atomic mission staff had been unable to find any Japanese person suffering from radiation sickness. To drive home the point that radiation was not a problem, General Groves invited thirty reporters out to the New Mexico site where the bomb had first been tested two months earlier. This effort paid off with a banner headline in the *New York Times*: 'U.S. Atom Bomb Site Belies Tokyo Tales; Tests on New Mexico Range Confirm That Blast, and Not Radiation, Took Toll,' *Life* magazine concluded after the escorted tour in New Mexico that no Japanese person could have died as a result of lingering radiation.
>
> In fact, radiation killed thousands of Japanese in the months after the bomb was dropped. The 1960 population census in Japan estimated that the leukemia mortality rate for persons entering Hiroshima within three days of the bombing was three times higher than it was in all of Japan.

For most of the world, this would only become known much later. Consequently, for the media in the West, and therefore most of the global public, what stood out from accounts of Hiroshima was simply the awe of the bomb. "The remote, impersonal yet awe-inspiring pictures of the atomic mushroom cloud [over Hiroshima, and Nagasaki] started circulating" (Hauger, 2016) and, through poetic narrative by Laurence and others, made a lasting psychological impression on not only the American, but the global, media public.

Two years after the bombings, Hines (1947) acknowledged that, since 1945, the press had widely been considered as the primary agency for mass education in the field of atomic energy, and asked whether the press was – beyond their extensive coverage of "the horror, the fear and the hope" – being effective as a means of mass education, as had been requested by committees of scientists, statesmen and the public itself. The press's considerable responsibility in this regard was summed up by David Lilienthal, chairman of the Atomic Energy Commission:

> How well the people understand [the facts and implications of atomic energy] depends largely upon our institutions of education and communication – the schools, the universities, the churches and religious organizations, the radio and, most of all, the press.
>
> This great venture into new fields of knowledge can progress no more rapidly than the public's understanding … And it is not enough that a few people understand. The comprehension must become widespread, and in the process we must come to grips with reality but without hysteria. This is not only a large order for the press and for educational forces. This, my friends, is a large order for humankind (Hines, 1947:315).

The same might be said of many potentially disruptive or harmful new emerging technologies.

To find out whether the press was indeed promoting public understanding, and not just "selling shudders", Hines (1947) analysed all content related to atomic energy in five major

newspapers for the month of August 1947, namely the *New York Times*, the *Christian Science Monitor*, the *Chicago Sun*, the *Salt Lake Tribune* and the *San Francisco Chronicle*. Hines (1947) summarised his findings on the August 1947 press coverage as follows:

1. The atom still was a potent news subject.
2. Space devoted to the subject in the five newspapers averaged almost a column a day in each and ranged from the *Tribune*'s half-column to the *Times*' average of a column and a half.
3. There was a general tendency to depend on press association reports and a general weakness of coverage developed locally.
4. The emphasis on political aspects – except in the *Monitor* – outweighed others by more than two to one.
5. Stress on atomic horror, shock or sensation was almost totally absent in the five newspapers.
6. Editorial and cartoon coverage was keyed strongly to the Hiroshima anniversary theme, yet there was little disposition to waste space on material of only historical importance. Attention was focused, generally, on atomic energy as a future force in the world politics or economy.
7. There was a minimum of atomic science writing except for the major stories noted. It was a general impression, although only an impression, that the science stories tended to be more lucid than those in other areas.
8. The press association coverage was mostly routine and uninspired. In general, the news from all sources was poured into the standard moulds, many times with a lack of coherence which almost defied interest or understanding. Material handled on the local plane seemed to be of higher quality, but there was very little of it.
9. If the newspapers were performing the educational function expected of them, they were doing so entirely within the limits of traditional practices.

The key term, according to Hines (1947:322), was "traditional", and he found that newspapers in August 1947 were telling the atomic story as completely and as well as they knew how, but not to the extent that scientists and the state wanted the press to prepare the public for an atomic age. Hines (1947:322) quoted Paul Smith, editor of the *Chronicle* at the time, who was known to take thoughtful interest in atomic energy as a news problem:

> I am most certainly of the opinion that so far we in the practicing newspaper profession have failed to meet fully our responsibilities in relation to the atomic age … How then, when we have failed so far in this area, do we achieve a mass understanding through the media of mass communications? Maybe we can do no more than shed enough light to suggest the depth of the darkness. Maybe even that would be a step in the right direction.

Lauder (2017) notes the story of news media post-Hiroshima is "fascinating" because, even though the media and the government were able to collaborate in the immediate aftermath to create a positive public perception – through censorship (by the US Office of Censorship), constructed narratives ('the A-bomb as vengeance', denial of radiation and marginalisation of victims, 'the bright atomic future' and 'necessary evil') and culture (individual fear and uncertainty during World War II and rampant anti-Japanese racism) – support for the atomic bomb has not lasted. Gallup polls from 1945 and 1995 see a dramatic shift from only 4% of the population opposing the bomb in 1945 to 49% saying they "would have tried some other way" in 1995 (Lauder, 2017).

In the Japanese media, the full truth was unfortunately also hard to come by, since the Imperial Japanese authorities did not want to appear weakened by the bombings and therefore censored information shared with the press. Wanklyn (2015) reports that the English *Nippon*

Times (now *The Japan Times*) described the ebb and flow of the war in considerable detail but relied on censored statements by the Imperial authorities and foreign news agency dispatches:

> News of the Aug. 6, 1945, bombing of Hiroshima was approved for print the following day and the Aug. 8 edition contained a terse statement within a longer article about U.S. and British air raids. 'Hiroshima was attacked by a small number of Superforts at 8:20 a.m. Monday,' the newspaper said, referring to the U.S. B-29 Superfortress bomber. 'The enemy dropped explosives and incendiaries. Damage is now being investigated.'
>
> Readers had to wait a further day to get a sense of the severity. 'New-type bombs were used by the small number of Superforts that raided Hiroshima on Monday morning, causing considerable damage to the city quarters,' the newspaper said on Aug. 9, citing an Imperial Headquarters statement. 'The explosive power of the new bomb is now under investigation, but it is considered that it should not be made light of,' the newspaper said.

After the report on Nagasaki bombing on 9 August, the newspaper first mentioned the second attack only on 12 August, quoting military authorities as calling the damage "comparatively slight" – perhaps one of the biggest understatements in history. It failed to report Nagasaki's destruction until 16 days after the event, and gave no reason for this (Wanklyn, 2015). The Home Ministry issued public statements, calling the new bombs "powerful" with a blast of "strong heat" that spreads "all over", and suggested people shelter under a covering "even if only a lone plane appears". In case of no covering, it suggested protecting oneself with "a blanket or futon", and that hands and legs should be given full protection because "people in the open are likely to suffer burns" (Wanklyn, 2015).

On 10 August, the Imperial authorities delivered a protest to Washington via the Swiss government, saying that, although the US had disavowed the use of poison gas on account of its indiscriminate nature, this bomb was far worse:

> The protest accused the US of committing 'a sin against the culture of the human race by using a bomb which harms more indiscriminately and is more cruel than any weapon or missile which has been used in the past'. It described Hiroshima as 'a common ordinary urban community without any particular military defense facilities … By individual cases of damage done, it was unprecedentedly cruel' (Wanklyn, 2015).

It would be remiss to discuss communication efforts surrounding Hiroshima and Nagasaki without mentioning the fact that the voices of the people directly affected by the blasts, who survived and became known collectively as the Hibakusha, were silenced for decades after the bombings, both directly and indirectly:

> More than 210 000 people were killed as a result of the atomic bombings of Hiroshima and Nagasaki. Most people were killed instantly, but many did not succumb until years later, when they had leukaemia and other diseases related to radiation exposure. The health and welfare ministry recognises 297 613 survivors, who are issued with special health certificates that entitle them to regular check-ups and treatment worth up to US$1 300 per month, depending on their conditions. However, considering the combined

> population of the two cities was about 630 000 in August, 1945, the government's number is believed to underestimate the true number of people affected by the bombs. In part, this is because many Hibakusha – meaning A-bomb survivors – have been reluctant to come forward because they fear discrimination. Many worry that their children will not be able to get married because of a widespread – but scientifically unproven – concern that the effects of radiation may be passed on to future generations. More than half a century after the bombs, more than 1 000 people per year are only now registering as survivors (Watts, 2000).

Consequently, the harrowing personal accounts of the Hibakusha, collected and documented by organisations such as Hibakusha Stories (Hibakushastories.org), the Atomic Archive (atomicarchive.com), NHK World-Japan (via the animated 'Letters from Hibakusha' YouTube series), and the Hiroshima Archive (Hiroshima.mapping.jp), only came to light in the past two decades.

These stories, of a blinding flash that wiped out their entire world, and of waking in darkness, hearing the screams of dying loved ones and soon realising they cannot help anyone around them or even themselves because their burnt, peeled skin and flesh were hanging from their fingertips, are not for the faint of heart – and have not entered mainstream pop culture even today.

For example, every year, new additions are added to the dozens of Hollywood films depicting aspects of the holocaust (*The Pianist*, *Saving Private Ryan*, *Schindler's List*, etc.), yet only one film about the bombing of Hiroshima, a 1995 Japanese-Canadian production called *Hiroshima*, has been released since 1953. This film was concerned primarily with the decision-making process leading up to the bombing.

The media, both in the US, Japan and elsewhere, have for most of the last 75 years since the bombings failed the Hibakusha miserably. Yet they are not the only silent victims.

At the end of World War II, the US military began recruiting soldiers as subjects for nuclear weapons research (Knibbe, 2019). An estimated 400 000 troops are believed to have participated in over 1 000 atomic bomb tests, some of whom were placed in trenches less than a mile from the test detonation, with no protection save for their uniform, helmet and a gas mask, and "no idea" what was about to happen (Knibbe, 2019).

These soldiers, who would come to be known as 'atomic soldiers', were sworn to secrecy by the US military and were only allowed from 2019 to share their stories – of severely traumatic events and a blast so bright that they could see the veins and bones in their hands "like an X-ray". "It haunts me to think of what I had witnessed," says one veteran in a film on these soldiers by *The Atlantic*, "and not realizing at the time the import of what we were doing … actually serving as guinea pigs" (Knibbe, 2019).

No wonder then, that Mohan and Tree (1995:160) conclude that the "the amnesia-ridden version of events offered by Truman, and repeated by much of the press as well as 'orthodox' historians, represents the original attempt at 'revisionist' history".

Most historians who have analysed the news media's response to Hiroshima have generally treated the media as reflectors of public opinion (Mohan & Tree, 1995):

> These scholars have suggested that wartime culture, official censorship, and a belief in American exceptionalism were largely responsible for the lack of dissenting commentary in the media.

> While these are important issues to keep in mind, viewed only in this way, the media become reflectors rather than shapers, as well, of popular opinion. According to this view, the media had not the means or reason to challenge the official line.

This assertion is false, according to Mohan and Tree (1995:159), who contend that the media failed to adequately and critically question the Truman administration's decision to drop the bomb, even after historians in decades since have determined that other potential courses of action existed that would have been viable and preferable to end the war without the bomb:

> The media coverage of the early 1990s shows an almost irreconcilable difference between contemporary news media and recent scholarly examinations of Hiroshima. In August 1990, the forty-fifth anniversary of Hiroshima, for example, the approximately 100 newspaper and magazine items that mentioned the atomic bombing of Hiroshima essentially avoided acknowledging even the existence of a historical debate about the dropping of the bomb.

Palfreman (2006:25), having studied media depictions of global warming and nuclear energy and the communication of these risks in the media, summarises how sentiment around nuclear issues in the media and the public remained positive in the decades after World War II, until things suddenly changed in the late 1970s:

> From the beginning, the power of the nucleus was the stuff of media myth: on the one hand offering a terrifying weapon that might destroy the planet, on the other a plentiful energy source that might save humanity. Despite this conflicted image, initially the public was not overly concerned about living in a nuclear age.

By 1951, scientists had figured out how to harness the same nuclear power of the bomb to generate electricity. It was, on the face of it, "a dream form of energy: a table-sized assembly of fuel rods could produce enough electricity for a small city for between one and two years" (Palfreman, 2006:25). Engineers, politicians and writers were awed by the power of the nucleus and spoke enthusiastically about its potential for good. Del Sesto (1981:315) notes that many of the accounts published in popular magazines in the 1940s and 1950s were as a result "widely optimistic and sensational" in their claims about the potential uses of nuclear power, simply because nuclear lent itself to fanciful claims and grandiose speculation that publishers probably saw as a way of increasing circulation. Del Sesto (1981) further notes that science and technology journalism was at this time underdeveloped, and so the nuclear story created vast pressure for adequate coverage, resulting in oversimplification and sensationalism.

The general positive sentiment was cemented after President Dwight D. Eisenhower made his landmark "Atoms for Peace" speech at the UN General Assembly in 1953, calling for international collaboration to shed the world's fear of the atom in favour of its promise for abundant energy and peace (IAEAvideo, 2021).

At the peak of the "Atoms for Peace" campaign (around 1956) – which led to the setting up of the International Atomic Energy Agency (IAEA) – up to half of the civilian articles about nuclear energy in the *Reader's Guide to Periodical Literature* had optimistic titles (Weart, 1988:301).

A 1984 report by the US Congress' Office of Technology Assessment, *Nuclear power in an age of uncertainty*, states that, at the time of the first citizen intervention against a nuclear

power plant in 1956, there was a great deal of positive mass media coverage of President Eisenhower's "Atoms for Peace" programme (US Congress, 1984).

In the early 1960s, most coverage was still positive, but a few protests against local plants – particularly the large demonstration at a proposed site of a nuclear plant on Bodega Bay, California in 1963 – received national publicity (US Congress, 1984). In general, however, the 1960s garnered little negative press comment about nuclear reactors, even following the meltdown of the Fermi-I breeder reactor located at Laguna Beach near Detroit on 5 October 1966 (Palfreman, 2006). Although this was a serious accident according to nuclear historian Spencer Weart (1988:301), the press "scarcely noticed" (Weart, 1988:301). Palfreman (2006) states that news coverage remained either neutral or positive well into the early 1970s.

But, as the 1970s wore on, "this positive public face of civilian nuclear power gave way to a darker image" (Palfreman, 2006:25). This transformation was driven by popular culture, by anti-nuclear advocacy and, in particular, by some highly publicised nuclear accidents:

> From the beginning there had been two potentially disturbing elements of nuclear mythology: nuclear energy's mutagenic potential and its raw power. Writers and movie producers found both fascinating. Radiation had long been known to cause cancer. Scientists had also used radiation to induce mutations in laboratory insects like fruit flies and in plants. Movies like *Godzilla* and *Them* revealed the public's dark fascination with radiation's capacity to transform life … As for the atom's raw power, by 1970 most people had seen truly terrifying images of H-bomb tests and heard about the problem of nuclear fallout. It was not a huge step to imagine that a nuclear reactor too might explode and spread radioactive 'fallout' everywhere (Palfreman, 2006:25).

Furthermore, some scientists raised concerns about radiation risks and, in the early to mid-1970s, environmental groups like the Sierra Club and Public Citizen (a group started by activist Ralph Nader) discovered that nuclear issues had the potential to resonate with the public (Weart, 1988:327). Once nuclear technology came under sustained scrutiny, the press began to report nuclear safety incidents more aggressively. As viewers were exposed to more negative nuclear stories – from the 1976 Browns Ferry incident to the protests against the building of a reactor at Seabrook, New Hampshire – nuclear technology started to acquire a distinctly negative image (Palfreman, 2006).

Then, in 1979, the balance of perception firmly tipped into the dark side of nuclear mythology with the partial meltdown of a reactor at the Three Mile Island (TMI) nuclear plant in Pennsylvania:

> Hundreds of TV reports, [newspaper] articles, and a series of books recorded this landmark event. While there was no significant release of radiation, the event was a public relations nightmare for the nuclear industry that called into question the competence and openness of the scientists, administrators, and regulators running the technology … Experts regard TMI and the media fallout as a turning point that marked a loss of public trust in nuclear energy. From this point on, TMI's gigantic cooling towers – which looked imposing, mysterious, and sinister – would become the most common iconic representation of nuclear reactors (Palfreman, 2006:26).

Trends throughout 1979 appeared to confirm a link between media coverage and public opinion: Public opposition rose sharply immediately following the accident, subsided within two months as media attention diminished, and then increased slightly during October and November, coinciding with media coverage of the final Kemeny Commission report (US Congress, 1984).

Following the accident at TMI, the Kemeny Commission found that the public's right to information had been poorly served by the media and authorities.

> Confusion and uncertainty among the sources of information combined with a lack of technical understanding by the media personnel were identified as contributing to the problem. Many of the reporters 'did not have sufficient scientific and technical background to understand thoroughly what they heard'. As a result of these difficulties in reporting on emergencies, the commission recommended that all major media outlets hire and train nuclear energy specialists and that reporters educate themselves about the uncertainties and probabilities expressed by various sources of information (US Congress, 1984:242).

On reviewing the mass media coverage and responses of people in the proximity of Three Mile Island, Mufson (1981:52) concludes it is clear that the accident had "significant psychological impact". Inhabitants quickly began viewing themselves as survivors and expressing a damaged sense of self. There was "an expression of being victimized at the hands of modern technology and the human beings behind that technology, which leads to a questioning and mistrust of traditional institutions once seen as infallible and now seen as agents of potential disaster" (Mufson, 1981:52).

Friedman (1981) concludes that both the local utility and the media must share the blame for overemphasising the safety, cleanliness and economy of nuclear power and underplaying its potential problems in the public information available even *prior* to the TMI accident. Covering a nuclear plant is not an easy task for small- to medium-sized newspapers or media outlets, says Friedman (1981), who suggests ways of overcoming some of the problems – including hiring a reporter with a background in science and technology to cover nuclear issues, seminars for editors and news editors, the use of more neutral sources such as independent scientists (and not just official sources with a vested interest in the plant in question), and to make sure to cover different viewpoints.

The US Congress's 1984 report makes several key points regarding the media's role in covering technologies that carry risk, such as nuclear power:

> The prominence given to disputes between technical experts over the risks of a technology appears to create uncertainty in people's minds, which in turn raises concern and opposition, regardless of the facts under discussion. If this is true, the media play a key role in encouraging public opposition by giving extensive coverage to the experts' disputes (US Congress, 1984:241).

The media's need for balance in the coverage of many issues, including nuclear power, may lead to understatement of the scientific consensus that the technology is acceptably safe (US Congress, 1984). This is again a reflection of the 'balance as bias' problem. Media personnel are, according to the report (US Congress, 1984:242), expected to bring various viewpoints before the public and, in the case of a controversial technology such as nuclear power, this generally means quoting both an advocate and a critic in any given story:

> One analysis of television news coverage showed that over the decade prior to Three Mile Island, most news stories dealing with nuclear power began and ended with 'neutral' statements. However, among the 'outside experts' appearing most frequently in the stories, 7 out of 10 were critics of nuclear power. Thus, while meeting the requirement of presenting opposing views, these stories may have oversimplified complex issues and failed to convey the prevailing consensus among scientists and energy experts.

The report (US Congress, 1984) finds no evidence that media personnel deliberately biased their coverage of nuclear power on the basis of personal convictions. The Kemeny Commission found that overall coverage of the TMI accident was balanced, although at times "confused and inaccurate" (US Congress, 1984). One of the biggest factors in inaccurate reporting on TMI was found to be the lack of reliable information available to the media (provided by authorities).

Another factor highlighted by the report (US Congress, 1984:243) is the fact that journalists are trained to be sceptical of news sources, including the nuclear establishment:

> For example, during the first two days of the accident at Three Mile Island, Metropolitan Edison withheld information on the situation from State and Federal officials as well as the news media. According to the Kemeny Commission, the utility's handling of information during this period 'resulted in the loss of its credibility as an information source'. Experiences such as this have led reporters to be particularly skeptical of nuclear industry sources and look to the critics for the other side of any given story.

Since few people (including reporters) understand nuclear technology well, problems may appear more threatening than they actually are (US Congress, 1984). Considerable expertise is needed to sift the facts and accurately interpret them for the public:

> By comparison, the media are not considered anti-airplane, even though most coverage of that industry focuses on crashes. Because the public is unlikely to view a single plane crash as an indication that the entire airline industry is unsafe, the airline industry is confident that all airplanes will not be grounded. With no such assurances for nuclear power, the nuclear industry may view coverage of accidents as a threat to its survival (US Congress, 1984:243).

Three Mile Island therefore was a dark turning point for nuclear power, but worse, of course, was yet to come.

In 1986, a reactor in Chernobyl, located in the then Soviet Republic of Ukraine, experienced the worst nuclear accident in history, leading to a fire that spread radioactive debris across neighbouring Byelorussia, Poland and the Baltic Republics:

> Within days, the radioactive mist drifted beyond Soviet borders and spread across most of Europe causing nervousness and fear. Some 135 000 Ukrainians were forced to leave their homes and thousands of local children later developed thyroid cancer. This nuclear disaster generated numerous TV news segments and [newspaper and magazine] articles, several books, a novel, and a

> play. This vivid and relentless negative coverage of the accident – for example, *Newsweek* in 1987 called nuclear energy 'a bargain with the Devil' – swayed public perceptions of nuclear energy around the world. A number of European countries – Italy, Sweden, Germany, and Austria – subsequently voted to phase out their nuclear energy programs (Palfreman, 2006:26).

Again, the withholding of information by Soviet authorities from the Ukrainian public and the media (in particular the international media) was a prevailing feature of the history of the incident. So much so that the critically acclaimed television series, *Chernobyl* (2019), based in large part on the seminal book, *Voices of Chernobyl* (1997) by Svetlana Alexievich, used as its marketing tagline: "What is the cost of lies?"

In 1991, the International Atomic Energy Agency convened a working group to assess the effects of the Chernobyl disaster (Palfreman, 2006). The report concluded that 32 confirmed deaths had been caused as a result of the initial accident, noting that the fallout would lead to an increased risk of cancer for people in the most affected area (somewhat greater than for the Hiroshima survivors). It also reported that there was a large rise in thyroid cancers – a treatable form of cancer – in children in the surrounding area. This had occurred because the local population was iodine deficient and the children's bodies had absorbed a radioactive isotope of iodine in the fallout (Palfreman, 2006). A recently released 20-year follow-up UN report by the Chernobyl Forum, a group of one hundred international scientists, confirmed this picture (Chernobyl Forum, 2006).

The Chernobyl Forum report (2006) goes on to argue that the accident's largest public health impact has been on the mental health of the affected populations, and attributes this negative psychological impact partially to a lack of accurate information.

In many ways, the Chernobyl accident was the nail in the coffin for nuclear power's image in the media and the public – at least for a time.

Friedman, Gorney and Egolf (1992) studied television news (three stations) and newspaper coverage (five papers) in the first two weeks after the Chernobyl disaster and note that, when the Chernobyl accident occurred, it only strengthened the already negative views on nuclear power in the United States and Europe. They conclude that the US media did not provide enough information to help their readers or viewers evaluate the nuclear industry's current and past performance, to understand background information regarding radiation reporting from Chernobyl, or to put the accident in context. Friedman *et al*. (1992:319) find "clear evidence that US media coverage … could have contributed to misunderstandings or lack of knowledge about nuclear power that had the potential to affect public attitudes toward the technology". They find, however, that although the media coverage lacked background information and proper context, the reporting was predominantly even-handed and did not purposely attack the nuclear industry or reveal an anti-nuclear bias:

> Media coverage of nuclear accidents such as Chernobyl can have serious ramifications, particularly if that coverage results in an overestimation of the risk of that technology and, consequently, more negative public attitudes toward it. While coverage of all of the factors involved in the Chernobyl accident might have contributed to such an overestimation, coverage of background factors relating to nuclear power and the nuclear industry by these newspapers and networks should not have done so. At the same time, however, these media organizations passed up a golden opportunity to help readers and viewers better understand a

> complex technology and more objectively evaluate its risks and benefits for themselves and for society (Friedman *et al*., 1992:321).

The mere fact that the accident happened, and the death toll and fears of fallout afterward, did serious damage to the image of nuclear power. Inglehart (1984:44) concludes that public misconceptions about nuclear power and the inability to separate nuclear power plants from atomic bombs persists, calling for a "rational weighing of nuclear risks". In analysing three decades of public opinion polls, Rosa and Dunlap (1994) find that public opinion has become increasingly unfavourable to nuclear power following the Three Mile Island and Chernobyl accidents.

Nuclear energy's defenders argue that other industrial disasters (such as the chemical accident at Bhopal, India that resulted in 2 500 deaths) had been worse (Palfreman, 2006), but efforts to argue the pluses of nuclear energy – from clean air to a generally good safety record – were largely unsuccessful and, after Chernobyl, the United States' mood remained "decidedly antinuclear" (Palfreman, 2006:27).

In the absence of new accidents, the focus of many nuclear stories in the 1990s concerned the apparently intractable problem of what to do with nuclear waste (Palfreman, 2006). The problem of having to safely store large amounts of radioactive waste material has since garnered a steady stream of negative publicity in the media (Brokaw, 1992). The media history of nuclear energy, then, is steeped in the "singular powers" – both good and bad – that derive from the uranium nucleus (Palfreman, 2006:27):

> Over time, the negative imagery has proved more powerful and enduring. So, today, even if people do not read many stories about nuclear energy, nuclear fear is not far away.

Palfreman (2006:31) says that, if the responsible media have a role in promoting an educated populace that will engage intelligently with public policy issues, they have failed to do so in this regard because, after decades of media coverage, research has shown that the public is still "extraordinarily confused" about nuclear issues. This might also suggest that nuclear energy simply is a complicated, genuinely confusing issue on which experts differ.

Palfreman (2006) notes that scientists and media scholars who express frustration with inadequate science reporting argue that it can lead to at least three basic distortions. First, journalists distort reality by making scientific errors. Second, they distort by focusing on human interest stories rather than scientific content. And third, journalists distort by rigid adherence to the construct of balanced coverage. Here, again, the concept of 'balance as bias' seems to be a problem when communicating the risks of a new technology.

Del Sesto (1981:325) offers notes on how journalists ought to approach such issues:

> Good science reporting, particularly in the case of nuclear energy, requires broad, multidisciplinary training and expertise; the science journalist must be flexible enough to move freely between topics. He must be able to relate scientific and technological discoveries to other sciences, to the social sciences, and to humanistic concerns which include both morals and purpose. Moreover, the popularization of science and technology has a clear social dimension: because the impacts of science and technology often have broad social consequences, an account of the discoveries alone is not enough; equally important is an *assessment* of the social effects. This means that journalists and popularizers must act as critics as well as reporters. They must *evaluate* as well as

> translate science and technology developments. Indeed it is probably impossible, and certainly very difficult, to divorce assessment and evaluation from good science journalism. These facts suggest that the task of popularization is equal to the very scientific and technological achievements themselves.

Del Sesto (1981:326) also believes popularisers must show that science and technology "have an internal beauty of their own, and real cultural and philosophical significance". In other words science and technology should be popularised because they are part of the general human endeavour and to avoid "mystification" that widens the gap between public understanding and science:

> The reporter must therefore show that science and technology, sometimes vague and esoteric, have a place in the everyday lives of people and should not be either worshiped or feared *a priori* (Del Sesto, 1981: 326).

Others have noted related lessons for the mass communication of a radical new technology like nuclear energy, such as Gamson and Modigliani (1989:35), who explore the relationship between media discourse and public opinion on nuclear power, arguing for a constructionist approach through which "public opinion about nuclear power can be understood only by rooting it in an issue culture that is reflected and shaped by general audience media". This helps to account for a decline in nuclear support after the coverage of Chernobyl, a rebound of more positive sentiment after the burst of media publicity over Three Mile Island had died out, and the gap between general support for nuclear power (generally heralded as safe by the media) and support for a plant in one's own community (which heightens fears by bringing the issue closer to home).

Gamson and Modigliani (1989) further highlight the limitations of conventional methods (in particular surveys) of assessing public opinion on issues such as nuclear: firstly, that they obscure ambivalence (people who are neither strongly for or against nuclear), and secondly, they blur the distinction between people with non-attitudes and those with ambivalent views. Gamson and Modigliani (1989) warn against the tendency to impose elite dichotomies (pro- or anti-nuclear) on a mass public whose beliefs are not always organised along such clear lines. The media then – journalists and news editors – must also be wary of reportage that only follows a 'for or against' mentality that obscures ambivalence, nuance, proper context as well as scientific uncertainty, adequate ranges of probability and possible conflicting evidence.

On a related note, Rothman and Lichter (1987:383) finds that journalists' (and news editors' and media owners') own ideologies (whether pro- or anti-nuclear) influence their coverage of nuclear energy, and media coverage of the nuclear issue is "partly responsible for public misperceptions of the views of scientists".

Corner, Richardson and Fenton (1990), in examining TV discourse on the issue of nuclear energy, find that central to the nuclear-risk debate as it is articulated both by texts (programme makers, news producers) and by viewers is the question of 'proof' versus 'probability'. The consequence of this is that, given inconclusive scientific proof that nuclear energy can be made 100% safe and a wide range of future probabilities, both the media and viewers end up 'talking up' or 'talking down' a particular effects scenario, with a polarising effect.

Mazur (1990) argues that it is the *amount* of reporting on an environmental or technological hazard, rather than what is reported on the topic, that is the primary vehicle of communication about such risks, and that the beliefs of the audience follow directly from the intensity and

volume of reporting (through repetition of messages and images). Mazur (1990:295) contends that extensive reporting on a controversial technological or environmental project not only arouses public attention, but also pushes it towards opposition – even if the news treatment is balanced. This helps to explain how the endless repetition of nuclear bomb imagery could have deeply engendered a negative connotation for nuclear energy in the mind of the public, despite scientific evidence and news reports underscoring its general safety. This, Mazur (1990:320) notes, is not a fault of the media:

> While the reporting in the press and television affects which hazards and technologies are given most attention by the public, we must avoid the simplistic interpretation that risks are merely journalistic constructions, created and sustained to sell advertising in newspapers or on television. Journalists do not create news out of nothing. Sustained news reporting requires a continual supply of fresh, newsworthy information from acceptable sources.

As a consequence, explains Mazur (1990), public fears and hopes around nuclear energy rose and fell along the lines of prominent news events that received large volumes of reporting, such as the US and Soviet Union nuclear test ban treaty in 1963, the Three Mile Island incident, Chernobyl, various protest actions surrounding new nuclear power plants, developments in the Cold War nuclear arms race, and so forth – all of which cumulatively create a picture of public fears and feelings toward nuclear, based on what receives the most quantity of reporting:

> Why should publicity about weapons affect opinions about power plants? The broad American public is not well informed about science and technology. In contrast to active protesters, who are often more knowledgeable about the issues which concern them, the large majority of politically inactive citizens form only a simple image of these topics when they are reported in the press and on television. Whereas the protester against nuclear power-plants has both the motivation and knowledge to read in detail and understand a news story about power-plants or weapons, and to distinguish fully between them, the layman may simply scan the headline and photograph, and perhaps read the first paragraph, going no further because he lacks both the interest and the scientific knowledge to follow the story in detail. Perhaps as a result, nuclear power-plants and nuclear weapons merge together in the public mind (Mazur, 1990:322).

Because the public is presented with such an array of complex issues in the news media (and now social media) every day, no one can be expected to master every topic that is reported on, especially if it is of a technical scientific nature:

> Inevitably, what an audience extracts from newspaper and magazine reports are highly condensed and simplified impressions about topics that they do not follow in detail – one could hardly obtain anything else from news programmes on television … In these circumstances, it is the *quantity* of reporting that has the greatest effect on public opinion rather than its content or quality. Accounts that convey the same simple image, despite variation in the details, gain impact through repetition (Mazur, 1990:322).

This problem has become exacerbated in the current era through the rise of instant, online media messaging and social media, in relation to which Owen (2020) makes the point that

what makes fake news reports feel true for readers online is simply that they are hearing the same thing over and over again – as fake news and bogus conspiracy theories go viral and get reposted, retweeted and reinforced millions of times a day.

So ingrained has the public's subconscious fear in response to the issue of nuclear energy seemingly become that Perko, Turcanu and Carlé (2012) find that, even when a minor nuclear emergency with zero safety risk to the public is communicated immediately, openly and transparently, emotions tend to heat up quickly in the media and the public.

In 2008, a nuclear event occurred at Krško nuclear power plant in Slovenia (Perko *et al.*, 2012). Even though it was classified as a level 0 on the International Nuclear Event Scale, the transparency policy of the Slovenian nuclear safety authorities prompted it to notify the international community – the first time that the European Community Urgent Radiological Information Exchange (ECURIE) notification system was implemented. The event was reported in all major European media and Perko *et al*. (2012) analysed 200 news articles in printed and other media in Slovenia and other countries:

> The analysis revealed that despite a transparent communication policy by the affected country and low level of emergency, this event triggered a high intensity of media coverage … The results clearly demonstrated that the media reports often included messages with negative connotation. Even if the event had no safety significance, the media linked the event with the nuclear accident at Chernobyl and used emotion-triggering words such as 'panic' and 'danger'. The operators and the nuclear safety authorities are obliged by law to be transparent from and to openly communicate about nuclear safety issues, regardless of the possibility of (ab)using the emergency for political purposes. With constant and transparent communication, the communicators can avoid misunderstandings. However, emotional reactions and heated political discussions may arise when this is not accompanied by an adequate and transparent response in communication by international organizations because the main media sources in countries with open political questions related to nuclear energy tend to end up being politicians, rather than the resident experts (Perko *et al.*, 2012:61).

Because of the ingrained emotional response often associated with nuclear power, the media (especially in countries where nuclear energy is on the political agenda), in other words, tend to quote politicians, who are often more vocal and emotional in their rhetoric, rather than resident experts – even if every attempt is made by experts and authorities to keep official communication clear, open, up to date and transparent.

The internet – and its overabundance of information – has of course added another dimension to this debate. Friedman (2011) examines the extensive global media coverage of the 11 March 2011 Fukushima nuclear disaster – the worst since Chernobyl – following a tsunami that struck the coast of Japan and subsequently the nuclear power plant, leading to three nuclear meltdowns, three hydrogen explosions and significant radiation fallout:

> The Internet made an enormous amount of information on Fukushima available, far more than was provided by the media during the Three Mile Island and Chernobyl accidents. While journalists contributed much of the news about Fukushima, citizens actively participated in blogs and on Facebook, Twitter, and YouTube, exchanging views and directing others to important

> news articles or videos. The Internet also gave the traditional media many opportunities for better coverage, with more space for articles and the ability to publish interactive graphics and videos … Consequently, radiation coverage of the Fukushima accident was better than that of the Three Mile Island or Chernobyl accidents. (Friedman, 2011:1)

The size of the Fukushima information explosion on the internet, and the speed of transmission to readers and viewers worldwide, however, presented a new problem for traditional journalists, according to Friedman (2011). While finding expert sources to help explain events was not as difficult as it had been during Three Mile Island or Chernobyl, at Fukushima the problem wasn't *getting* expert sources; it was *vetting* expert sources. It became increasingly important for reporters and citizens to make "intelligent, discriminating use of the glut of online expertise" (Friedman, 2011:63).

Friedman (2011) also bemoans the internet's influence on the newspaper industry, leading to the laying off of many specialty reporters and science journalists who are capable of vetting expert views and opinions, and to understandably explain complicated, technical topics.

> Despite these problems, the Internet also has brought advantages. A different media world exists today than in 1979 or 1986. News events such as Fukushima draw millions of people worldwide, and the Internet gives them the ability to participate in discussions with journalists and among themselves, as well as to provide information about these events. This is the 'new media' as it is called in journalism, with active citizen participation and news selection. From a new media perspective, Fukushima has become iconic because of the massive outpouring of global information and interest, and its coverage in both the traditional and social media will be a standard against which future reporting, particularly of radiation, will be measured (Friedman, 2011:63).

In spite of these positive elements, Kim, Kim and Kim (2013), in a study of levels of public acceptance in 42 countries, find that the Fukushima nuclear disaster – like Three Mile Island and Chernobyl before it – changed public attitudes toward nuclear energy significantly and negatively. In particular, they note the effect of the suppression of information by government authorities and withholding it from the media and the public:

> After the Fukushima accident, the Japanese government was criticized for releasing inaccurate or unreliable information, which appears to have reduced public acceptance of nuclear energy (Kim *et al*., 2013:827-828).

Koerner (2014:240) concludes that media coverage of all three major accidents, at Chernobyl, Three Mile Island and Fukushima, overwhelmed scientific claims of safety and security in nuclear energy production, due in part to nuclear power having been "seemingly stigmatized" in American culture. A content analysis of media coverage in domestic and international newspapers following all three accidents revealed that over 70% of the headlines had negative undertones and over 50% of those mentioned fears for safety, health and the environment, or uncertainty about the outcome of the nuclear incident (Koerner, 2014). Chernobyl garnered more headlines in regard to trust of the government and the nuclear industry. The Three Mile Island and Fukushima headlines imply that the government response was more rapid and information was more readily available to citizens from nuclear administrators; however, formal commission reports on Fukushima later confirmed that information was withheld from the public to prevent panic in the population (Koerner, 2014:246).

Trust, according to Koerner (2014:246), takes a long time to build and very little time to lose.

To counter this trend of negative reporting, Koerner (2014:248) proclaims that knowledge transfer (regarding controversial technologies) requires more than providing reports and data and must include a dialogue between scientists and the public to identify priorities and answer questions:

> Negative media coverage can be linked to public perceptions, signalling fear and distrust for the nuclear industry, and causing reactive policy development. The success of nuclear energy – and other technologies – is highly dependent on public support and good publicity that cannot be achieved without scientists getting involved and publicizing positive nuclear achievements, such as improvements to safety, efficiency, and reliability.

The implication, of course, is that the media then have the responsibility to report on positive achievements as much as on negative achievements, which goes against the grain of traditional reporting, where *bad* news, in terms of selling stories and gaining audiences, has always been good *news* (better selling, at least).

Koerner (2014), like Friedman (2011:63), mentions how, in the new media world, it further becomes the inevitable responsibility of citizens to discriminate between credible sources, less credible sources, and fake news – as the internet and advances in communications technologies and social media have created vast amounts of uncertainty about where to turn for factual scientific sources. This occurs to the extent that the public is often "drowning in information, while starving for wisdom" (Wilson, 1998:294).

Perhaps the reason that the controversy around the issue of nuclear energy – and the associated difficulty in reporting on it – has endured for decades is not just the endless repetition in the media of nuclear bomb imagery, nuclear plant meltdowns and the spikes in reporting after accidents, but the fact that some new technologies cut into such core questions – like whether human beings should 'play God' by splitting the atom – that it alters the public's worldview entirely. As Friedman *et al*. (1992:305) put it:

> The introduction of a new technology can have profound effects on society. The technology can be a powerful tool for change and people will praise or fear it for its impacts. In some cases, a particular technology can colour public opinion about science or technology in general – whether they are moving society too quickly or taking it in the right direction, or whether science and technology need more regulation. Nuclear power is such a technology.

The theory of evolution and the discovery of climate change, as has been detailed in previous sections, had similar grand – and divisive – effects upon society and the public psyche. In the next section, the key lessons from each of these historical case studies in the literature are summarised and presented for comparison (Table 1).

2.4 Key lessons from history

Below is a table detailing the key lessons that can be taken from this literature review on research detailing the historical mass communication efforts surrounding the theory of

evolution, climate change and nuclear energy as examples of new scientific discoveries that had massively disruptive effects on society.

Those key lessons that seem to be common factors in all three of the case studies have been colour-coded for easier reference. In other words, key lessons with the same colour convey very similar concepts across the three case studies from the literature.

Table 1: Key lessons on mass communication on disruptive novel science and emerging technology in history (coloured by similarity)

Evolution	Climate change	Nuclear energy
It can take decades for a scientific theory or technology to be accepted, or even understood.	The complexity of a new scientific concept, and the often slow progress of science, can confound proper communication efforts, to the extent that it can take a century to reach scientific consensus on an issue.	A new technology can be both powerful and enabling, and also destructive in ways initially unfathomable even to the scientists who discovered or invented it.
Attention might initially be focused on the person(s) behind the initial discovery (as their credibility and their claims are tested by peers against prevailing knowledge) – rather than the discovery itself.	Faulty assumptions, and poor experimentation and instrumentation, can delay proper understanding of a new scientific idea by decades. In some cases, science and technology themselves need to 'catch up' with an idea.	Initial estimations of the value of a new technology are often either overhyped (e.g. the promise of 'free energy for all') or understated (e.g. initial scepticism about the practical feasibility of building an atom bomb, or the consequences of radiation fallout) by the authorities and the media.
There can be extreme public pushback when science threatens religious beliefs (science vs. religion). New science, in other words, can challenge pervasive world views (which often extend the time until acceptance).	There is extreme pushback when a technology or new science challenges core cultural beliefs (such as that humanity lives 'in harmony' with nature, that natural systems inevitably 'balance out', and that humans could not possibly have a lasting effect on the vastness of nature). This is especially true if people are asked to think in terms of decades and centuries into the future.	The implications of a powerful new technology could take decades to be properly understood (as with radiation fallout, radiation sickness and after-effects, the problems of nuclear waste storage, etc.).
Language – in other words, proper *context* – matters greatly (e.g. the grand misunderstanding of 'survival of the fittest').	Prominent events (such as Hansen's testimony in 1988 and the various IPCCs, etc.) can be massively influential in popularising scientific concepts and increasing media coverage.	Against the backdrop of war, the implications of new science or a new technology are viewed differently than what otherwise would have been the case. Consequences can include a resulting arms race to weaponise the technology, the disregard for normal moral-ethical considerations when faced with an 'enemy', and increased secrecy among scientists and governments.
Prominent events around a new discovery take precedent in the news cycle.	On complex scientific issues, journalists and the media inevitably also become educators of the public.	Even when scientists and the media, after consideration, accurately anticipate the potential destructive consequences of a new technology, against the

		background of war, its destructive power will still be hotly pursued for fear of the enemy 'getting there first' – and this might be justified.
The media favours *conflict*, and often frames new science in term of extreme viewpoints (e.g. science vs. religion).	Various micro- and macro-scale pressures play a role in the production of news (media ownership, advertising, deadlines, political agenda, norms and values of journalists and news editors, etc.) and these pressures inevitably shape how novel science is framed.	Scientists, by nature, are not often wont to speculate about the future, sticking to facts and acknowledging *uncertainty* and the existence of *probabilities* – which tasks the media to 'speculate beyond the data' in order to inform the public of the potential consequences of new science.
The mainstream media might be more inclined, initially, to report on novel science or technologies than science journals (because of the lure of sensation, and less resistance to potentially disruptive new evidence).	In developing countries in particular, a lack of funds and proper training for journalists can be a major barrier to sufficient local reporting (e.g. on climate change).	The media's portrayal of prominent events (Hiroshima, Nagasaki, TMI, Chernobyl, Fukushima) has a massive effect on how society views new science and technologies. If prominent events are negative in nature, their coverage can overwhelm scientific claims of safety in the long term.
Scientists and journalists are also influenced by strong personal beliefs (including religious beliefs), ideologies and bias – that could lead to unobjective, unbalanced reporting.	Uncertainty (and probabilities) is a crucial part of science and ought to be a part of science reporting too. The media, however, tend to 'translate hypotheses into certainties'.	Through the lens of war, even accurate, comprehensive reporting on the human suffering caused by a new technology can be seen in a positive light due to a lack of empathy – and even open disdain – for an enemy people (with coverage rather focusing on the awe of the destruction itself, rather than on its victims). Censorship exacerbates this.
Levels of knowledge (education), or the lack thereof (among journalists, public officials and citizens), affect public perceptions of new science and evidence (and the less educated are not less opinionated).	'Balance as bias'. Giving voice to opposing views not supported by evidence, in the name of balance, can become a form of bias – and a weight-of-evidence approach might be best in order not to mislead the public.	The withholding of information about a new technology by government and scientists from the public (for instance censorship due to war), creates a negative public perception.
New science can change science (and its processes) itself.	Proper *context* for assertions about novel science and technologies (about risks, effects, agendas and interests, etc.) is crucial and often lacking.	Propaganda about a new technology can be very effective (e.g. the legitimisation of dropping the bomb as an accepted narrative).
More new scientific discoveries might be required for the acceptance of a new scientific theory (e.g. genetics proves evolution).	Increased understanding increases humans' desire to positively change their behaviour.	The media's responsibility to educate the public on the technicalities of a new technology can be a heavy burden, easily strained by traditional newsroom dynamics (budget constraints, a lack of training and expertise, a lack of will, deadlines, etc.).

New science can be met immediately by competing alternative theories (by those who disagree, or misunderstand), causing public confusion.	Novel science, especially when it is contentious and involves a lot of uncertainty, can become extremely *politicised and polarising*. Denialists, activists, politicians and propagandists who exploit scientific uncertainty and the norm of balance for political or economic gain have been extremely effective in confusing and misleading the public.	The direct victims of a new technology can be silenced for decades through information censorship and discrimination – leaving them voiceless, unless the media step in to tell their stories.
Alternative views and perspectives can enhance public accessibility, understanding and acceptance among different groups (embracing the uncertainty and varying probabilities of new science can afford space for broad views and greater acceptance).	The *global* is often highlighted without proper context or appreciation of the *local* landscape of the issue (revealing a need for context, personalisation and engagement).	The media ought to be ever critical of government decisions, even during wartime (perhaps especially so). If not, the media become 'reflectors' rather than 'shapers', and may in effect aid in distorting history.
Misunderstanding or misappropriation of the risks and implications of new theories or technologies can have harmful effects on society that the media would do well to *anticipate* in their reporting.	In the face of many pressures and potentially misleading politicised external influences, a form of advocacy journalism might be required in order to properly inform the public.	Once public trust in officials, scientists and government to manage a new technology has been lost (e.g. after deliberately withholding information like radiation exposure), it might be extremely hard to regain (TMI, Chernobyl, Fukushima) – 'trust takes a long time to build, and very little time to lose'.
	Be wary of 'hot takes' that make for good headlines (CFCs causing an ice-age, etc.) but might not be supported by evidence. Remain critical, also of the veracity of the science that is presented.	The repetition of messaging, especially imagery (atom bomb mushroom clouds, looming nuclear plant cooling towers) can be extremely powerful to shape the public psyche.
	The media ought to take into account not only the objective facts, but how audiences will *feel* about the risks that those facts represent (i.e. if it will challenge their core beliefs).	It is extremely important that journalists who report on new technologies should have some technical understanding of it – otherwise it becomes impossible to educate the public.
		The media often highlight 'pro-' or 'anti-' viewpoints that polarise, but it is misleading to assume the public can be neatly split into 'pro' and 'anti' categories regarding a new technology – many people have ambivalent views.
		The *quantity* of reporting (the repetition of messages) is often more impactful than the quality of individual news reports.
		Journalists can distort reality by making scientific errors, by keying human-interest stories rather than objective scientific *context*,

		and by rigid adherence to 'balanced' coverage, especially if views expressed are not weighted by evidence.
		The media ought to take into account not only the objective facts, but how audiences will *feel* about the risks that those facts represent (i.e. if it will challenge their core beliefs) – and anticipate, evaluate and assess possible social effects of science. In other words, be engaged in a dialogue with the public from an early stage.
		Nuclear power paved the way for a greater understanding of the need for social responsibility in anticipating the potential implications of scientific research – for scientists, the media, and society in general.
		Proper *context*, in all respects, is often of vital importance to ensure accuracy and to prevent damaging misconceptions (e.g. putting nuclear fears in proper scientific context, or to properly warn of radiation dangers).
		The media should avoid an overreliance on official sources (especially politicians), and verify claims through independent experts.
		The internet and social media have caused an overabundance of information (including false information and fake news). The media are then tasked with ensuring (and investigating) the credibility of expert sources – and not exacerbating the spread of viral falsehoods or unfounded fears. The media should aim for wisdom, rather than simply information.
		A new technology can alter the public's worldview entirely by cutting into core beliefs (such as whether humanity ought to 'play God' by splitting the atom).

Although all of these lessons are important to remember when trying to communicate potentially disruptive new science and technologies, nine of the key lessons were common to all three the case studies and might therefore be held in somewhat higher esteem.

To create a basis for the proposed media ethics theory, these common Nine Tenets – for the ethical communication of emerging science and technology – were further condensed and summarised as follows:

1. New scientific discoveries and emerging technologies become disruptive when they challenge *widely held core human beliefs*.
2. It takes many *decades* for a new technology or scientific discovery – and all its positive and negative impacts – to be understood adequately (and in many cases, it might never be fully accepted by all).
3. Because of the media's propensity to report along lines of *conflict* (science vs. religion, climate activists vs. climate deniers, pro- and anti-nuclear, etc.), the media often highlight extreme viewpoints on controversial discoveries and technologies (either 'for' or 'against'), which frequently lead to an accidental or deliberate *polarisation* and *politicisation* of the issue, obscuring nuance and objectivity.
4. The media's coverage of *prominent events* regarding a new technology or scientific development is massively influential with regard to how the public views that technology or idea.
5. A rigid adherence to 'balance' can cause significantly harmful bias in the media when it comes to science and technology. The media therefore ought to balance reporting, claims and expert opinions on the *weight of evidence*.
6. Proper *context* – in all respects – is often crucial for accurate, responsible reporting on technologies and discoveries.
7. A lack of *adequate knowledge* on the part of journalists, officials and politicians (due to ignorance, a lack of technical expertise and training, personal bias, etc.) seems to be a major barrier to true understanding of novel science and technologies in the public sphere.
8. The media ought to take into account not only the objective facts, but how audiences will *feel* about the risks that those facts represent – and anticipate the possible societal effects early on.
9. When it comes to new technologies and scientific developments, journalists and science popularisers should learn to embrace *uncertainty* and the concept of *probabilities*, and make it part of their narrative in order to be most truthful in educating the public on potential future risks.

Inevitably, there will be consequences of future scientific discoveries and disruptive new technologies that will be completely unforeseen and unprecedented – and that may, in spite of the very best efforts at accurate, transparent, sensitive and responsible communication by scientists and journalists, remain unknowable until the technology or the discovery is made. As Ernest Rutherford said in 1936 – before the discovery of nuclear fission – on the question of the social responsibility of scientists:

> During the last few years, there has been much loose and uninformed talk of the possible dangers to the community of the unrestricted development of science and scientific invention. Taking a broad view, I think that it cannot be denied that the progress of scientific knowledge has so far been overwhelmingly beneficial to the welfare of mankind … It is, of course, true that some of the advances of science may occasionally be used for ignoble ends, but this is not the fault of the scientific man but rather of the community which fails to control this prostitution of science … It is sometimes suggested that scientific men should be more active in controlling the wrong use of their discoveries. I am doubtful, however, whether even the most imaginative scientific

> man except in rare cases is able to foresee the ultimate effect of any discovery (Badash *et al.*, 1986:224).

The same holds true for the science journalists who have to communicate such discoveries. Nevertheless, any attempt at creating a theoretical framework for media ethical principles that might guide science journalists in this regard in the future must, at the very least address, these Nine Tenets.

In 1936, Rutherford proposed that the government create a "Prevision Committee", which would seek to determine when the application of a discovery might have an adverse effect on the public. Alas, such committees are mostly absent from governments today.

A novel, future-centric media ethics theory of the communication of potentially disruptive science and technology – based on the identified Nine Tenets – could however be used to draft a practical field guide for science journalists, educators or citizens who are facing these problems with regard to the emerging technologies of today.

In the next chapter, the relevant existing media ethics theories, risk communication theories and emerging technology ethics theories that inform this study's own proposed approach are examined.

CHAPTER 3

3. Theoretical background

3.1 Media ethics: meta-ethics, global resonance and responsibility

This study will, apart from the Nine Tenets arrived at in the previous chapter, be guided by certain first principles in meta-ethics – firstly because these principles are what has guided all ethics since their inception, but secondly because second-order, more specific *normative* media ethics theories are often too dependent on particular circumstances, political systems, cultural contexts, socio-economical climates and media technologies, whereas this study aims to arrive at an ethics theory deliberately *divorced from time* (as far as is realistically possible) so as to be as applicable as possible at any point in (future) history.

Such a theory must obviously take into account the prevailing socio-political values, beliefs, circumstances and cultural context of the day, but must not *rely* on them. Otherwise the theory becomes irrelevant once the cogs of history turn, replacing old political systems or ideological spheres with new ones. It needs to be a basic theory, relying on logical, meta-ethical principles rather than era-specific ideology.

Most media ethics theories are based on related normative theories of mass communication, which are frequently era-specific. For example, authoritarian media theory is heavily influenced by authoritarian politics, while democratic-participant theory is mainly applicable in democratic societies (Fourie, 2001:269-275). As soon as new political dispensations, cultural paradigms or social phenomena arise (such as postmodernism or post-colonialism), new normative theories on the role of the media will emerge – including new ethical perspectives.

Similarly, media theories concerned with *culture* (e.g. hegemony) are necessarily limited to the ideological persuasions and cultural context of their time (Fourie, 2001:354-381; 2015a:271-284). Theories on the *effects* of the media on society have also evolved dramatically as the relationship between the media and its audience has changed from completely passive to increasingly active (Fourie, 2001:290-310; 2015a:227-267). It is obviously true that the media's portrayal of new science and technology has an effect on society, but theories concerned with explaining these effects will inevitably need to be updated continuously as media consumers' behaviour keeps changing, due for instance to technological advances (such as the internet and social media), or new political or cultural beliefs. Theories on media *audiences* have changed equally dramatically as the media landscape (and its audience reach, appetite and interactivity) grew exponentially in the past 50 years, leaving media audiences increasingly segmented, media technologies increasingly varied and media ownership increasingly fragmented (Fourie, 2015b:389-412).

Media ethics based on ever-changing normative media theories, each containing specific perspectives about media culture, media effects and media audiences, are consequently too impermanent for the goals of this study. Because these media ethics theories are tied to fundamental values as articulated by a specific political and cultural ideology (Oosthuizen, 2015:5; Retief, 2002:11), they cannot easily be applied generally and, as such, *meta-ethics*, concerned with evaluating ethics theories based on what moral principles they are founded upon, is more applicable.

The two prevailing systems of meta-ethics are known as *teleological* ethics, chiefly concerned with the *consequences* of a given decision or action, and *deontological* ethics, concerned with the *duties and obligations* of an ethical agent (Oosthuizen, 2015; Retief, 2002).

According to Oosthuizen (2015:16) and Retief (2002:8), teleology is closely associated with John Stuart Mill's utilitarianism, which can be summed up as striving to achieve the greatest happiness (or pleasure) for the greatest number of people; in other words, the action that leads to the best outcome for the majority of society is the most ethical (good) choice. Two major disadvantages of this approach is that the focus on the majority could easily marginalise a minority group, and it is also very difficult to accurately determine the long-term consequences of any decision.

Deontology, chiefly developed by the German philosopher Immanuel Kant, on the other hand, focuses on universally applicable *moral duties* and responsibilities (Retief, 2002:9). What counts is the *intention or motive* behind the act, and not so much the consequences. Kant's *categorical imperative* for ethical behaviour states that a person acts ethically if he or she would be willing to see a decision applied to everyone in society in a similar situation (Oosthuizen, 2015:14; Retief, 2002:9-10). The problem becomes how one divorces one's duties from the consequences of one's actions.

Both the teleological and deontological schools of ethics can create serious problems when it comes to the communication of emerging science and technologies. Take, the example, the dropping of the nuclear bomb on Hiroshima, discussed at length in Chapter 2. Reporters who initially failed, either by obscuring facts or by simply quoting misleading official reports, to truthfully and accurately report the devastating damage of radiation fallout on the Japanese people might well have felt – in teleological terms – that the consequence of dropping the bomb equated to 'the greatest good for the greatest number of people' by ending the war, and that they were justified in sticking to the official story to support that narrative. In deontological terms, they might even have felt it was their patriotic duty to report how the bomb had 'saved the West' by ending the war, rather than on the plight of the bombed enemy. Nevertheless, as a consequence, the truth of the sickness and enormous suffering caused by radiation fallout (in turn an important potential consequence of nuclear energy) was for a time widely ignored.

These two systems of thought are often oversimplified as being theoretical opposites. Retief (2002:7), however, makes it clear that, in journalism, they can and should be combined in certain circumstances, or be weighed against one another to find the best fit for a given ethical dilemma. Another ethical paradigm, Aristotle's *golden mean*, then often comes into play.

Both teleology and deontology can lead to unacceptable extremes (Retief, 2002:10), either tending to strict legalism, or an unstructured 'morality' without set principles that can lead to relativism. "One of the big dangers in modern (or postmodern) society," says Retief (2002:10), "is that people tend to write ethics off as 'relative' – as if there are no journalistic principles. Indeed there are such principles … Nothing is more detrimental to the cause of excellence in journalism than an 'anything goes' attitude."

Both extremes then ought to be avoided. Somewhere between absolutism and anarchy, "a golden mean must be found" (Retief, 2002:10). Greek philosopher Aristotle's solution was to focus on the virtue and good character of the individual (who would inevitably make more ethical decisions). One of the main exponents of such *virtue ethics* was that a person of good character must shun any forms of extremity and choose a path in between – *virtue lies somewhere between vices* (Retief, 2002:10). This is the doctrine of the golden mean, striking a balance between teleological and deontological considerations. It does not necessarily always lead to a 50/50 situation, because one extreme might be closer to the ethical truth than another. But the idea is to find a compromise that avoids harmful extremes.

Although other philosophers, like Bertrand Russell and Karl Popper, have critiqued Aristotle's philosophical ideas, this study makes use of Aristotle's golden mean as a loose

guiding principle in the endeavour to find a similar balance between communicating the risks *and* the benefits of emerging science and technology as a means to limit harm.

Two more aspects of media ethics that play a central informative role in this study, are the ideas popularised by Wasserman (2017, 2018), of the need for non-elitist journalism ethics with global relevance and resonance, and by Van Niekerk (2018, 2020), of the core concept of *responsibility* with regards to future ethics and emerging technologies.

Wasserman (2018) argues the acceleration of globalization via communication infrastructures has necessitated an attempt at constructing ethical frameworks with "global relevance and resonance" (Wasserman, 2018:449). The implication for this study being that a new media ethics framework regarding the communication of emerging technologies ought to ideally be applicable anywhere, ought not to be relegated only to the realm of professional journalism and cannot be elitist:

> …the decoupling of professionalism and journalistic ethics has become necessary, given widespread disruption of the legacy journalistic paradigm. The increased possibilities for citizens to create and participate in media production, as well as the waning influence of legacy news platforms, have shown that media ethics must be rethought separately from professionalism. Media ethics can no longer be limited only to media institutions but must include everyone participating in the production, circulation, and adaptation of media content. This shift in the media landscape has necessitated thinking about journalism ethics as 'open' (i.e. participatory, fluid, incomplete) rather than 'closed' (limited to a professional class of journalists, fixed, elitist) (Wasserman, 2017:316).

This is why the field guide presented in this study has a central aim of being as simple and accessible as possible, in order to be globally useful, relevant and not merely applicable to science journalists but to the general public and social media content creators (and users) as well.

Lastly, this study also draws inspiration from the works of Van Niekerk (2018, 2020) who has written extensively on future ethics with regard to emerging technology issues such as biotechnology, robotics and artificial intelligence, arguing that *responsibility* needs to remain a central focus:

> The key concept in this regard is responsibility. Only by fully accepting responsibility for what is done, will the development and implementation of these new techniques and therapies yield the efficacious outcome that they promise future generations. To be responsible means to be able and willing to always provide well-argued reasons for every action, but also to acknowledge the possibility of, and to take responsibility for, failure. Very few things in life are inherently good or evil; the same applies to the new genetic biotechnologies. Their value and their moral acceptability will always depend on the good that they can achieve and the suffering they can avoid. Decisions in this regard will have to be made on a case by case basis, and will only succeed moral scrutiny if those decisions are couched in the sustained acceptance and execution of the sense of responsibility that is the hallmark of our species (Van Niekerk, 2018:59).

Van Niekerk argues that, as our technological powers increase in the Fourth Industrial Revolution, so too will our sense of responsibility in how to wield those powers, need to increase:

> The control exerted over these phenomena [technologies like artificial intelligence] to prevent harm will become an ever-increasing part of the ethics of the future. What will or ought not to change, is the intuition that the most important category of ethics is responsibility. The Fourth Industrial Revolution is essentially a reflection of the growth of our power over nature and society. More power must mean the acceptance of a more developed and more focused sense of responsibility (Van Niekerk, 2020).

Keeping in mind the needs for responsibility and global relevance, some additional theories and concepts from the fields of risk communication, emerging technology ethics, science communication and press codes of ethics also need to be briefly discussed as part of the theoretical background to this study.

3.2 Bearing risk in mind

The communication of new science and technologies to the public will inevitably also touch on concepts related to *risk communication* theory. Risk communication models, however, are most often dependent on a specific risk to the public at a specific point in time (a nuclear radiation leak, a viral pandemic, safety regulations at a mine, etc.) and, as such, are also highly contextual and change over time. Furthermore, risk communication focuses primarily on the potential negative consequences of a technology, discovery or event, and is generally not concerned with the potential benefits. Nevertheless, some risk communication theory principles bear mentioning.

Frewer (2004) states that public perceptions of risk, usually based on psychological factors, are often quickly dismissed on the basis of "irrationality" and are thus frequently excluded from policy processes by risk assessors and managers (or the media, experts and authorities). This is because "the technical risk estimates traditionally provided by experts do not influence people's behaviours and responses in the same way as their risk perceptions" (Frewer, 2004:391). Therefore, risk communication should take account of the actual concerns of the public (as opposed to only those risks highlighted by experts). Frewer (2004:391) continues:

> When the public want information about a risk, they prefer a clear message regarding risks and associated uncertainties, including the nature and extent of disagreements between different experts. Furthermore, societal priorities for risk mitigation activities may not align with those identified by expert groups. Dismissing the former as irrelevant may result in increased distrust in the motives of regulators and industry, with consequences for public confidence in regulatory activities linked to public protection. Awareness and understanding of public concerns must be the basis of an effective risk management strategy.

In other words, public sentiment regarding new technology risks matter, and may differ from expert views, and also the public *want* to know about potential uncertainty.

Surveys by Gardner and Gould (1989:225) gave rise to a very similar conclusion 15 years earlier by stating that members of the public tend to define 'risks', 'benefits' and 'acceptability' in a "complex, multidimensional manner; and that their definitions differ significantly from those used by professional risk-managers and other technical experts in quantitative assessments of risk and acceptability".

These points line up well with what has been mentioned in the Nine Tenets above, about taking into proper account how audiences will *feel* about risks, and about the importance of embracing uncertainty as a natural part of any scientific narrative. At the same time, if public concerns – that turn out to be unfounded by evidence – are given too much sway, it could easily lead to a 'balance as bias' scenario, which again highlights a weight-of-evidence approach.

Sheppard, Janoske and Brooke (2012) draw similar conclusions when summing up theories and models of risk communication applicable to the *preparedness phase* of a risk event (preparing and informing the public before a coming risk event, as opposed to the response and recovery phases of risk events, which are of less concern here).

These risk communication theories and models recommend, in summary (Sheppard *et al.*, 2012:16):

- incorporating community members into planning;
- identifying in advance multiple channels to disseminate risk messages during a crisis; and
- understanding how publics perceive risks prior to disseminating messages.

Dunwoody and Peters (1992:23) similarly suggest a framework for media risk information effects: that audiences are active risk message information processors, that individuals will utilise different information channels to inform themselves of risks they deem relevant, and that individuals may often interpret media messages as conveying societal-level rather than individual-level risk information.

Science communicators and journalists are not always empowered to increase the amount of information channels to help inform the public, but they can make efforts to increase public awareness of and engagement with the content, to ensure the breadth and accuracy of reporting, and to adequately anticipate audience fears and responses.

Renn and Benighaus (2013), in attempting to provide a structured framework for technological risk perception, conclude that the intuitive understanding of technological risks is a multidimensional concept that cannot be reduced to the product of the probabilities and consequences of a technical risk assessment alone. Nevertheless, although risk perceptions differ considerably among social and cultural groups, there are two common features that appear to be universal: the multidimensionality of risk beyond probability and the extent of damage, and the integration of beliefs related to the perceived risks, perceived benefits, and the context in which the technology has been introduced and diffused into a holistic judgement (Renn & Benighaus, 2013:307).

The conclusion drawn (Renn & Benighaus, 2013:308) is that value expectations and cultural background are significant determinants of subjective risk perception when it comes to new science and technologies.

Any proposed media ethics framework for the communication of emerging science and technologies therefore should take into account the importance of prevailing societal values,

expectations and cultural contexts in order to be able to adequately anticipate and address public concerns.

3.3 Emerging technology ethics

Several researchers, notably Brey (2012, 2017), Lucivero, Swierstra and Boenink (2011), Moor (2005) and Sandler (2014), have proposed different but similar approaches to the ethics of emerging technologies.

Moor (2005) established Moor's law: As technological revolutions increase, their social impact and ethical problems increase.

This highlights the need to identify ethical problems early on in the *introduction* stage of technology development (as opposed to the *permeation* stage and *power* stage), when the technology is often still largely esoteric and considered an intellectual curiosity (Moor, 2005:112). This is because Moor (2005:113) argues that technological revolutions "do not come from nowhere" and that a pre-revolutionary period exists in which basic concepts and understanding develop that make the introduction stage possible. Ethical issues should be identified at this early stage in order to steer technology development responsibly:

> I believe the outcome of technological development is not inevitable. We at least collectively can affect our futures by choosing which technologies to have and which not to have and by choosing how technologies that we pursue will be used. The question really is: How well will we choose? (Moor, 2015:112).

Lucivero *et al.* (2011) warn that ethicists should not take for granted the plausibility of expectations and visions of emerging technologies (as expressed by scientists, experts or journalists who may be biased out of a desire to secure funding, acclaim or audience reach), especially in the early stages of development when the technology is still malleable. They further say that proper ethical assessment of the plausibility of such expectations should take into account not only the technology's *feasibility* and societal *usability*, but also its inherent *desirability* – which often allows a more conservative, objective stance.

The ethicist, according to Lucivero *et al*. (2011:140), contributes to the quality of expectations of a new technology by "exploring the social and human context in which the technology is expected to operate", and by integrating lessons on moral change that may be learnt from the philosophy and history of technologies (as, for instance, was done in the literature review in Chapter 2, on which the Nine Tenets are based). Ethicists need to avail themselves of the societal context when a new technology surfaces, because "not every potential user or stakeholder deems plausible techno-scientists' universal claims of desirability", and "the allegedly universal benefits that a technology is supposed to bring about are, de facto, not unanimously shared or understood" (Lucivero *et al.*, 2011:136). Specifically, the following recommendations are made for the ethical assessment of emerging technologies (Lucivero *et al*., 2011:139-140):

- As far as technical *feasibility* is concerned, ethicists need to critically assess the context in which specific claims on behalf of emerging technologies are made, and make sure that a number of experts are consulted – and confronted with each other.
- In terms of social *usability*, ethicists should aim for 'thick descriptions' of the practice in which the technology is supposed to be embedded, and such envisioned practices should be discussed with potential users and stakeholders.

- Finally, ethicists should critically appraise the claims regarding the *desirability* of the technology by anticipating moral controversies and looking to history to determine the potential for techno-moral change.

Brey concludes in 2017 that the ethics of emerging technologies "is still in its infancy" (Brey, 2017:14), and proposes a new approach to the ethical study of emerging technologies, called Anticipatory Technology Ethics (ATE). Brey's ATE approach allows for detailed and specific forecasting of technologies for ethical analysis and builds on the previous approaches of Ethical Technology Assessment (e-TA), the techno-ethical scenarios approach and the ETICA approach (Ethical Issues of Emerging ICT Applications). Brey (2012:3-7) provides a critique of these approaches, pointing out the weak points of each before explaining his proposed ATE approach to remedy these weaknesses.

The ATE approach distinguishes three levels of ethical analysis of emerging technologies: the *technology level*, on which general ethical issues surrounding the technology are considered; the *artefact level*, on which the ethics surrounding the types of physical artefacts, systems and procedures that could result from the technology are considered; and the *application level*, on which ethical analysis focuses on the various ways of using a specific artefact (Brey, 2012:7-8). A number of different forecasting methods are recommended for each of the three levels, including consultation with engineering scientists to chart the internal features and development of the technology, reviewing existing futures studies, and interviewing expert panels to forecast future artifacts and applications (Brey, 2012:11).

Ethical analysis using ATE is performed at two initial stages, the *identification* and *evaluation* stages. At the identification stage, moral values and principles are operationalised and cross-referenced with technology descriptions resulting from forecasting studies. The values and issues are derived from an ethical checklist, as well as from existing technology ethics literature and bottom-up analyses. At the evaluation stage, the potential importance of the identified ethical issues is evaluated, and these issues are elaborated to be used for improving technology development, policy direction, better governance of the technology, etc. (Brey, 2012:11).

Sandler (2014:12-16) identifies several extrinsic concerns (the environment, health and safety, justice, access and equality, individual rights and liberties, autonomy, authenticity and identity, and dual use) and intrinsic concerns (playing God, hubris and respecting nature) that are common to new, emerging technologies, and then presents a framework for ethical analysis. Sandler (2014:19-20) believes "a fairly comprehensive ethical analysis of an emerging technology" can be accomplished by:

- Identifying any *benefits* the technology might produce (with respect to both human and nonhuman flourishing), including how large the benefits would be and how likely they are to occur.
- Identifying any *extrinsic concerns* that the technology may raise, including how likely it is to do so.
- Conducting a *power analysis* to identify who is empowered and who is disempowered by the technology, as well as how they are empowered or disempowered.
- Conducting a *form of life* analysis to identify how the technology might restructure the activities in which it is involved, as well as the personal, social and ecological conditions of people's lives.
- Identifying any *intrinsic concerns* that the technology is likely to raise.
- Identifying any *alternative approaches* to accomplishing the ends at which the technology aims, including less technologically sophisticated possibilities.

Crucially, such analysis ought, according to Sandler (2014:19), to be done "over the course of the technology's lifecycle" – as opposed to the as-early-as-possible perspective of other mentioned approaches. The idea is to leave room for changes in the technology and its applications that may introduce new ethical problems.

These approaches and conclusions are worth noting, but are chiefly concerned with a careful, detailed, in-depth ethical analysis of different emerging technologies. As such, they are only useful for the communication of emerging technologies when the communicator, educator, journalist or layperson has the time and ethics training for such an analysis – as well as an audience ready to engage with such material.

For the purposes of this study, this is problematic. In the era of social media and the internet, science journalists, communicators, influencers and especially media consumers will very rarely have the time for such in-depth ethical analysis. Journalists are compelled by online editors and their audiences to get news (including science news) out *as fast as possible* – and online audiences often share content they like *instantly* in order to get "likes" from their own audience in the form of their friends and followers on social media. Science content deemed interesting is consequently often shared without a second thought for the validity or ethics involved.

This study is an attempt to address this through a novel media ethics theory that can inform a simple, logical, easy-to-use field guide for science communicators in the ever-online, instantly shared digital era.

Furthermore, the approaches mentioned are concerned with the ethics of different emerging technologies themselves, and not the ethics of the *communication* of such technological advances or new science per se.

For these reasons, the existing theoretical approaches serve here mainly as rich, valuable background for a novel media ethics theory detailed in Chapter 5.

3.4 Press codes and models of science communication

A final aspect to consider for a theoretical background is the emergence of various standard Press Codes of Ethics that have emerged ever since it was realised that the media might be harmful to the public, and that "the media play an active role in shaping and constructing controversy rather than just reporting it" (Mazur, 1981:114). Furthermore, it becomes important how these codes of ethics relate to existing models of science communication and science journalism.

Informed by the different normative media ethics theories that have been developed (Oosthuizen, 2015:2-3), press codes are aimed at helping journalists and news editors to determine when it is appropriate to publish which content to limit societal harm.

A typical contemporary example of such a code of ethics is that of the Society for Professional Journalists (www.spj.org/ethicscode.asp), which is comprehensively built around the following four key points:

- Seek truth and report it
- Minimise harm
- Act independently (without undue influence)
- Be accountable and transparent

Most modern press codes encompass, at the very least, these four ideals. So where does this leave science journalism and science communication?

While most codes of ethics for journalists apply just as well to science journalism *in general*, the fields of science and technology have additional considerations. For instance, the four points above hardly address all the issues raised by the Nine Tenets discussed earlier, and codes of press ethics generally do not account for the great disparity in terms of specialised, expert knowledge that exists between scientists and laypersons.

As recently as 2018, delegates at the 5th World Conference of Science Journalists agreed that science journalists "need a code of ethics if they are to communicate increasingly complicated science accurately" (Jia, 2018), further stating that "various journalistic codes have been adopted by the media worldwide, but few have been suggested specifically for science reporting". A major problem that was highlighted was the frequent overhyping of research findings.

Rob Morrison, vice-president of Australian Science Communicators, presented research showing that almost half of the news releases posted on the science press website EurekAlert in 2006 were labelled as a 'breakthrough', stating that overuse of the term fuelled the hype around science, but noted that such sensational language was all too often required to grab the attention of editors and audiences (Jia, 2018). Bob Williamson, a professor of medical genetics at the University of Melbourne and an active science communicator, said an ethics code could help science journalists defend themselves against being required to hype or hide information (Jia, 2018).

Another concern was the increasing influence of public relations in science communication, with institutions "using science reporters to paint a positive image of their work" (Jia, 2018). Proper ethical rules and descriptions could therefore also help journalists distinguish science news from public relations material. Both of these issues might, at least to some degree, be addressed by a weight-of-evidence approach, as suggested in the literature review in Chapter 2, but other problems remain.

To help address some of these issues, Claassen (2019) created a useful list of principles tailored to help guide science journalists in avoiding ethical problems that frequently occur when trying to communicate science. Other science communicators have created similar guides. Claassen (2019:199) lists ten essential ethical principles to summarise "what every science journalist should know about science", that adequately supplements existing press codes of ethics so as to best avoid moral dilemmas in science journalism.

As it turns out, these ten essentials line up quite well with the identified Nine Tenets.

To illustrate this, and to ensure the Nine Tenets are sufficiently fleshed out in concept and description for further use, the Nine Tenets were compared to Claassen's "ten essentials". In Table 2, the ten issues are placed next to the specific tenet to which it corresponds the best. It becomes evident that all ten can be said to be sufficiently covered by the identified Nine Tenets.

Table 2: Comparing the Nine Tenets with Prof. George Claassen's "ten essentials"

Nine Tenets	**"Ten essentials" (Claassen, 2019:204)**
1. New scientific discoveries and emerging technologies become disruptive when they challenge widely held *core human beliefs*.	

2. It takes many *decades* for a new technology or scientific discovery – and all its impacts – to be adequately understood.	**Understand the difference between textbook science and frontier science.** (Textbook science is settled, accepted scientific knowledge, while frontier science is science that is still being conducted and is therefore still uncertain and unconfirmed. The implication is that it takes a long time for frontier science to become textbook science. What the media labels a 'potential breakthrough' might, in a few years, turn out to be nothing at all.)
3. Because of the media's propensity to report along lines of *conflict*, controversial and extreme viewpoints are often highlighted, which frequently leads to accidental or deliberate *polarisation* and *politicisation*.	**Beware of conflict of interest.** (The independence of scientists is as important as the independence of journalists. Journalists should always ask, who funded the study? Were all the results published, and was the research registered, or maybe even abandoned? If so, why?)
4. The media's coverage of *prominent events* regarding a new technology or scientific development is massively influential with regard to public perception and acceptance.	
5. A rigid adherence to 'balance' can cause significant harmful bias if not based on the *weight of evidence*.	**The question of balance, fairness and evidence.** (The *audi alteram partem* rule is not an absolute rule in science reporting, because evidence becomes the vital aspect.) **Use the primary source first.** (Many journalists report on science from a secondary source, like news releases by universities and research institutions – which often exaggerates or negates important context.)
6. Proper *context* – in all respects – is crucial for accurate, responsible reporting on technologies and discoveries.	**Avoid offering misleading or harmful tips without sufficient evidence.** (Journalists often fail their moral obligation of being accurate in their reporting on science when, because of the nature of news presentation, the news is often summarised by publishing lists of tips on scientific or other subjects that do not necessarily provide the full findings or corpus of research.) **Anecdotes are not reliable data.** (Journalists reporting on science have a moral obligation to point out that anecdotes can be dangerous because they are mostly selective and taken out of context.)
7. A *lack of adequate knowledge* on the part of the communicator or sources is often a major barrier to true understanding of novel science and technologies in the public sphere.	**Accentuating positive impacts, and ignoring negative impacts.** (It is vitally important that journalists and science communicators achieve a balance between the positive results of research findings *and* the negative aspects, often hidden away in the conclusions or discussions section of peer-reviewed articles.) **The difference between science and pseudoscience.** (A scientific theory is testable and can be falsified, while a pseudoscientific claim cannot.)
8. Science journalists and communicators ought to consider not only the objective	**Understand risks and benefits.** (All new technologies have risks and benefits.

	facts, but how audiences will *feel* about the *risks* that those facts represent, to anticipate moral implications and possible socio-cultural effects.	Activists might emphasise risks, while scientists might emphasise benefits. The moral obligation becomes to emphasise that nothing is 100% safe or certain, and to give a balanced, respectful view based on evidence.)
9.	When it comes to new technologies and scientific developments, journalists and science popularisers should learn to embrace *uncertainty* and the concept of *probabilities*, and make these part of their narrative.	**Science works with uncertainty.** (Uncertainty is a sign of 'honest science', revealing a need for further research before reaching a conclusion. Cutting-edge science is highly uncertain and often 'flat-out wrong'.)

Although of great value for science communication in a general sense, Claassen's ten essentials do not cater specifically for the ethical communication of emerging science and technologies – and is not intended to. It does not, for instance, cover the importance of prominent events to popularise (or demonise) particular technologies, or how technologies can deeply challenge core human beliefs, and even though certain aspects of both lists are similar, the exact wording is important to distinguish impacts brought about by *emerging* (early, unsettled, uncertain) science and technologies. As such, the Nine Tenets and the ten essentials necessarily diverge in their purpose.

Others have also attempted to create models for better understanding of science communication. Bucchi (2008) and Schiele, Claessens & Shi (2012) discuss various perspectives, theories and models to explain how science communication happens – for instance, the model of science communication as a continuum (Bucchi, 2008:77) – and to understand what aspects are necessary for 'good' science communication. But these models are largely academic in nature, are not concerned with emerging science and technologies in particular, or with the ethical concerns around them, and do not offer a practical guide for such communication.

Secko, Amend & Friday (2013) presents four models of science journalism: the science literacy model (to inform audiences about science), the contextual model (to inform audiences about science as it relates to them), the lay-expertise model (to empower communities and promote engagement) and the public participation model (to promote active engagement and education in support of democracy) (Secko, Amend & Friday, 2013:73). But again, these models are quite general in nature and mostly academic, concerned with the applicability of different types of science journalism for different cultural and engagement purposes – and does not provide a theoretical foundation for effectively, and practically, communicating potentially disruptive emerging science and technologies.

Given this context, as well as the valuable background provided by all the mentioned views and theories regarding the ethics and communication of emerging science and technology, the need for a simple, tailored media ethics theory and associated practical field guide for such communication, based on the identified Nine Tenets, remains clear.

In the following chapter, the research design and method is set out for the creation of the Flaming Torch Media Ethics Theory, and for the testing of the theory through a series of semi-structured interviews with experts in three chosen current emerging technology fields.

CHAPTER 4

4. Methodology and design

4.1 Approach

As mentioned in the opening chapter, this study essentially has two parts. The literature review (Chapter 2) examined mass communication efforts surrounding three historical case studies of important past technologies and discoveries (evolution, climate change and nuclear energy), and the resulting impacts they had on society.

Through a grounded theory approach (discussed below) the case studies informed a set of *key lessons* that were identified in each case, resulting in a list of Nine Tenets common to all three examples that can be used as a guide for the effective, ethically responsible communication of emerging science and technologies.

In Chapter 3, relevant existing media theories, media ethics theories, emerging technology ethics theories, risk and science communication theories and press codes of ethics were highlighted to provide additional background and context to the Nine Tenets – informing the need for a new media ethics theory detailed in the following chapter. This is because the existing media theories examined (in media ethics and also media effects, media culture, audience theory etc.) does not provide an adequate foundation specifically tailored for the communication of new science and technologies.

The second part of the study involves the testing of this new theory – to be called the Flaming Torch Media Ethics Theory – to assess its usefulness as a basis for a simplified, easy-to-use practical field guide for the ethical communication of current and future emerging technologies and science. In line with the general characteristics of a theory, the Flaming Torch Media Ethics Theory aims to:

- Describe the ethical complexities that often arise when people try to communicate emerging science and technologies.
- Predict the communication failures that might result from these ethical complexities.
- Prevent (control) ethical failures of communication around emerging science and technologies, at the hand of a useful, practical guide as a logical outflow of the theory.

4.2 Design

Both parts of the study are necessarily qualitative in nature, since the literature review, the Nine Tenets, the resulting new theory and the field guide are all interpretation-based, descriptive and predictive (as opposed to a quantitative design that would perhaps have been more useful if the aim was to simply assess or explain the current state of affairs).

The study therefore has an interpretive philosophy and an inductive, grounded theory approach, relying heavily on logic and common-sense assumptions informed by the extensive literature review as well as expert opinions (qualitative data) for the purpose of inductive theory development. Grounded theory is useful in this case, as it allows for the development of theory based on the discovery of emerging patterns in data (Scott, 2009). The literature review being the primary data from which nine common factors organically emerged to become the Nine Tenets that forms the basis for the emergent Flaming Torch Media Ethics Theory.

The presentation of the Flaming Torch Theory, based on the Nine Tenets, and a series of in-depth, semi-structured interviews with experts in three identified current emerging technology fields, namely Bitcoin/blockchain, artificial intelligence and human gene editing – in order to test and refine the Flaming Torch Theory – make up the first half of the second part of the study. The interview responses represent a second data set from which emergent patterns can help test, guide and further refine the Flaming Torch Theory.

The disadvantage of the chosen qualitative design is that the outcomes are not readily quantifiable or measurable, but the aim with this study is rather to use the richer, deeper qualitative dataset (via the literature review and expert interviews) to arrive at a set of principles that have the veracity (of key lessons from history and the wisdom of top experts) to be applied into the future with sufficient confidence.

Finally, the refined, amended Flaming Torch Theory is presented in Chapter 7 and used to create the resulting Ten Tenets Field Guide, in Chapter 8.

4.3 Methods and selection

To draft the Flaming Torch Theory, the example of one of humanity's first technologies – the flaming torch – was used to illustrate the duality at the core of the ethical problems around the uncertainties of new science and technologies (risks and benefits, burning or guiding). A thought experiment is used to flesh out the initial theory, by examining how a prehistoric science journalist might use the Nine Tenets to guide him or her in the writing of a letter to announce the discovery of carrying a flame by use of a torch. The thought experiment allows for the assessing of the practicality of the Nine Tenets. Subsequently, a core principle, a purpose and a set of logical statements and guiding questions for each tenet was drafted to flesh out the list of Nine Tenets into a draft media ethics theory, here called the Flaming Torch Media Ethics Theory 1.0.

In order to test the new theory at the hands of current emerging technologies, experts from the fields of Bitcoin/blockchain, artificial intelligence and human gene editing had to be selected for interviews to review the Flaming Torch Theory and its underlying tenets. There were three criteria for selecting the experts:

- Clear expertise as either an experienced scientist, developer, engineer or as an experienced public communicator in the relevant emerging technology field.
- Renown in the relevant field.
- Willingness to participate under their real names and identities (not anonymously), in order to ensure maximum credibility with regards to their expertise, and the assessment of the new theory in recognised, real-world terms.

The aim was to get the best experts that were available, taking a top-down approach. The logic was that should the most well-known expert (for argument's sake, Elon Musk as head of SpaceX) not be available, then the available second-choice respondent from the particular organisation would likely still be a highly-regarded expert. As such, Marcus Swanepoel, the founder of Luno, the largest cryptocurrency exchange in Africa, was not available, but Marius Reitz, Luno's General Manager for Africa, was. And although Dr Rosalind Picard, renowned pioneer of affective computing (human-like artificial intelligence), was unavailable, Rachel Gordon, an MIT-alum and chief communicator in MIT's computer lab, was. And so forth.

Any such purposive sampling of a small group of individuals will of course be limited in scope, since another group of individuals might yield very different responses. This is why experts were chosen from three different fields of emerging technologies, and why three

experts per technology were chosen, from both technical and communication backgrounds. The hope being that this built-in diversity across fields and perspectives will allow for differentiation between those communication and ethical issues specific to each technology and, more crucially, those issues that are found to be common to all three technologies and are of concern to all or most of the experts. This proved to be a largely effective strategy, although a secondary study with a different set of emerging technologies and different experts will of course likely further enhance the findings here.

Cognisance was also taken of the fact that such a grouping of experts needs to adequately reflect global diversity in terms of gender, race and culture. In this sense, expertise, standing and renown (merit) came first, with the undertaking that, should the initial identified experts lack sufficient diversity as a group, the list would be adapted or expanded as needed. Fortunately, this proved unnecessary as the identified experts who agreed to participate represent a diverse grouping in terms of gender, race and cultural backgrounds. A short bio for each of the experts are presented along with the interview transcripts in Chapter 6.

Semi-structured in-depth interviews were chosen as a format because, while a set of standardised questions are needed to accurately compare expert responses in reviewing the Flaming Torch Theory, broad, open-ended questions were also crucial to assess whether the theory might have missed important aspects. Experts were also encouraged to respond as they saw fit, in order to ensure rich, personalised feedback, and so responses were not standardised. Semi-structured interviews provide "latitude to move in unanticipated directions" (Du Plooy, 2011:198). Doing so allowed for the Flaming Torch Theory to be adequately and confidently refined in Chapter 7.

The methodology for the semi-structured interviews and the analysis of the resulting feedback was as follows:

- One scientist/engineer/developer per technology and two communication specialists per technology were identified, to arrive at three experts to be interviewed for each of the three emerging technologies – totalling nine experts.
- The nine experts were contacted, requested to participate voluntarily, and the necessary ethical permissions surrounding informed consent, confidentiality and privacy were explained and obtained – including their consent to be personally identified in the research. The Stellenbosch University Research Ethics Committee (REC) granted ethical clearance (project number 22860) before the interviews were conducted.
- The interviews were scheduled and conducted via email – firstly to ease international participation, and secondly for clarity to best avoid misinterpretations or omissions.
- In two instances, experts indicated (due to time constraints) a desire to rather participate in a recorded video interview (via Zoom), which was then transcribed in the same format as the other interviews.
- Each interview was divided into two parts in order to ensure unbiased, uninfluenced responses.
- First, each expert received a set of basic, open-ended questions surrounding what he or she would consider the most important ethical and moral problems or dilemmas that the technology they are working on has encountered or may encounter in the future – and what measures are being taken, or should be taken, to communicate such risks to prevent or mitigate social harm. Only once the responses to these first questions were received, were the experts presented with the Flaming Torch Theory in the second part of the interview. This was done to provide a baseline of uninfluenced, unbiased responses prior to exposure to the theory.
- Second, a list of potential steps for the communication of that particular technology, as informed by the Nine Tenets and the resulting Flaming Torch Theory, were

presented to the interviewees for review. Experts were asked to respond to each tenet in turn and to state whether they believed these to be sound for practical application as a guide for communication in their field.

- The feedback from experts was compared and analysed to tweak and refine the Flaming Torch Theory for further application.

After completion of the interviews and after analysing the responses, the most important points of critique were identified and summarised in Chapter 7, to produce an amended, refined and improved theory, here called the Flaming Torch Media Ethics Theory 2.0.

The second iteration of the Flaming Torch Theory was then used to create a simplified, practical field guide in the form of a short list of recommendations (or questions) for those wishing to communicate about emerging science and technologies.

Because a chief aim of the study is to create a field guide that is as simple as possible in order to be suited for the era of instant, global consumption via social media, the list of recommendations are presented as a poster as well as a series of text card images – "The Ten Tenets of Talking Tech" – that can be easily posted or forwarded via Twitter, Instagram, Whatsapp and the like.

The Ten Tenets Field Guide is presented in Chapter 8, and a proposed strategy for its dissemination, as well as the need for further research, is detailed along with concluding remarks in Chapter 9.

In the following chapter, the initial Flaming Torch Media Ethics Theory 1.0 is first presented.

CHAPTER 5

5. The Flaming Torch Media Ethics Theory 1.0

The crux of the problem addressed by this study is that every emerging technology or scientific discovery brings with it both known and unknown potential benefits, and potential risks for society.

Thinking back to one of humanity's earliest and most fundamental technologies – the flaming torch, granting human beings control over fire – this often volatile dichotomy might be succinctly described as follows:

Like a flaming torch in the hand, any new technology or scientific discovery can either light the way in the darkness, or burn the whole forest down.

This is a fitting core principle of the new ethics theory. What makes technologies and discoveries ethically complex is the simple fact that many of the risks, benefits and eventual consequences are initially, but often for decades, largely unknown. As such, certain informed assumptions about future eventualities and ethical problems become necessary, creating the need for a set of guidelines to steer such assumptions.

To illustrate how the Nine Tenets might serve as the backbone of such a theory, we might consider the following thought experiment:

Imagine an early human ancestor happened to discover how to make a flaming torch for the first time. For argument's sake, let us assume he or she had the ability to write and wanted to communicate this discovery in a letter to a neighbouring tribe. In other words, the early human technologist would not be present in order to answer all of the tribe's different questions and concerns in person, as is often the case with modern mass media communication and social media.

The question then becomes: What information would the early human need to include in the letter in order to accurately, responsibly and ethically convey the significance of the flaming torch discovery, while limiting potential harm – if he or she had been guided by the Nine Tenets?

Let us take each Tenet in turn and briefly discuss how it might relate to such a letter.

1. **New scientific discoveries and emerging technologies become disruptive when they challenge *widely held core human beliefs*.**

   Our human ancestor's letter would need to acknowledge that the discovery of the flaming torch has the potential to be quite divisive or disruptive for tribespeople because it challenges core beliefs that people during this human era might have held, for example:

   - Human beings cannot control fire (it is uncontrollable).
   - Humans *should not* control fire (it will anger the gods).
   - Humans *should not* control the forces of nature (and upset the natural order).

2. **It takes *decades* for a new technology or scientific discovery – and all its impacts – to be adequately understood.**

There would also needs to be acknowledgement of the fact that the human ancestor cannot know the long-term consequences of him or her taking a flame from one place to another. For instance: "I have not touched the flame to many things other than sticks and dry grass, so be careful to burn other materials as I don't know what will happen. Also, in experimentation we accidentally burned down a section of forest and I am unsure how many years it will take for it to regrow."

3. **Because of the media's propensity to report along lines of *conflict*, extreme viewpoints are often highlighted, which frequently leads to *polarisation*.**

   The letter would need to state that, although the benefits of controlling fire might be obvious, it can also be dangerous – and that ideally tribe members should discuss all aspects of the discovery, the positives *and* the negatives, openly to ensure no single extreme point of view becomes the default or dominant narrative on account of the opinions of individuals who might have their own hidden agendas. For instance, individuals might feel that flaming torches "ought to be banned immediately" for safety, or to appease the gods.

4. **The media's coverage of *prominent events* regarding a new technology or scientific development massively influences public perception and acceptance.**

   The discovery of controlling fire with a torch would obviously have been a monumental event. As such, the human ancestor would probably know that the story of the discovery would be told and retold for generations to come. For this reason, he or she would need to include as much information as possible about the circumstances surrounding the discovery in order to minimise any misconceptions or the need for assumptions. For instance:

   "It was a clear day with no wind. I had made a fire for cooking at midday and I had played with a stick in the fat of a deer before putting the stick in the flames of the fire and noticing the fat kept burning as I took the stick out. My friend Zero was with me and he saw me walk 10 paces before the flame died. We took a thicker branch, two fingers in width, and lathered it with a fistful of deer fat and put it to the flame. We were able to walk 100 paces before the flame died."

   This information would also be crucial for anyone in the other tribe to be able to successfully and safely repeat the experiment to verify the discovery.

5. **A rigid adherence to 'balance', not based on the *weight of evidence*, can cause harmful bias.**

   It would be prudent for our human ancestor to include a paragraph warning the tribespeople that, should anyone else suddenly come forth with perhaps more fanciful claims about controlling fire ("I can make lightning strike the earth by rubbing my hands during a thunderstorm"), they should ask the budding new fire technologists to first *prove* their claim before giving them voice in a public forum – so as not to mislead or give a platform for those simply seeking power or attention.

6. **Proper *context* is often crucial for accurate, responsible reporting on technologies and discoveries.**

   Context is obviously predicated on particular circumstances, which make it impossible to generalise. In this instance, the letter might include context such as: "I was able to make a torch from a stick on *many occasions* and at *different times*. It was not a once-off mystical event, and I had not been praying at the time so I can

reasonably assume it was not an act of the gods but a repeatable, physical act by myself."

7. **A *lack of adequate knowledge* on the part of a journalist is often a barrier to public understanding of novel science and technologies.**

   The letter would also need to warn tribespeople that, should they want to spread the news to friends or family or their own neighbouring tribes, they should first make sure they have either taught themselves to make a flaming torch safely, or at least that they completely understand how it should be done without burning themselves, their dwellings or their entire village down.

8. **Science journalists ought to consider not only the objective facts, but how audiences will *feel* about the risks that those facts represent, to anticipate moral implications and possible socio-cultural effects.**

   Already knowing that the discovery will challenge the tribe's belief system, the ancestor would need to try to anticipate the emotional response of his or her audience. For instance:

   "Some members of the tribe might feel that flaming torches are too dangerous to use, or are blasphemous. Be respectful of their feelings in this regard and be gentle in educating them. It might be necessary to decide on some new tribal laws for the proper use of flaming torches with respect to those who wish to have nothing to do with them."

9. **When it comes to new technologies and scientific developments, journalists should embrace *uncertainty* and the concept of *probability*, and make these part of their narrative.**

   Although linked to the second tenet, the ninth tenet has a much higher time preference and seeks to acknowledge the *immediate* unknowns that remain (as opposed to unforeseeable, related outcomes and consequences decades hence). In this regard, the human ancestor might say:

   "This is an exciting discovery that greatly enhances human capability, but there is much we still don't know. I have yet to cross a river while carrying a flaming torch, and have not ventured deep into a cave using one as a light source. I suspect we might be able to eventually make torches that last the whole night, but I cannot be certain. I hope you will join me in answering some of these questions and look forward to hearing any concerns or ideas you yourself might have."

This, of course, is simply one hypothetical example, and there will no doubt be many ways one could interpret and adapt the Nine Tenets, depending on the specific contextual scenario for a given new technology or discovery. But it does seem to illustrate that, even with a basic, ancient technology as example, the Tenets would have use in facilitating accurate, responsible and ethical communication in order to limit harmful disruption.

To shape the Nine Tenets into a working, practical media ethics theory, the Tenets were unpacked into nine *logical statements* and a set of *guiding questions* that might best aid future communication efforts surrounding emerging technologies and new discoveries.

Table 3 provides the initial attempt at organising the proposed Flaming Torch Media Ethics Theory into these three levels of engagement for science journalists and science communicators.

Table 3: The Flaming Torch Media Ethics Theory 1.0 (draft version)

CORE PRINCIPLE: *Like a flaming torch in the hand, any new technology or scientific discovery can either light the way in the darkness, or burn the whole forest down. Often both. Therefore, any attempt at communicating new science and technologies shares in the weight of that responsibility.*

This theory is concerned with the accurate, responsible and ethical communication of potentially disruptive new emerging technologies and scientific discoveries in order to limit harm to humanity.

Science journalists (and any science communicators) should help their audience to find the golden mean between the risks and benefits of new science and technologies, always guided by the weight of evidence, to be able to 'carry the torch' with the necessary confidence and care.

An examination of past revolutionary scientific and technological discoveries (such as nuclear energy, the theory of evolution and climate change) and how they were communicated to the public led to the identification of certain key lessons. To help inform the best decisions from as early as possible after invention or discovery, the following Nine Tenets and associated logical statements and guiding questions should be remembered when trying to communicate potentially disruptive new science or technologies:

Nine Tenets	Logical Statements	Guiding Questions
1. **New scientific discoveries and emerging technologies become disruptive when they challenge *widely held, core human beliefs*.**	If the emerging technology or new scientific discovery challenges any deep-seated human beliefs, morals or cultural values, make sure to mention this fact. If possible, state the specific values or beliefs in question – so that open debate in this regard can begin as early as possible in the technology's development, or shortly after a discovery, so as to properly and respectfully acknowledge potential conflicting perspectives or moral-ethical value crises.	• Does the technology or discovery alter the human condition in a fundamental way? • Could people with certain religious or cultural beliefs feel threatened by the existence or use of this technology or discovery? • Does the technology or discovery create moral dilemmas for humanity, and have you stated such? • Who stands to benefit from this technology or discovery, and who might be disenfranchised or marginalised – and if so, have you acknowledged this? • What expert source might you consult to give a perspective on how humanity might navigate its values, morals or beliefs in a world where this technology exists?
2. **It takes *decades* for a new technology or scientific discovery – and all its effects – to be understood adequately.**	Whenever possible and appropriate, acknowledge that you are discussing *frontier science* – not textbook science – which concerns early-stage development that will inevitably lead to unknowable (even by top experts) future outcomes or consequences. Encourage early debate about the	• Have you stated when the discovery was made or the technology was first invented – i.e. how 'new' this development is? • Imagine the technology becomes everyday and exists for 20 years – what would that look like? • Have you acknowledged

	various potential long-term consequences (both positive and negative), steering clear of hyperbole and sensation or causing undue panic (unless corroborated by sufficient evidence).	all the necessary unknowns? • Have you asked experts involved with the technology or discovery what they believe the long-term consequences or potential offshoots might be (as opposed to the more 'punchy' immediate benefits or risks)?
3. Because of the media's propensity to report along lines of *conflict*, extreme viewpoints are often highlighted, which frequently leads to *polarisation*.	Refrain from pitting expert sources with different views against each other simply for the sake of sensation or 'balance'. Leave room for nuance. Efforts should be made to determine any potential hidden agendas that sources might have, such as whether they are politically or morally opposed to the technology or discovery in question, or if they somehow stand to gain financially. Let only the *evidence* determine whether your content sways to the positive or negative.	• Are you skewing towards a mostly positive or mostly negative view? If so, ask yourself why. • Make sure you are aware of any conflicts of interest: who funded the experts you are quoting? Why was the research done in the first place, and for whom? Is your source affiliated to particular political or religious groups? • Are you sure your communication (article, post, video clip, etc.) is backed up by evidence and not emotion (such as fear or hype)?
4. The media's coverage of *prominent events* regarding a new technology or scientific development massively influences public perception and acceptance.	If you are covering or discussing an event that might in the future be historically significant for the technology or discovery in question (for instance a highly publicised launch event or announcement or a major disaster or accident) – then be aware that what you write or say today might determine how people view this technology or discovery *for decades or even generations to come* (think Hiroshima or Chernobyl). Be responsible, and be honest.	• Are you sure your communication is based on sound science and evidence, rather than on the mood of the moment, the emotion of a hyped-up event or some horrible accident? • In the case of a launch event or announcement, have you stated who paid for the event or the publicity, and have you consulted outside sources? • In the case of an accident, it is important to acknowledge tragedy and human suffering – but make sure the emotion of the day does not obscure scientific facts.
5. A rigid adherence to 'balance', not based on the *weight of evidence*, can cause harmful bias.	*Let the weight of the evidence always determine the weight of opinion.* Do not give voice to a source simply because he or she provides balance by opposing expert views –	• How have you chosen your sources? Based on their evidence? Or based simply on what they will be saying (for instance, entertaining, political,

	unless the source can provide *adequate, sound evidence* on which to base his or her opinion. Equally, do not trust any claims by a so-called expert who cannot provide sufficient evidence. Alarming, shocking or popular claims can go viral even if completely unfounded, misleading or actively harmful.	controversial or extreme counterpoint opinions to sell the story or increase its reach)? • Can all your sources back up their opinions or claims with adequate, sound evidence (and not anecdotes)?
6. Proper *context* is often crucial for accurate, responsible reporting on emerging technologies and discoveries.	Make sure not to omit important context without which people might not be able to make informed decisions or judgements about the new technology or discovery. Always ask yourself if your audience would be fairly well-informed about the discovery or technology (within inevitable space and time constraints) if they have read *nothing else about it*.	• Look at all the facts you are presenting – is any additional context required without which people might get the wrong idea? • For instance, under what circumstances might the technology *not* work? Has the technology been tested in real-world conditions, or only in a laboratory or computer model? Under what conditions might a new medical treatment *not* be effective? And so forth.
7. A *lack of adequate knowledge* on the part of a journalist is often a barrier to public understanding of novel science and technologies.	Always try to understand the technology or discovery you are communicating yourself, if only on a basic, conceptual level. If you do not understand, or feel that you lack the necessary technical expertise, make sure to ask a qualified, *independent* expert to look over your explanations and help clarify what might be misleading.	• Do you understand the technology or discovery you are trying to communicate? • Have you listed both the positive *and* negative aspects involved? • If you do not understand, which of your sources might be able to better explain it to you, or to look over your work to check the facts and clarify potential misconceptions? • Are you confident your sources have an adequate understanding of the topic? If not, find a better source.
8. Science journalists ought to consider not only the objective facts, but how audiences will *feel* about the risks that those facts represent, to anticipate moral implications and possible socio-cultural effects.	Think about your audience's pervasive cultural, moral and religious beliefs, customs and lifestyles. Actively consider how they might view the emerging technology or discovery in question, how it might affect their daily lives, and how they might *feel* about the risks and benefits it represents. Carefully consider the possible	• How will this technology or discovery change the daily lives of people, their morals, values or beliefs, and how might they feel about it? • Which peoples will be most (or least) affected by the emergence of this technology or discovery – and have they been given

	emotional public responses and, if possible, help to steer the conversation toward healthy, open public debate with enough space for a variety of possible views and attitudes.	a voice to air their hopes, fears and concerns? • Which peoples might be overlooked within the context of this new science or technology? (For instance, taxi drivers would hardly want to celebrate autonomous vehicles.)
9. When it comes to new technologies and scientific developments, journalists should embrace *uncertainty* and the concept of *probability*, and make it part of their narrative.	Be sure to note which aspects of the discovery or technology scientists or developers are still uncertain about, still need to test, or have indicated need further research. If necessary, explain that outcomes expected by experts are based on probability, not certainty. Uncertainty in this regard need not be detrimental to communication. Some scientifically plausible *mystery* might well make content more engaging.	• Be careful not to present accepted or expected *probabilities* as facts. • State any relevant and known remaining *uncertainties* (do not shy away from uncertainty). • Have you adequately explained the various probable outcomes, which ones are most likely, and why? • Are you confident your communication efforts will not lead to unrealistic expectations based on assumed, but as yet unconfirmed, certainties?

In the next chapter, feedback from the interviews that were done with the nine experts from the three chosen fields of emerging technologies is discussed. Each expert was presented with the draft Flaming Torch Theory, as well as a breakdown of their particular technological field according to the Nine Tenets, in order to assess the theory's completeness and viability in real-world conditions.

CHAPTER 6

6. Assessing the theory: Expert interviews

6.1 Initial questions

Nine experts (identified in 6.3) were contacted and voluntarily recruited to participate in in-depth, semi-structured interviews to help assess the Flaming Torch Media Ethics Theory as it pertains to their field. After informed consent was received, the purpose of the research was explained and the first set of interview questions were posed to the experts.

These initial questions had the purpose of establishing a baseline for each expert's thinking on these issues, wholly independent of the content of this study and prior to any exposure to the Flaming Torch Theory or the Nine Tenets. As such, experts were asked to only highlight issues of concern and not to go into much detail, seeing as their final feedback after studying the theory and its tenets would allow for that in the next stage.

The three initial questions that were posed were:

1. What, in your personal opinion, are the most important potentially disruptive consequences, impacts or moral or ethical problems that [Bitcoin/blockchain, artificial intelligence or human gene editing] might have for humanity in the future?

2. What do you think can be done to best communicate this technology to the public in such a way as to help mitigate these threats, impacts or concerns?

3. Do you currently take ethics into consideration when communicating the technology that you or your company is working on to the public? If so, how?

Once these answers were received, the second, final set of questions was presented to the experts with the specific aim of assessing the proposed media ethics theory based on the Nine Tenets. For this purpose, it was necessary to unpack each of the three emerging technologies according to the Nine Tenets as they pertained to the issues in the specific field to provide an example of how a science communicator without in-depth technical knowledge might do the same.

6.2 Bitcoin, AI, human gene editing – and the Nine Tenets

At the time of writing, it was becoming clear that the emerging fields of Bitcoin and other blockchain-powered cryptocurrencies, artificial intelligence and associated advances, and human gene editing techniques like CRISPR-Cas9 would cause significant technological, social, cultural and economic disruption (and possible revolutions) in the coming decades.

In July 2021, the government of El Salvador planned to distribute $30 of free Bitcoin to every Salvadorean after becoming the first country in history to draft legislation that would accept the cryptocurrency as legal tender (Quiroz-Gutierrez, 2021); The World Economic Forum proclaimed, "We need to talk about Artificial Intelligence", bemoaning the growing information gap between developers of AI technologies and the policymakers trying to regulate them (Bora & Timis, 2021), going on to list the top nine ethical issues in AI (Bossmann, 2021), such as mass unemployment due to AI, how to eliminate AI bias and how to control a complex, evolving intelligent system; and, for the first time, researchers appeared to have effectively cured a genetic disorder (sickle cell anaemia) by directly injecting a CRISPR therapy into patients' bloodstreams (Houser, 2021). The disease is but one of around

6 000 human genetic disorders that might similarly be cured by gene editing, and Ricks (2021) has asked, "Are we ready?", in response to news that the era of germline editing – which make possible the permanent alteration of hereditary human genetics – has arrived.

MIT Technology Review's lists of "10 breakthrough technologies" for both 2020 and 2021 (MIT Technology Review, 2020, 2021) were dominated by technologies directly or indirectly related to these three emerging fields. These include:

- "Digital Money"
- "Data Trusts"
- "Hyper-personalized medicine"
- "Anti-aging drugs"
- "An Unhackable Internet"
- "AI-discovered molecules"
- "Quantum Supremacy"
- "Tiny AI"
- "Multi-skilled AI"
- "GPT-3"
- "Remote Everything"

Finally, the *Big Ideas 2021* report by ARK Invest (ark-invest.com/research-center/) lists 15 "big ideas" regarded as the most promising leading innovations for potential investment, including "Bitcoin's fundamentals", "Bitcoin: Preparing for institutions" and "Digital wallets"; "Deep learning", "Virtual worlds" and "Automation"; and "Long read [gene] sequencing" and "Cell and gene therapy: Generation 2" from the three emerging fields respectively.

To test the Flaming Torch Media Ethics Theory and the underlying Nine Tenets, it now becomes necessary to relate developments in each of these three emerging fields to the questions posed by the Nine Tenets.

In the three tables below (Tables 4, 5 and 6), each of the Nine Tenets are listed next to some initial possible considerations based on a broad, concept-level understanding of each technology as it was presented to the identified experts in order for them to more clearly assess whether the Tenets appropriately address possible harmful moral-ethical quandaries to be avoided when communicating about the specific field, and to add issues that might not yet be covered sufficiently.

Table 4: The Nine Tenets and blockchain (Bitcoin and other cryptocurrencies)

Nine Tenets	**Possible considerations**
1. New scientific discoveries and emerging technologies become disruptive when they challenge *widely held core human beliefs*.	Core beliefs that are or might be challenged by blockchain technology, Bitcoin and other cryptocurrencies: "Governments and banks are necessary for people to trade fairly among themselves." "Software-encrypted 'digital money' cannot be a real currency, because it isn't backed by anything that physically exists." "The US dollar will always be the world reserve currency." "A decentralised financial system cannot work because someone has to be *in charge*."

	"Money cannot be programmed like software to gain various different functionalities." "A global economy cannot function without regulation by central banks."
2. It takes *decades* for a new technology or scientific discovery – and all its effects – to be understood adequately.	When communicating blockchain-related developments, it is important to convey (when appropriate) that no matter how passionate Bitcoin maximalists, the proponents of central bank digital currencies (CBDCs), Etherians (fans of Ethereum) or any other fan or technologist campaigning for the adoption of their preferred cryptocurrency might be – no one truly knows which, or if, cryptocurrency will be mass adopted in the future, how it will be regulated (or banned), or how it might change human lifestyles, the global financial system, international trade, national economies or government priorities or functioning in decades to come. It is becoming fairly certain, however, that cryptocurrencies will change the functioning of the global economy, and this will have far-reaching consequences that could appear quite suddenly, but whose full effect might take many years to become clear.
3. Because of the media's propensity to report along lines of *conflict*, extreme viewpoints are often highlighted, which frequently lead to *polarisation*.	Bitcoin, Ethereum and hundreds of other cryptocurrencies have each amassed loyal, cult-like followings. This creates easily exploitable angles of conflict for science journalists and communicators. When necessarily comparing cryptocurrencies, point out differences in technology, policy or point of view for the sake of *clarity*, and not merely to cause sensation or fall into the trap of regurgitating a "Bitcoin (or Ethereum etc.) *over all*" mentality that some sources may have.
4. The media's coverage of *prominent events* regarding a new technology or scientific development massively influences public perception and acceptance.	In Bitcoin's case, the effect of prominent events, such as the first publicly traded company to invest significant treasury assets in Bitcoin (by MicroStrategy in August 2020) or CEO Elon Musk's announcement in February 2021 of his company Tesla buying $1,5 billion worth of Bitcoin, becomes obvious because it is inevitably reflected in the Bitcoin price. Musk's tweets (as probably the world's most influential technologist) about Bitcoin, for instance, resulted in price drops and surges of between 4% and 20% (Molla, 2021). Equally apparent is the effect on price and sentiment when there is *miscommunication* around such events. On 13 June 2021, the Bitcoin price dropped following rumours that Tesla had secretly sold its Bitcoin position, only to rise again when Musk tweeted that such rumours were inaccurate and that Tesla had only sold around 10% of its Bitcoin holdings as a test of its liquidity (Molla, 2021). In such cases, the effect of communication around prominent events in the Bitcoin and crypto space is undeniable and puts a clear responsibility on communicators – and social media consumers who retweet and repost – to make sure they do not spread false information that could result in potentially huge financial losses.
5. A rigid adherence to 'balance', not based on the *weight of evidence*, can cause harmful bias.	When communicating on cryptocurrencies, be guided by *evidence* and not merely by *claims*. Thousands of altcoin projects, many with impressive white papers, make grand claims about new blockchain functionalities and innovation – and raise millions in speculative investment – often without having built a functioning blockchain at all. Do not give voice to those who cannot back up their claims with working, demonstrable technology.
6. Proper *context* is often crucial for accurate, responsible reporting on emerging	For example, many communicators in the space are quick to point out the drawbacks of Bitcoin (e.g. it is "slow, expensive, volatile, limited in functionality", etc.), usually to champion the newer project they want to discuss, and often excluding the crucial context that differentiates Bitcoin in fundamental ways from most other cryptocurrencies (at least up until

technologies and discoveries.	this point): that it is truly decentralised, truly scarce, and has much higher network effects due to its recognisability. In all respects, do not negate context, without which the audience will not have the full picture (for instance, a project's impressive scalability and low transaction fees might come at the expense of decentralisation or security).
7. A *lack of adequate knowledge* on the part of a journalist is often a barrier to the public understanding of novel science and technologies.	Most journalists, and even science journalists, do not have the knowledge or technical expertise to understand blockchain technology – often even at a basic, conceptual level. When communicating blockchain developments, it is crucial that the communicator familiarise him- or herself with the basic concepts involved (e.g. what is meant by a public, decentralised ledger, cryptography, public and private keys, hardware and software wallets, mining a block, etc.?). If the communicator does not understand the technology (or at least the concepts on which it is based), then the audience has almost no chance of gaining any proper understanding from the resultant communication.
8. Science journalists ought to consider not only the objective facts, but how audiences will *feel* about the risks that those facts represent, to anticipate moral implications and possible socio-cultural effects.	Consider all the core beliefs listed (Tenet 1) that technologies like Bitcoin might challenge and consider how your audience might feel about the risks that these facts represent. Bear in mind that different audiences may feel vastly different about these beliefs. For instance, for libertarians craving individual sovereignty and for the millions of unbanked citizens in Africa or Asia, a secure, free cryptocurrency wallet over which they have full control and that is easily accessible from a simple mobile phone might be seen as a massive technological leap forward and even a means out of poverty. For leaders of the G8 countries, which are the beneficiaries of money printing by the current central banking system, a decentralised cryptocurrency that empowers individuals by removing the need for third parties like banks can be seen as a legitimate threat to their power. To avoid harmful future disruption, communication efforts need to acknowledge these different perspectives and emotions and foster healthy debate about the various implications from as early on as possible.
9. When it comes to new technologies and scientific developments, journalists should embrace *uncertainty* and the concept of *probability*, and make these part of their narrative.	Blockchains and cryptocurrencies are entirely new and exciting phenomena. Communicators should revel in the speculative and uncertain nature of crypto and should frequently acknowledge that even the experts don't have a crystal ball – to encourage imaginative debate. It is very possible that, just like no one knew that the birth of the internet would herald the era of social media, there is a *high probability* that blockchain technology, Bitcoin, Ethereum or another cryptocurrency project will herald techno-cultural shifts as yet completely unforeseen. At the same time, there is no *certainty* whether or not Bitcoin or any other cryptocurrency will indeed achieve mainstream adoption at all.

Table 5: The Nine Tenets and artificial intelligence (AI)

Nine Tenets	**Possible considerations**
1. New scientific discoveries and emerging technologies become	Core beliefs that are or might be challenged by developments in artificial intelligence: "Humans will always be the smartest entities on earth."

	disruptive when they challenge *widely held core human beliefs*.	"AI will one day cause me to lose my job." "I will always know what is real and what is artificial." "AI, and those in power of AI, should not be able to monitor my emotions or behaviour without my consent." "Machines are not supposed to be smarter than humans." "Machines or computers can never (or should never) achieve consciousness." "You cannot form a deep, meaningful connection with a machine." "Advanced, humanlike AI will eventually kill us all."
2.	**It takes *decades* for a new technology or scientific discovery – and all its effects – to be understood adequately.**	Deep learning through advanced, evolving algorithms and the availability of enormous datasets to be accessed by neural networks over the internet are causing AI to far outpace Moore's Law, which states that computer power doubles roughly every two years. Stanford researchers found that AI computation doubles every *three months* (Saran, 2019). This means that AI is advancing at an accelerated, exponential rate – not even taking into account what could become possible when quantum computing becomes commercially viable. This makes it almost impossible to predict AI capabilities even five years into the future, which should be made clear in communication on the topic.
3.	**Because of the media's propensity to report along lines of *conflict*, extreme viewpoints are often highlighted, which frequently leads to *polarisation*.**	The internet, social media, wearable fitness and health devices and ever smarter AI assistants like Siri, Alexa and Google have already made it clear that humanity can have a nuanced, complex relationship with machine intelligence systems. Humanity's relationship with more advanced AI systems will inevitably be even more nuanced and complex, enabling both amazing and terrifying possibilities that might easily become polarising, especially in the media. Communication efforts should therefore be equally nuanced and should steer clear from extreme "AI will kill us all" or "AI will free us all" narratives.
4.	**The media's coverage of *prominent events* regarding a new technology or scientific development massively influences public perception and acceptance.**	Important AI advances are frequently overhyped in the media, such as IBM's Deep Blue beating grandmaster Garry Kasparov in chess in 1990, or Google's AlphaGo beating world champion Ke Jie in 2017. These events often skew heavily toward the AI in question having "outsmarted" its human challengers – giving the impression that the AI systems are smarter than humans. The same was true of coverage of the GPT-3 language AI model unveiled in 2020, with various demonstrations of how it could create written content or programming code much faster than humans, with minimal input parameters. Such coverage of AI breakthroughs are often highly misleading to the public, because the reports frequently fail to specify adequately that the particular AI system is often only *smarter* than humans in the task it was *specifically designed to master* – and that these advances hardly represent anything close to artificial general intelligence (true, human-like AI). Such coverage has undoubtedly contributed to public perceptions that AI systems are more intelligent (and nefarious) than they may appear. Think also of the impact that global marketing campaigns for films like "The Terminator" or "The Matrix" have had on people's perceptions about AI. Be cognisant of how you contribute to the ongoing historical conversation about AI when covering important developments and events.

5. A rigid adherence to 'balance', not based on the *weight of evidence*, can cause harmful bias.	The internet is full of over-the-top claims about AI, both in terms of its capabilities and its potential for future harm. When communicating about AI advances, however, care must be taken not to give voice to those with entertaining or controversial claims for the sake of it (or simply for views or profit), but rather to those with the technical knowledge or factual evidence to back up their claims. Otherwise the public will not have an accurate picture of what current AI is capable of – and what it is not (yet) capable of.
6. Proper *context* is often crucial for accurate, responsible reporting on technologies and discoveries.	When it comes to AI, the context of what is *not* yet achievable is often missing from media reports and social media posts. For instance, most experts are in agreement that, although huge advances have already been made in AI, especially in the last few years, the technology is actually yet quite far from achieving artificial *general* intelligence (that would be comparable to the intelligence of a human brain). Also, in many cases, what is called "AI" often boils down to a single, smart algorithm programmed to do a specific task really well – as opposed to an intelligent system or neural network capable of deep learning. In this sense, the blanket term "AI" is often used misleadingly and covers a very wide range of technological capabilities that ordinary people are usually not equipped to distinguish. That is the role of the responsible communicator.
7. A *lack of adequate knowledge* on the part of a journalist is often a barrier to the public understanding of novel science and technologies.	AI is a particularly hard concept for laypersons to understand properly, with most people probably picturing some unseen digital "hive mind" behind their computer screens or something akin to a humanoid robot, instead of the actual lines of code and systems of programming that make up these kinds of technologies. When it comes to communicating AI, science journalists should make sure to properly define what type of AI system they are describing, the actual scope and limits of the programming involved, and what kind of machine learning (if any) was used in the development. In this sense, it becomes important for communicators to partner with trusted, experienced, independent AI developers and programmers who will be able to help convey technical programming concepts in simpler but accurate terms.
8. Science journalists ought to consider not only the objective facts, but how audiences will *feel* about the risks that those facts represent, to anticipate moral implications and possible socio-cultural effects.	Depending on the audience, people might have very different attitudes and emotions associated with the concept of AI. Communicators should ask themselves who in society (and in their audience) may be at risk of losing their jobs to automation or AI in the future? How might this cause a knee-jerk reaction in certain public sectors? Concurrently, who is in control of the AI systems being discussed? In other words, who stands to gain profit or power from these systems being deployed at large? For instance, AI surveillance systems might give governments far greater power, with inescapable effects on citizen freedoms, social systems and prevailing culture. Communicators do not need to have all the answers regarding how such developments will affect society, but it can be crucially important to ask the questions and to ask them soon enough.
9. When it comes to new technologies and scientific developments, journalists should embrace *uncertainty* and the concept of *probability*, and make these part of	Some of the big questions that remain to be answered in terms of AI are how it will alter the landscapes of personal privacy as well as state and private security. These are open questions that will require years of debate and trial and error to produce fair, workable solutions. Also, it remains an open question when – or if – the so-called *singularity* (when artificial general intelligence becomes possible) will actually occur, and what the implications might be. Again, it is impossible to answer many of these questions now, but

their narrative.	communicators must be open and honest about the uncertainties and aid audiences to properly discuss the many probabilities.

Table 6: The Nine Tenets and human gene editing

Nine Tenets	Possible considerations
1. New scientific discoveries and emerging technologies become disruptive when they challenge *widely held core human beliefs*.	Core beliefs that are or might be challenged by developments in human gene editing: "Human beings shouldn't 'play God' by altering people's genetic makeup." "I cannot change the genes I was born with." "It is unethical to edit the genes of unborn babies because they cannot give their consent." "Human gene editing will result in superhuman beings that will ostracise *normal* humans." "Gene editing will irreversibly alter the earth's biosphere."
2. It takes *decades* for a new technology or scientific discovery – and all its effects – to be understood adequately.	A key feature of gene editing, of any organism, is that, if the genes modified are hereditary, the full consequences (intended or unintended) might only manifest in subsequent generations of offspring. In this sense, when it comes to human gene editing, it may take even longer than with other technologies to fully fathom the various effects. Communications of the technology should make this clear wherever appropriate in order to help foster a long-term view on how development ought to take place.
3. Because of the media's propensity to report along lines of *conflict*, extreme viewpoints are often highlighted which frequently leads to *polarisation*.	When it comes to human gene editing it is easy to focus either exclusively on the benefits of gene editing – to potentially cure various genetic disorders, or to focus primarily on the controversial aspects of the ethics of editing hereditary gene features. This is why nuance is important. Genetically modified (GM) foods already serve as an example of how controversial, polarising and political the issue of gene editing can become. To avoid such polarisation, communicators ought to be encouraged to employ a sober, nuanced and comprehensive view of the many benefits, dangers and challenges posed by human gene editing.
4. The media's coverage of *prominent events* regarding a new technology or scientific development massively influences public perception and acceptance.	Two clear examples exist that illustrate how influential media coverage of prominent events in the story of human gene editing has been: The announcement in 2018 by Chinese scientist He Jiankui that he had created the world's first genome-edited babies was met with an "international outcry" (Cyranoski & Ledford, 2018), because other scientists and ethicists felt that the otherwise normal twin girls, whose genomes were edited to make them resistant to HIV, was unnecessarily exposed to potential future unknown "off-target effects". In contrast, CRISPR-Cas9 inventors Emmanuelle Charpentier and Jennifer Doudna received worldwide acclaim when the media reported on them being awarded the 2020 Nobel Prize in chemistry for their joint discovery (Wu, Zimmer & Peltier, 2020). Such events – and how science journalists and other communicators report on them – leave a lasting public impression and invariably become part of the history of the technology's development.

5. A rigid adherence to 'balance', not based on the *weight of evidence*, can cause harmful bias.	Those opposed to gene editing technologies are often motivated not by evidence of harmful effects, but rather on the basis of moral, ethical or religious concerns. These concerns might well have merit and deserve thorough debate, but, in simple communication of developments in gene editing, voice should be always be given primarily to experts with sufficient evidence of the risks or benefits being discussed (as opposed to fear-mongering or unsubstantiated hype).
6. Proper *context* is often crucial for accurate, responsible reporting on emerging technologies and discoveries.	One example of some crucial context for developments in human (or any) gene editing that should not be left out of communications in this field is whether any particular development is concerned with *somatic* gene editing or *germline* gene editing. Somatic gene editing refers to gene manipulation of an individual organism, whereas germline editing refers to editing the genes in germline cells such as eggs, sperm or embryos, which will affect *all subsequent generations* of the gene-edited organism. This difference is quite crucial and should always be made explicit in communications of the issue, as should any possible expected or known side-effects of the editing of specific genes.
7. A *lack of adequate knowledge* on the part of a journalist is often a barrier to the public understanding of novel science and technologies.	The most popular gene editing technique, CRISPR-Cas9, is very difficult to explain without the use of some kind of infographic or video animation. Where possible, communicators should utilise these aids and make sure they themselves understand the basic concept. Otherwise, reducing gene editing to analogies of "cutting and pasting" genes like one does using a word processor (apt though the comparison might be) may lead to misleading oversimplification of the issue.
8. Science journalists ought to consider not only the objective facts, but how audiences will *feel* about the risks that those facts represent, to anticipate moral implications and possible socio-cultural effects.	Emotions and attitudes concerning human gene editing will be vastly different for different substrata of society and media audiences, depending on people's cultural or religious beliefs, social status, economic standing, etc. For some, human gene editing will be a complete taboo due to their religious beliefs – to the extent that advances in human gene editing will almost inevitably result in protest action by certain groups. For others, human gene editing will be nothing more than the next exciting form of performance enhancement (like human growth hormone or creatine). For many, it will bring hope for potential cures for hundreds of genetic disorders. At the same time, others might come to know of the availability of such gene therapy cures, but might not have the economic means to pay for the treatment and become disillusioned as a result. Any responsible communication on advancements in human gene editing should ever be mindful of the emotional forces that will inevitably come into play as the technology produces commercial treatments and becomes a cultural, moral and political issue.
9. When it comes to new technologies and scientific developments, journalists should embrace *uncertainty* and the concept of *probability*, and make these part of their narrative.	Due to the intricacy of billions of genetic interactions – especially when talking about hereditary traits – gene editing presents an enormous amount of potential unknown and unknowable unintended consequences that may manifest in subsequent generations. Communication efforts should not shy away from this fact, but should also not fail to state accurately the statistical probability of possible negative consequences – which are often small if responsible standards of trials and testing were complied with. In this sense, potentially vast uncertainties can be balanced by sound, statistical evidence for the probability of favourable outcomes.

The nine identified experts were presented with both the draft Flaming Torch Media Ethics Theory (Table 3), as well as the breakdown of their specific field according to the Nine

Tenets (Table 4, 5 or 6). They were asked to comment and elaborate on each of the Nine Tenets as they pertain to their field specifically, and subsequently to comment on the potential viability, usefulness and completeness of the Flaming Torch Media Ethics Theory as it was presented.

The following section contains tables providing each expert's feedback on the three initial questions – prior to exposure to the Flaming Torch Theory, their comments on each of the Nine Tenets, and their views on the viability, suitability and completeness of the theory, along with a hypothetical field guide based on the tenets. Each table is followed by a summary of notable comments by each expert, focusing in particular on points of *criticism* that ultimately helped to inform improvements to the theory.

6.3 Expert feedback: Bitcoin, blockchain and cryptocurrencies

6.3.1 Marius Reitz

Table 7: Bitcoin and cryptocurrency feedback – expert 1

	**Marius Reitz** General Manager Africa – Luno.com Luno is one of the most popular cryptocurrency exchanges and wallets in Africa, with a strong focus on educational content to help drive cryptocurrency adoption.
	Responses
Initial questions	
1. *What do you feel are the most important potentially disruptive long-term consequences, effects or moral or ethical problems that the arrival of Bitcoin and cryptocurrencies might cause for humanity in the future?*	Cryptocurrencies such as Bitcoin disintermediates the financial system by removing central banks, commercial banks and payment gateways from the process of value transfer and value storage. The arrival of cryptocurrencies, some of which are completely anonymous, therefore has created a sense of financial freedom for many. I am also from the school that thinks most people have good intentions and will do the right and moral thing if they are given more freedom. However, with freedom comes great responsibility. It is no different with money. Freedom of where to spend/send your money should not come at the expense of someone else's future (human trafficking, drug smuggling) or government income (tax evasion). We already see this happening in the traditional financial system – people use cash and the internet (messaging platforms) to coordinate crimes – governments don't ban messaging platforms, as they provide a net benefit to society (benefits outweigh the risks). From a technological point of view it's very easy to see that cryptocurrencies will form part of the evolution of money. From a moral or ethical perspective, we are still confronted by the same problems.
2. *What do you think can be done to best communicate this technology to the public in such a way as to help mitigate potential negative risks, effects or ethical concerns?*	Crypto incumbents such as Luno have a great responsibility on our shoulders – a responsibility to build a bridge between the existing financial system and a future financial system that could potentially include a decentralised cryptocurrency such as Bitcoin. The responsibility does not stop with building an easy-to-use and safe product (the mobile application, user interface, etc.), but includes the way in which Luno and other crypto intermediaries communicate with their customers, the general public and other interested parties such as regulators and the media.

	There is a dearth of quality information in the public domain, mostly emanating from a lack of technical knowledge, but also driven by sensation and greed, the need to drive clicks and comments, sales and high engagement rates, regardless of the factual correctness. The regulation of the crypto industry will ultimately lead to closer monitoring of crypto intermediaries (such as Luno) and their activities and will make it easier for the general public to distinguish between a licenced crypto operator and a potential charlatan. Licenced crypto operators will be under more regulatory scrutiny. Social media platforms should play an increasingly important role and use their algorithms to detect impersonators, profiles soliciting financial advice and pages promising guaranteed returns. Media outlets have just as important a role to play to ensure responsible reporting and communication of information, and should reject companies not regulated (or at least vetted against strict criteria) from placing advertisements and their hidden agendas. However, while regulators and journalists still grapple with the benefits and risks of a technology that could lay the foundations for a future financial system, cryptocurrency companies and influencers such as Luno will have to play an increasingly important role to put quality, unbiased and ethical information in the public domain.
3. *Do you currently take ethics into consideration when communicating the technology that you or your company is working on to the public? If so, how?*	Yes. Luno has a long-term vision to upgrade the world to a better financial system – a vision that includes equal opportunities and financial access to everyone, regardless of whether you're a migrant worker in Africa or a rice farmer in Asia. I work in cryptocurrency because I wholeheartedly share this vision. I am not driven by short-term financial goals; my key performance measures do not include revenue and improved profitability. Luno is owned by a company that shares this vision. The one element underpinning almost all communication, in my personal capacity to friends, family and the media, or from Luno's perspective, is EDUCATION. I never create a sense of urgency to "invest" (FOMO), no mention of guaranteed returns (or even the word "invest"), and treat all customers with the same level of respect and show empathy when required. Luno or I are the single source of crypto information for many people, people who won't be able to separate science from fiction and hype from reality.
Comment on the Nine Tenets	
Tenet 1: *New scientific discoveries and emerging technologies become disruptive when they challenge widely held core human beliefs.*	It is important to address common misconceptions constructively, and provide references to the past whenever possible. Comparing a new technology, or an iteration of an existing technology, with something that people are familiar with lets the reader view it from a different perspective. In the example of cryptocurrency, this entails recognising the fact that the only constant in the history of money is change itself. Over the past thousands of years, the way the world thinks about and uses money has changed many times. Even if cryptocurrency fails, it would have succeeded in challenging people's mindsets, that things can be done differently from what we are used to. Tim Urban's piece on why 'visionaries' like Elon Musk can see the future better than most people best summarises the current situation of the evolution of money. Most people don't see the world as it is, but more as it was, 10 to 50 years ago. A very small minority of people simply see it as it is today. The first tenet is necessary and important when communicating a new technology that is completely left-field, with the potential to completely

	disrupt one of the large-scale systems used by humanity, namely money.
Tenet 2: *It takes decades for a new technology or scientific discovery – and all its effects – to be understood adequately.*	I agree with this view. Bitcoin is different from other technologies in the sense that it has a value itself, determined by the supply and demand forces in the market. The Bitcoin price has been a double-edged sword for the crypto industry. On the one hand, the interest from an investment perspective fuels the market, with each new participant taking a small ownership stake in the development of Bitcoin. However, most people tend to be fixated on the Bitcoin price, with the price being used as the proxy for whether the industry is growing or not. Price has dominated the media headlines, in particular in South Africa, over the past decade. This has put the spotlight squarely on Bitcoin as an asset, or speculative investment, as opposed to the $ billions in value it can unlock for consumers across Africa in decades to come. As a result, not many people understand the significance of Bitcoin as a technology yet.
Tenet 3: *Because of the media's propensity to report along lines of conflict, extreme viewpoints are often highlighted, which frequently leads to polarisation.*	Cryptocurrencies such as Bitcoin and Ethereum are technologies, each with their own unique characteristics, aspects that solve a different need or use case. One cannot and should not paint them all with the same brush and use the blanket term "crypto" when covering aspects such as regulation, anonymity, adoption and price fluctuations. Cryptocurrencies can be categorised into four broad categories, each performing a different function: - Payment tokens - Utility tokens - Security tokens - Non-fungible tokens When writing about cryptocurrency, compare the crypto in question, e.g. XRP, to the technology people currently use, e.g. VISA, to better highlight its use case and allow the readers to form their own opinion, in this case on how global payment systems could evolve in years to come.
Tenet 4: *The media's coverage of prominent events regarding a new technology or scientific development massively influences public perception and acceptance.*	I agree with this view. This year, a tier 1 publication (*Financial Times*) reported that Walmart started accepting Litecoin payments across its massive retail footprint. Given the high regard for the FT and Walmart's distribution network (with the possible ability to accelerate the adoption of crypto), the Litecoin price rallied, just to come crashing down when it was squashed as a rumour only. The impact of misreporting of course is not limited to cryptocurrency only, and impacts us on many different fronts, from finance to politics. The impact of factual inaccuracies or misinformation can potentially have a bigger impact on crypto, though, as compared to other industries. Due to the relative ease of access (requiring only an internet connection and computer), any person, irrespective of age, gender, credit score or location, can now store, send or receive value. This gave rise to a new type of "investor" over the past five years, mainly because of this ease of access, lower minimums than traditional investments when buying, e.g. Bitcoin (R1 minimum on Luno), especially young people in emerging markets such as Africa. These market participants consume information online and regard certain comments by influencers as buy/sell signals or financial advice. With the democratisation of finance, previously inaccessible markets and products are now available to more people across the globe. With this shift comes greater responsibility to report accurately and avoid sensation,

	for the sake of consumer protection.
Tenet 5: *A rigid adherence to 'balance', not based on the weight of evidence, can cause harmful bias.*	Many new projects, such as ICOs (initial coin offerings), are new, innovative models to build networks. ICOs are unfortunately following a very similar pattern to the blockchain hype – lots of scams, incompetent teams, projects that don't (and shouldn't) use the particular technology to be successful, over-funding, etc. This was in part exacerbated by clickbait media reporting during the 2017-2019 period. I do think that we have seen a slight shift to more responsible reporting since then, once the devastating impact of these failed projects on investors became more apparent. The reality is that most of the 4 000+ cryptocurrencies in existence do not have sufficient market traction, trust and track record that would constitute evidence. This does not mean that they don't have the potential to solve unique use cases in the future. Journalists should at the very least include disclaimers in their articles, warning of the high risks involved in buying certain lesser known cryptocurrencies. A problem we're currently facing is media publications taking money from new crypto projects for sponsored ads or advertorials. These projects then get broadcasted and boosted across various distribution channels such as Facebook and Twitter, reaching millions of readers. Media houses should conduct due diligence before taking any advertising money from crypto projects. Certain advertising standards should be met prior to crypto projects being put on a pedestal and broadcasted online.
Tenet 6: *Proper context is often crucial for accurate, responsible reporting on emerging technologies and discoveries.*	Many detractors expect Bitcoin to immediately be superior and better than fiat currency/the next best crypto and use this approach to garner followers – Bitcoin must be cheaper, faster and more secure, right now. The reality is that Bitcoin has the potential to be all of this and more, but will take many years to reach such a point of mass market adoption. Take the internet, for example. The first concept was developed in the 1960s, with network effects only kicking in in the early 2000s. In the '90s, not many people communicated via email, as simply not enough people had access to the internet. In other words, there was no incentive for people to communicate via email. The same analogy applies to using Bitcoin for payments. I agree that sufficient context is important when communicating a technology that is yet to achieve network effects.
Tenet 7: *A lack of adequate knowledge on the part of a journalist is often a barrier to public understanding of novel science and technologies.*	This page, 99bitcoins.com, is perhaps a good barometer of the lack of basic knowledge or understanding of blockchain/crypto by mainstream communicators. According to 99bitcoins' Bitcoin Obituary, which documents every time a major press publication says Bitcoin or crypto is 'dead', Bitcoin has now 'died' 435 times. One of the gravest mistakes made by the crypto industry is to overestimate the level of crypto knowledge of the average person, including journalists. Whilst we have seen Bitcoin not dying as often as during previous years as per 99bitcoins, misinformed journalists present a risk to the ongoing development of the cryptocurrency industry. One risk in particular is that of central banks banning crypto in their respective countries. Central banks, and African central banks in general, hold publications from certain countries such as China or Russia in high regard. We often see central banks taking a certain position, such as banning crypto miners, because of Bitcoin's perceived negative impact on the environment, purely based on what they read online.

	A lack of basic understanding, and the lack of credible expert evidence in articles, can therefore serve as stumbling blocks for the companies innovating in the crypto/blockchain industry.
Tenet 8: *Science journalists ought to consider not only the objective facts, but how audiences will feel about the risks that those facts represent, to anticipate moral implications and possible socio-cultural effects.*	Media publications have readers from diverse backgrounds, with different beliefs and outlooks on the future. I agree that, despite objectivity, people's perceptions and beliefs should be taken into account when content is published. Crypto companies such as Luno have a diverse customer base, with almost equal split across age and gender demographics as well as religious views. In my experience, allowing customers/readers to comment, ask questions and challenge your thoughts as a journalist or business allows for an open and collaborative approach. This often leads to faster adoption, as people feel that the technology is not pushed from top down but follows a grassroot or bottom-up approach.
Tenet 9: *When it comes to new technologies and scientific developments, journalists should embrace uncertainty and the concept of probability and make it part of their narrative.*	Agreed. Uncertainty will always be a key factor when reporting about emerging technologies such as blockchain and Bitcoin. What we do know with a high degree of certainty is that three major factors are currently driving change. These are 1) our collective mindset changes, 2) rapidly changing consumer demand and 3) technology as the enabler. This trifecta is the catalyst for future change – not only in the way we use money, but also how we communicate, etc. What we do know is that the efficiencies that people demand (move money around freely, instantly and securely) require massive economies of scale, and achieving this will probably involve something like a decentralised cryptocurrency, whether Bitcoin, Ethereum or another decentralised currency that is yet to be discovered. So I agree, if we consider how previous evolutions played out or how other industries were disrupted, e.g. how the communications industry evolved from landline phones to Skype calls, then it was typically by something left-field, something new and not just the optimisation of the existing system.
Questions on theory viability and practical value	
Do you feel this theory provides a complete, appropriate and viable foundation for the accurate, responsible and ethical communication of potentially disruptive or revolutionary emerging technologies or new scientific discoveries? Please elaborate and indicate if you find there are aspects that are missing and ought to be added.	Yes.
Would a simple, practical field guide (e.g. a one-page PDF) for the communication of potentially disruptive emerging technologies and discoveries, based on the Flaming Torch Theory, be valuable to you in the real-world conditions that you work in?	Yes. It would be most useful for preparing for media interviews. It could also serve as a valuable guide for crypto content teams.

6.3.2 Discussion of comments – Marius Reitz

On the whole, Reitz agrees with the Nine Tenets as stated and feels that the theory is viable and would be useful in the form of a field guide. His responses to the three initial questions also do not present any issues that are not adequately covered or dealt with in the draft Flaming Torch Theory.

6.3.3 Amiti Uttarwar

Table 8: Bitcoin and cryptocurrency feedback – expert 2	
	**Amiti Uttarwar** First known female Bitcoin core developer Amiti was profiled in *Forbes*' "30 under 30" feature in 2020. After working at Coinbase, she took a residency at Chaincode Labs in 2019 to become a Bitcoin core developer, which resulted in a sponsorship by the Hong Kong-based company, Xapo, and the landmark OKCoin/HDR Global joint grant to work on Bitcoin's underlying code (BitMEX, 2020).
	Responses [transcribed from video interview]
Initial questions	
1. *What do you feel are the most important potentially disruptive long-term consequences, effects or moral or ethical problems that the arrival of Bitcoin and cryptocurrencies might cause for humanity in the future?*	Bitcoin and other cryptocurrencies could deeply influence how we organise and interact as a human society. While there is potential for better privacy and censorship resistance, these tools could also be used for increased surveillance and mass dehumanisation of people. The potential of the tool is so powerful that the moral and ethical concerns are fundamental – we need to carefully consider what it means to improve society and develop heuristics to build when its impossible to fully conceive the extent of long-term consequences.
2. *What do you think can be done to best communicate this technology to the public in such a way as to help mitigate potential negative risks, effects or ethical concerns?*	I think the most important aspect of communication is that it is accessible to wide audiences. This means it needs to be simple, interesting, and distributed in many languages. Different people have different learning styles, so the types of materials need to be diverse.
3. *Do you currently take ethics into consideration when communicating the technology that you or your company is working on to the public? If so, how?*	I work on Bitcoin Core and am often questioning and communicating about the ethical considerations of this technology. I am a big advocate for trying to make the technology as accessible as possible – not just on the level of what the tool is capable of, but also in terms of how it is used.
Comment on the Nine Tenets	
Tenet 1: *New scientific discoveries and emerging technologies become disruptive when they challenge widely held core human beliefs.*	So, the tenet makes sense in the context of Bitcoin, for sure. And these examples all make sense. I think Bitcoin demonstrates that by challenging the belief of what is money and how does it work. And something I find really interesting is [that] in many ways Bitcoin doesn't actually challenge those core beliefs. It's just challenging where society is right now. What I mean by that is there is a lot of ways in which Bitcoin is exactly like cash. If I hand you a dollar bill, then someone can't stop me from doing that unless they're right there slapping it out of my

	hand. You know, if I hand you a dollar bill, we don't need a third party to say, "Oh, what if we disagree as to what happened?" There is this kind of baked-in dispute resolution of who has the bill, right? But, at this point in time, I think I've read some statistic that said that 90% of all our money is digital. So digital currency is the more accepted norm of how money works today. And Bitcoin challenges that. But if we're bringing it back to the principles of cash and gold as 'natural', like because of the scarcity of gold, then it's not actually new. It's just turning it into a scarce digital asset. I do see a lot of people get very confused in trying to understand Bitcoin because they're applying the principles of what our current monetary systems in the digital age look like. So a simple example was last night when I was trying to explain the Lightning Network to my dad and he was asking, "OK, but then, who's covering the risk?", right? So I had to explain that – with Bitcoin if there's a dispute, you resolve it immediately, atomically, at the settlement layer without needing a Visa or a bank. Another fundamental principle that makes Bitcoin work is how distributed the system is. That is very hard for people to comprehend. I've been spending the last couple of years trying to comprehend it, on a daily basis, and I kind of get it, but it's still hard. So, we're challenging what money looks like. But I think at a deeper level, the decentralisation is really what is the fundamental paradigm shift. Trusting something where no one is in charge, and building a system that works under those conditions. So that was what initially captured my interest. The language I used was introducing a new trust model. Because historically we've only really had a couple of trust models. One is direct. I get to know you, we build trust, we can do business, we can have debt, we can make future promises. And then the second one that really has allowed our society to scale to the mass billions of individuals that we're at today, is a hierarchical trust model. I trust the bank, then the bank decides who to trust for settlements and I can do transactions with anyone in this widespread network. So what Bitcoin is offering is a different trust model, and it's saying that two strangers can come to an agreement about what happened (e.g. a transaction) without actually needing to trust one another or any third party. And I think that really, truly challenges how our society works.
Tenet 2: *It takes decades for a new technology or scientific discovery – and all its effects – to be understood adequately.*	Oh yeah, easy. I frequently say, like, in a world where Bitcoin succeeds – and it doesn't have to be a "hyper-Bitcoinisation" world, just one where people are able to use it as money – it's going to take generations to play out, at minimum. You know, it's such a fundamental proposed shift. And even though it already kind of works, like you can already use it, there's so many stories of use cases popping up for different kinds of peoples in different societies around the world. Everything is either growing or shrinking, and if Bitcoin continues to grow, the implications, the potential, the side consequences that have domino effects, et cetera, [are] not something I will ever be able to comprehend within my lifetime. I think it's just simply going to take hundreds of years in order for us to fully understand what this thing is.
Tenet 3:	Yeah. I think something that's very prominent in the Bitcoin

Because of the media's propensity to report along lines of conflict, extreme viewpoints are often highlighted, which frequently leads to polarisation.	ecosystem is Twitter as a platform and Twitter fundamentally values and emphasises polarisation. And so the fact that that is a prominent platform for Bitcoin conversations, I think, is very encouraging to loud, aggressive claimers. And that sucks, in my opinion, it really, really sucks. I understand that click-baity titles receive more clicks and it's the same principle on Twitter, right, if you prick people's emotions, they're more likely to engage. I think it's a huge disservice. One example that I see commonly, beyond Twitter, beyond the internet, in groups of people, I see this trend along gender lines. Most men have some sort of curiosity, or even an over-inflated claim about Bitcoin. Whereas the majority of women that I know feel, oh, it's too complicated, I can't understand, and they just immediately put up walls. The world I would like to see is one where we can engage in, "Hey, there's this really crazy, powerful, disruptive potential thing. Let's talk about it and evaluate it and understand it deeper". But that's not what sells. In an age where five billion things are competing for our attention, our attention naturally goes towards incentivising claims. There's also one more component in Bitcoin that I see often. Money is just a shared belief. There's no intrinsic value to it unless we decide to accept arbitrary, specific rules. And I do think the fact that there are these idiotic, aggressive people that are willing to die over Bitcoin, they behave like religious fanatics or part of a cult or whatever. I in no way support or advocate or encourage that kind of behaviour, but I also realise the fact that there are a lot of people in this world who experience it like that, means that Bitcoin will retain some sort of value. You know, money and religion are two things that humans go crazy about, and in Bitcoin, you see that intersection. But the fact that no matter how ridiculous the prophecy is, the fact that there is a large amount of people who buy into it means that this shared fiction has fuel in the face of scepticism. So I do recognise and appreciate that, yeah, these crazy, stupid, aggressive people actually contribute something to the value of the shared fiction that I buy into. But on the flip, I also think they detract a lot of value because I do not want to live in a world where Bitcoin and blockchain become a very used technology but is not managed in a decentralised way. In other words, where governments have figured out how to put backdoors into the cryptography we use and now are using these digital currencies for hyper surveillance, whether it's Bitcoin or they figure out a Central Bank digital currency that rides the wave of crypto and cypherpunks or whatever, but then is utilised for more harm rather than the freedom that is its potential. And there's so many different ways that it could go wrong. I would rather Bitcoin disappear than be hijacked for harmful ends. So I think that predominantly Bitcoin and crypto really has a very, very polarising narrative, everywhere I look. People have very strong opinions, whether their opinion is, "I'm not capable of understanding this", or "this is what criminals use", or "I drink the Kool-Aid and I will die for it", whatever it is. We see such strong, polarising views. And overall, I feel like it detracts from the stability of a foundation that we can build on in a nuanced debate. I see the opposite in the Bitcoin developer culture. It is hard to get developers to make claims, which is something I truly, truly adore about the developer ecosystem of Bitcoin. Like, the people who are the most prominent, respected individuals are always arguing multiple sides of a yes or no question. And sometimes that is the

	other extreme where it's like, "Dude, come on, just make a claim". So, a nuanced debate is, I think, much more fruitful. And I have no clue how, as a community, we get a larger group of people to engage in those nuances. I like your metaphor of a flaming torch because, it can be a toy or it can be a tool. And even if it's a tool, it can be used for good or for bad. And so I really like that metaphor. It's extremely applicable to the way that I see the ecosystem. It's something I worry about a lot.
Tenet 4: *The media's coverage of prominent events regarding a new technology or scientific development massively influences public perception and acceptance.*	Yeah, definitely agree. It's human psychology, right? Initial impressions can have a very long-lasting impact. So when there is something really big, it's hard to undo. If you've made a judgement, it's hard to undo it, even if there's evidence in contradiction. A more specific example that you might not be familiar with, is in the extended Bitcoin community the engagement around certain Bitcoin topics, for instance the "blocksize wars", have definitely left a huge impact on how any development or consensus changes or widespread upgrades can occur. And it is an extremely frustrating, hyper-political thing because although the developers might all agree that this way makes sense and this way doesn't make sense, because of this social scarring from the blocksize wars there are random loud voices [disrupting the conversation]. And due to the nature of decentralisation, you can't just fire someone who's being stupid. You can't just kick them off of the Slack channel. You know, they just are there. So I've witnessed how in this open source society trying to come to consensus, we have a lot of struggles where these really deep-seated convictions are an emotional reaction to prominent past events, even if they're no longer applicable. The whole community has to tiptoe around it in order to make any progress. So the emotion definitely lingers in this society, even long after the event itself.
Tenet 5: *A rigid adherence to 'balance', not based on the weight of evidence, can cause harmful bias.*	Totally agree. I mean, the weight of evidence is so important, but it's very hard to communicate. Working in an open source development environment, my attention is the strongest constraint that I experience and then that is also applicable to the community as a whole. In Bitcoin Core, as a developer group, the scarcest resource we have is attention, but not all attentions are equal. Someone who's been working on the protocol for several years versus someone who's looking at the GitHub repo for the first time, their attentions are worth different amounts, right? So that's a big vulnerability of the community because you can't say, "Hey, no, you haven't demonstrated that you're worthwhile to give attention to". As an individual, you can do that, but we don't have any mechanisms for doing that at the societal level. Everyone has to make a judgement for yourself. And in order to be able to make that judgement, well, you have to have a lot of context, and the problem becomes how do you extrapolate that when you are communicating. So, for example, the attention bias that you get on Twitter is very difficult to influence. You do control who shows up in your feed, but people retweet and comment on random stuff, you know, you follow someone for like, I don't know, haircuts, and then all of a sudden they're talking about cryptocurrency too. At least with journalists, they have the ability to influence like, in this article, where is the attention that I'm drawing the readers to? So there is more ability to have intentionality. But yeah, it's extremely difficult

	when as a community we're trying to say, "Hey, how do we expand?" Like, "How do we spread the gospel?" Right? I've clearly drank the Kool-Aid. I clearly think that Bitcoin is a powerful thing that can be potentially used for positive. I am sceptical enough that I don't think that it's necessarily going to be used for positive in our human society. And, at an individual level, I'm terrified that it's going to actually do more harm than good because that's kind of what we often do as humans. But I think the challenge of how do we communicate with the proper attention bias, is extremely hard.
Tenet 6: *Proper context is often crucial for accurate, responsible reporting on emerging technologies and discoveries.*	The number six tenet is definitely hard to nail down, and nebulous, but I also do agree [with the importance of context]. One thing I see in Bitcoin is like reporters don't have anything to talk about anymore, so they're just like, "It's bad for the environment", right? And even though I've seen some extremely strong counterclaims, it's so easy to latch on to that because you can come up with a precise number of exactly how much environmental impact Bitcoin is having. And we cannot come up with a precise number of how much environmental impact our conventional banking system is having, and so the proper context is left out. One piece of feedback for you to think about is how incentives tie into this, because incentive models are a lot of what I look at as a heuristic for predicting trends. For example, the incentive for miners is to use cheaper energy, and then with the context of our society of renewables being cheaper, then over time, like even if Bitcoin's number is higher than the conventional banking system right now, I would still say that the incentive of each of the players means that, over time, Bitcoin will become more renewable. So for me, when looking at the long term impacts of things, really thinking about incentive models is how I would go about it [which can help to provide context and perspective].
Tenet 7: *A lack of adequate knowledge on the part of a journalist is often a barrier to public understanding of novel science and technologies.*	I would say that the seventh tenet feels like a subsection of the incentive model thing to me. What I've seen is, a lot of times individual journalists get a lot of pressure from the editor, their organisation, whatever, there's pressure of time, there's pressure of clicks, and so they're not given the freedom to go and understand the thing. They just need to churn it out. I get interview requests and have seen the wide variety. I've seen thoughtful journalists who, for example, I worked with Rory Murray at Forbes and he was just amazing. I don't ever want to work with any other journalist because he had the space and the support, as well as the individual drive to really go after the topic and understand it fully, and to find an interesting angle within it and then propose it. There were elements of how to sell to the public, but there was also an element of, you know, discovering truth and communicating it. But then I've also gotten Twitter DMs from people who were like, "Excuse me, I need a quote by tonight". And then they misspelled my name. And I don't think it's fair to put it only on the journalist, because a lot of times they're just trying to do their job, but their job has such tight, unfair constraints. And so I feel the incentive model thing is needed there too. There isn't enough funding and incentives for people to be doing in-depth research to communicate that in clear ways.

	With Aaron Van Wurdim, he is just an incredible technical communicator. And I've been so impressed with how he covers the Bitcoin and crypto space. And then I've seen others in both environments, where the same journalist can write pieces that are thoughtful and hard-hitting and so, so good, but then they also write shitty pieces. And there's clearly behind-the-scenes context of some constraints. So, as an ecosystem, how do we construct these things? If you're designing a society, can you turn Twitter attention into some sort of tiny elements of funding that give space for reporters to write deeper things? How can you create these positive feedback loops? So yeah, in relation to tenet seven, if what we're incentivising as a community is superficial and immediate, versus if it's thoughtful and spacious, becomes important.
Tenet 8: *Science journalists ought to consider not only the objective facts, but how audiences will feel about the risks that those facts represent, to anticipate moral implications and possible socio-cultural effects.*	I agree. For sure. In my own personal view of the world, a phrase that has resonated with me or just a phrase that I've come up with is, "Feelings are the only real things". I think that it's extremely important to acknowledge that as humans, the only things we can perceive is that which we perceive. And so when we're communicating or trying to understand objective truth, right, like Bitcoin has an objective truth that lives beyond anything we can perceive. Even if we're the ones participating in the system. The objective truth keeps happening, whether we perceive it or not. But on the other side, people will have emotions about objective truth, whether you want them to or not. So in a way, the perceptions are the truth for emotional reactions. But I think it's a very hard premise, because as a communicator you have to consider different groups, but then you also have to assign proper weights [to the validity of emotional responses]. It's just an intrinsically challenging problem to hold to both. Just one meta commentary about something you should be very clear on is the different kinds of communicators. So for example, you know, here you say science journalists ought to write … But then the way I answered is more for communicators in general. So you should always just clarify that. But I fully agree that it has value for both. For example, I wouldn't call myself a social media influencer or definitely not a science journalist, but that said, keeping this [the Nine Tenets] in mind, if I decide to tweet, like revisiting these heuristics before I decide is this a good tweet or not, could be valuable.
Tenet 9: *When it comes to new technologies and scientific developments, journalists should embrace uncertainty and the concept of probability and make it part of their narrative.*	Totally. And here, I definitely think journalists should pioneer the communication around uncertainty, even if that's not palatable to the general public at all times. That's why there's a niche field of people who are more willing to put in that energy [to create a compelling and understandable narrative around uncertainty and probability]. So yeah, that'd be great!
Questions on theory viability and practical value	
Do you feel this theory provides a complete, appropriate and viable foundation for the accurate, responsible and ethical communication of potentially disruptive or revolutionary emerging	Yeah, I think it's a valuable basis and foundation. I can't speak to if it's a complete model right now, I'd have to think about it a lot more. But it all seems viable and at least fairly complete – and valuable. If these sorts of heuristics were more widely used by communicators, I think that would be really valuable.

technologies or new scientific discoveries? Please elaborate and indicate if you find there are aspects that are missing and ought to be added.	
Would a simple, practical field guide (e.g. a one-page PDF) for the communication of potentially disruptive emerging technologies and discoveries, based on the Flaming Torch Theory, be valuable to you in the real-world conditions that you work in?	I definitely think that you should use images. For communicating this kind of idea? Definitely images, but more of the minimal kind like icons or drawings that kind of represent the different components, like petals of a flower or whatever to make it simple. The other thing I found in making technical material more approachable is the use of playful fonts. I made these little comics for explaining Bitcoin technical ideas and I did a handwritten font using my own handwriting. So when people say they can't understand it, things like silly pictures and handwritten fonts, actually help to penetrate that wall. You could also have a couple of different versions, like one that's more dense and technical for science journalists and one that's more simple and visual for trying to spread it around on Twitter, you know? Especially if you use a graphic designer who understands the psychology component. I think that would be extremely valuable in trying to propagate the seed.

6.3.4 Discussion of comments – Amiti Uttarwar

Uttarwar's answers to the initial questions fall within the scope of the theory and she generally agrees with the Nine Tenets; however, she highlights, in several ways, the importance of *incentives* in the communication of Bitcoin and cryptocurrencies as an emerging technology sphere.

Uttarwar emphasises the importance of remembering that social media content, and media content in general, is driven by "incentivising claims" in order to increase audience reach and engagement, likes, views, followers, shares and profits. This, according to her, also determines what communicators choose to highlight or leave out when communicating about science and technologies. She also states that science journalists are not often themselves incentivised to invest the needed time and energy to properly research and understand a technical topic. Her view on incentives can be summarised by her quote that, "…if what we're incentivising as a community is superficial and immediate, versus if it's thoughtful and spacious, becomes important".

She also states that it is important to clarify which kinds of science communicators (scientists, journalists, educators, influencers, etc.) the Nine Tenets are aimed at, since they all have different roles, aims and responsibilities in society.

6.3.5 Raoul Pal

Table 9: Bitcoin and cryptocurrency feedback – expert 3

	**Raoul Pal** CEO and co-founder of Real Vision Group, Real Vision Crypto and Global Macro Investor (https://www.realvision.com/about) A former Goldman Sachs hedge fund manager, Raoul frequently features on Cointelegraph.com's "Top 100 People in Crypto" list, and is a leading communicator on Twitter and YouTube, driving crypto mass adoption.
	Responses [transcribed from video interview]
Initial questions	
1. *What do you feel are the most important potentially disruptive long-term consequences, effects or moral or ethical problems that the arrival of Bitcoin and cryptocurrencies might cause for humanity in the future?*	So I think the issue of concern to me is, all of cryptocurrency and digital assets are basically built around behavioural incentives. It's behavioural economics. Behavioural economics is really a way of motivating people, and it can be used for positives and negatives. So, the biggest concern is how that can be used to impact society in a negative way. Because the advent of big data, plus this new reward system, is kind of B.F. Skinner stuff on crack. So that's my big concern is, what are the nefarious use cases outside of the positive use cases?
2. *What do you think can be done to best communicate this technology to the public in such a way as to help mitigate potential negative risks, effects or ethical concerns?*	I think it's all about realising that this is a distributed network and distributed technology, and therefore it's in all of our power. It does not have to be about allowing power to coalesce within a few hands. So if you can distribute the network, then you can achieve broader, better goals. And that should mitigate the nefarious use. There's always going to be nefarious uses, but at its core, you can create communal benefits as opposed to communal negative outcomes.
3. *Do you currently take ethics into consideration when communicating the technology that you or your company is working on, to the public? If so, how?*	No. Yes and no. It's not the primary source of message at this stage, because adoption is the primary source because you can't do good without adoption. You can't change the world without it [your tech] being adopted. If you start with the negative message, you won't propagate the message and therefore you won't create network effects. And that's the battle that you're currently seeing with media versus the groundswell. The groundswell is trying to create the positive message. The media's pushing the negative message. But yes, you won't get adoption of new technology unless you start with the positives. But of course, acknowledge the risks.
Comment on the Nine Tenets	
Tenet 1: *New scientific discoveries and emerging technologies become disruptive when they challenge widely held core human beliefs.*	The system of money, the dual ledger system, these things have been with us for thousands of years and 500 years or so in the dual ledger system. And most people don't realise the benefits of changing the system. Because the destruction of the system itself is a slow, evolving thing, and people don't see it. So they don't think it's possible, or necessary, and they think and hope, as all humans, that somebody else will figure something out and that 'the authorities' will find a way [to do it better]. Generally speaking, we've seen it with climate change and with all of the things you're talking about – that is not how things work. What it comes down to is, it has to come from the ground up. Where people think and challenge that status quo and say, "It doesn't have to be". And some of the points that you raised about a decentralised financial system at first sound ludicrous to people who have been institutionalised. But once you start thinking through, "OK, what does that mean and how much more robust is that as a system?", you have to take that leap of faith. The fact that millions of people trying to protect a network is actually much more robust than a handful of people trying to protect a network. And, you know, understanding networks is a new breakthrough. And it

	takes time, because it's letting the stabilisers off your bike and realising you can do it on your own. I think the hive mind, the behavioural incentives of the crowd, particularly around the system of money, is to protect it, and not let it burn. They will make mistakes, but what happens is, much like an ant colony, it teaches itself to survive. And that is wildly different than expecting a central banker to be able to figure it out. So I agree with the basic tenet.
Tenet 2: *It takes decades for a new technology or scientific discovery – and all its effects – to be understood adequately.*	People can't think in an exponential fashion, they tend to think linearly and they tend to think in incremental terms and not in quantum terms. So it is really hard for them to understand what could be, you know? Knock-on effects, living in the future, is not natural to most people. So that's definitely true. Also I think a key point is the acknowledgment that we don't know. It's no end state. Once you acknowledge there's no end state, what you're doing is you're enabling, that frees the mind up to understand that, who knows where it's going to go.
Tenet 3: *Because of the media's propensity to report along lines of conflict, extreme viewpoints are often highlighted, which frequently leads to polarisation.*	People fear change, and that creates polarisation. It's as simple as that. So, you either embrace it or you end up thinking it's the enemy, and it's the worst thing. The answer is always in the middle.
Tenet 4: *The media's coverage of prominent events regarding a new technology or scientific development massively influences public perception and acceptance.*	I'm not sure how applicable that is anymore. Depending how you define 'media', I think social media has changed this. If you think of crypto, it has been driven by a wall of FUD [fear, uncertainty, doubt] on one side, and on the other side this bottom-up distribution of [positive/adoption] news and spreading the word, that I think is kind of different. So, it's not driven by, yes, there are things like the Mt. Gox hack and Silk Road, for instance, that drive points in the narrative. But what is unique about this one, particularly, is the bottom-up elements of it. Now that is media, too, but it's just driven in a different way. So, you've seen how the media comes with things like, "It's dirty", you know, "It uses all the electricity", and then the community changes the narrative. You're seeing it now that "cryptocurrencies" get negative narratives, so they're changing the terminology to "Web3". That's happened at a hive mind level because, who wants to get in the way of the next iteration of the internet? Nobody! Nobody wants to stop the next wave of the internet. Arguably, Twitter [which operates like a hive mind] is now more powerful than any newspaper or television channel on Earth.
Tenet 5: *A rigid adherence to 'balance', not based on the weight of evidence, can cause harmful bias.*	Yes, and I don't think there's any way around that. Because there is a duty in media to do that, however ridiculous it is, because if not, they're driving a one-way narrative. And who's the source of truth here? That's the hard thing. And it really held back the climate change narrative, sadly, and' it's held it back with the coronavirus narrative as well. But it's hard to say that one person is the bastion of the truth. Because the journalists at the BBC decide that it's really tough, it's really tough. So really, it's about how the battle is won. The force of the arguments based around evidence, scientific evidence particularly, have to be given more space. I mean, the scientific method is a decent way of trying to do this. And we're not doing that in journalism, particularly when it comes to scientific things, which is probably wrong. Nobody cares about your

	opinion, what they care about is your evidence. So yes, to that certain extent, if you can come with evidence-based, peer-reviewed debate, fine. Opinion? It's worthless. So if you can weigh opinions based on evidence, that's great. But it's extremely hard to do.
Tenet 6: *Proper context is often crucial for accurate, responsible reporting on emerging technologies and discoveries.*	Also, I think within that people need to ask the question, where did that FUD [for instance] come from? You know, there's an element that it is planted to the journalists to purposely attack the idea. We've seen it in all of these, nuclear, we've seen it in climate change, we've seen it in evolution and we see it in crypto. There's an element of that I think that we need to understand within it [the discussion about the context within which communication takes place].
Tenet 7: *A lack of adequate knowledge on the part of a journalist is often a barrier to public understanding of novel science and technologies.*	Or approach it and say, "I don't understand it, and I formed this opinion and I want to speak to somebody about that". That's an open dialogue that actually helps people. And your negative or positive opinion may be right or wrong, but that's the way of doing it. As opposed to writing these voice of God pieces about why it's all terrible or why it's all good without the actual understanding. Now, most of these things are too complex for anybody to understand. So nobody's an expert, right? That's the point. There are very few people who are true experts. But that's OK, too.
Tenet 8: *Science journalists ought to consider not only the objective facts, but how audiences will feel about the risks that those facts represent, to anticipate moral implications and possible socio-cultural effects.*	If you want to propagate an idea, you have to understand the emotional impacts on all of the people. Because actually, most of the FUD, in whatever it is, is driven by emotion. I found this out actually in climate change Twitter, by mistake, I got kind of thrown into it. And I was arguing with these people saying, "Look, you've got to understand Pascal's dilemma, why would you not take it? Why would you not try and change the outcome?" Because the worst thing that can happen is, we have a less polluted world. The best thing to happen is we save everything. The other way around runs catastrophic risk. So why would you not do that? And what it came down to, why they were angry and why they feared change, is because they thought the government would raise tax on gas prices. So they were up to here in debt, these were middle Americans, and that's what their fear was. So it wasn't about saving the planet, it's like, I can't afford my bills. And if you do this, you're going to change my life. And I can [rather] just keep my shit together. Understanding that emotion is really important if you want to propagate the idea more effectively. And I think it's the same with crypto. By showing people it's not a threat, it doesn't have to be a threat. By the central bank of Singapore saying, "We can work with the private sector. We understand this is a new technology, let's integrate with it". As opposed to what is happening is, "You're trying to take control of our currency, and everything might blow up, what the hell are we going to do?" or "You're not going to pay taxes!?" That's the fear, right? Why do governments fear this? It's for nothing else than taxes. They need to get their taxes. If not, they can't pay the bills. It's the same argument. So, acknowledge where that's coming from – that they don't want to lose control of money, because it gives them power and it allows them to collect taxes. So yes, it's super important. It's an emotional response. And it always comes back differently, right? So, people never reflect their emotions as a true emotion. They're reflected as something else – defensiveness, anger, all of these things.
Tenet 9: *When it comes to new technologies and scientific developments, journalists should embrace*	I mean, I can't believe more in that, right? It's just probabilistic outcomes. Like "Crypto technology, blockchain technology, looks like it's really interesting. I haven't quite seen the use cases that squared away with me in my mind, but I understand that there's a potential that this

uncertainty, and the concept of probability, and make it part of their narrative.	could happen". And then, "Let's look at the possibilities and probabilities of that", is a much better way of approaching life in general. Because it gives you a context to grey as opposed to black and white. And grey is quite hard for people to deal with, because you can't keep hold of it. But once you get probabilities, it gives a contextualisation to grey, which is the unknown. Once you embrace the unknown, the world is much more accessible and interesting, and it's a clearer understanding. People tend to have an anchoring, so they tend to anchor themselves on what they know or what they understand of the world today. And that slows down the spread of knowledge. Because bitcoin?' It's gold. You know, digital gold, is actually just anchoring. What people don't want is, "Here's a scarce digital asset, built on a blockchain, that has an incredibly robust network. What could this be?" That is much more interesting than say, "Well, I understand something like this, so let's just call it that". That's the anchoring, anchoring bias.
Questions on theory viability and practical value	
Do you feel this theory provides a complete, appropriate and viable foundation for the accurate, responsible and ethical communication of potentially disruptive or revolutionary emerging technologies or new scientific discoveries? Please elaborate and indicate if you find there are aspects that are missing and ought to be added.	There's something about, I don't know where it fits in but, about 'knowing where we are' in the journey of knowledge that is incredibly useful. Somebody developed a blockchain – that's Satoshi's whitepaper – and at that point, everything is unknown. So the negatives and positives are equally weighted. The further the adoption of that idea, the more you have to kind of bank what has been acknowledged. There's something within that, that journalist's don't do. You know, if the technology's been around ten years, it's gone through two or three S-curve moments. It has been robustly tested and there is a large group of people who have a generalised understanding. It's kind of like your weighted theory about evidence. There's something about where you are in the adoption of the idea, that lowers the credibility [of criticism]. I mean, Nouriel Roubini saying it's all a scam, that's ridiculous. Now you can say there are elements of this I'm not comfortable with, BUT I've seen what's happened [so far]. So I think there is an ethical duty of journalists to acknowledge that. That it's also about where we are, in climate change, for instance. It's something to do with weighing the evidence. So maybe it's within that, but it's just, nonsense to, you know, refute so much stuff when so much is kind of banked knowledge as to where we are in the knowledge journey. Evolutionary theory is pretty much universally accepted outside of some religious teachers. And if you're going to cover that, you have to say that this view is now an outlying view versus the body of understanding as it stands today. So there's something in that. Because journalists have an authority that's given to them by the very nature of what they do and they need to use that authority in a more open way. So I'd like to just see that included somehow.
Would a simple, practical field guide (e.g. a one-page PDF) for the communication of potentially disruptive emerging technologies and discoveries, based on the Flaming Torch Theory, be valuable to you in the real-world conditions that you work in?	How do you motivate them to do that? The issue here is of the motivation of the journalists [or communicators] themselves. It won't be valuable until you identify what's in it for them. Honestly. Because, all great marketing has to take into account the human behaviour of the person you want to receive it. So, you say, "Use these nine things and you will become X and that will make you Y", is much more powerful than simply "Here's nine things that you should do".

	"Yeah? Fuck you. Why should I do them?" So if you were to show examples of journalists that embraced this kind of understanding and what it did to their authority and career, i.e. there are net tangible benefits by doing so [then that could work]. Because why should Gillian Tett at the *Financial Times* give a shit? She doesn't care what you have to say. But if you said, "Oh, but the history books would think of you this way, that you were the person who brought the discussion", that's why great interviewers like Charlie Rose and David Dimbleby and David Frost were great. Because they did a lot of these principles. And that gave them trust. People trusted them. And with trust comes power and acknowledgment, all of that. So that's the only thing I would think about. If not, you're preaching at them.

6.3.6 Discussion of comments – Raoul Pal

Pal highlights several issues not covered by the theory or tenets. Firstly, he mentions the role of positive or negative "behavioural *incentives*" in how disruptive technologies are both used and communicated. In particular, he mentions that communicators will only make use of or aid in the dissemination of such a theory, or the Nine Tenets, if they themselves are incentivised to do so (for instance by being persuaded that they will be better judged by history if they were to communicate in this way).

Secondly, Pal makes several mentions of the role of the audience collective on the internet and social media – the "groundswell" or the "hive mind" – as a powerful force that is able to counteract many political agendas, misinformation and biases that the media, political leaders, corporations or lobby groups might hold. According to him, social media and vastly distributed networks of connected individuals allow for a kind of automatic course correction for false narratives that did not exist before the era of the likes of Twitter, Facebook and WhatsApp. Through these *decentralised* networks, Pal argues power does not have to "coalesce in a few hands". This is discussed in more detail in the concluding chapter.

Pal also argues that the media have a duty to provide a balanced spectrum of opinions, even if some opinions might seem ridiculous, because otherwise it becomes a "one-way narrative" and therefore creates a single, and likely flawed, source of truth. In this case, the tenet in question might have been misunderstood, since the issue is not to omit a range of different views and perspectives, but simply to ensure that those of differing views have some evidence for their claims.

Lastly, Pal raises the point that "knowing where we are" in the technology journey is incredibly useful. He posits the idea of "banked knowledge", arguing that even if a technology like Bitcoin is far from mass adoption, if it has already been robustly tested over years and there is a large group of people with a generalised understanding of how it works, then communicators should acknowledge that fact and make good use of the *banked knowledge* to "lower the credibility of criticisms". If science journalists had been more diligent to communicate the accepted *banked knowledge* around the evidence for man-made climate change, for example, mitigation might perhaps already have been farther along.

6.4 Expert feedback: Artificial Intelligence

6.4.1 Rachel Gordon

Table 10: Artificial intelligence feedback – expert 1	
	**Rachel Gordon** Communications Manager at MIT's Computer Science and Artificial Intelligence Laboratory (CSAIL) https://www.csail.mit.edu/
	Responses
Initial questions	
1. *What do you feel are the most important potentially disruptive long-term consequences, effects or moral or ethical problems that the arrival of Artificial Intelligence might cause for humanity in the future?*	I view artificial intelligence as a tool: you can cause grievous damage with a hammer but also create something beautiful. The ubiquity of AI at this point is well known – it's probably more difficult to avoid using it now than to not. Currently, AI is not much smarter than a three-year-old. Getting neural networks to understand when they can't trust themselves is a burgeoning area of research that will get us closer to adequate confidence for time-sensitive decisions in autonomous driving, medical diagnostics, or muddying through deep fakes. Currently there's no firm legal framework for who's at fault if a machine makes a mistake. I think focusing on distinguishing between interpretability, explainability, and transparency of AI systems will ensure the trajectory of this tool progresses in a way that will continue to benefit humanity.
2. *What do you think can be done to best communicate this technology to the public in such a way as to help mitigate potential negative risks, effects or ethical concerns?*	Communicating scientific information should always be intellectually honest. Clear, straightforward, and in a way that's digestible by the public. Our access to information is boundless. To be competitive in the McWorld of the Internet where every corner is largely oversaturated or inflated with hype, the external temptation for clicks, and the rapid fire spread of misinformation can be dire. With science education, I believe in the importance of stressing sources in curriculum. There is an objective difference between a double-blind peer-reviewed study and a post on Reddit. There also is a bit of a gap between the science community and the public – the language and rhetoric is extremely difficult to understand if you are not an expert. There's a tremendous responsibility, thus, for science communicators to break down how a given technology or system works, what measures were taken to ascertain efficacy, and what applications and implications exist.
3. *Do you currently take ethics into consideration when communicating the technology that you or your company is working on, to the public? If so, how?*	In medical and scientific communications, there's motivation to oversimplify or exaggerate results for clicks, because when using tools like psychometric data, we can understand who is clicking, and why. As a scientific educator, I would serve no purpose in making someone believe a given technology will solve all of their maladies, that a proof of concept is ready before extensive testing, or that a machine is far more capable than it actually is. Commonly, in academia, if you are writing about research, a lead author on the project will review it before it is published – you can't simply put forth news at your own volition. To be an ethical writer and educator, you need to be a good reader. Having a deep understanding of how the technical system works and how it could affect humanity are critical components for ethical, intellectually honest writing.
Comment on the Nine Tenets	
Tenet 1: *New scientific discoveries and*	As a science reporter, intellectual honesty, coupled with a keen understanding of our own bias and a deep knowledge of the subject matter,

emerging technologies become disruptive when they challenge widely held core human beliefs.	is the fusion needed for thoughtful presentation. Fear is largely inevitable surrounding any "disruptive" technology, emerging medicine, philosophical breakthrough, but we must strive to look for angles to assuage. This can be done tactfully when we are guided by ethics and the desire to help people. For example, if I'm writing a story about AI to help the elderly age in place, it behoves me to include a detail that AI is still not much smarter than a three-year-old, a nurse's productivity has increased by X amount of hours given the addition of using AI, and the robot in question will only take data from specified areas. It's critical to emphasise that AI is no different than any tool that can be used for good or evil: use cases in deep medicine, navigation, and agriculture demonstrate harnessing something powerful for good, just as discussion of deepfakes, cyberattacks, and data manipulation show the bad. I believe in the validity of this tenet – we recently saw how crucial this was with misinformation surrounding the COVID-19 vaccines. One of the big differences between humans and AI is judgement, but we're still seeing many sensationalised titles or films demonstrating the opposite. We're still pretty far away from replicating that in machines. With social media, globalisation, and entertainment value, the onus is on a combination of scientists, government, and journalists to get together and present information in a way that takes widely held core human beliefs into account.
Tenet 2: *It takes decades for a new technology or scientific discovery – and all its effects – to be understood adequately.*	Flourishing in an age of accelerations requires owning what we don't know. In many presentations of preliminary medical findings (ideally), we will see a clear outline of what stage a clinical trial is in, immediate findings, and a statement acknowledging that it will take more time to ascertain long-term side effects. AI, being quite broad in its applications and complex in its nuances, should be treated with the same attention. When presenting new research, there exists the temptation to highlight, as you mentioned, immediate applications, with little nod to potential consequences – which can of course be difficult to know as the field is still rapidly changing. Incorporating open dialogue contributes to more balanced, intellectual honesty. I've observed almost an allergy to widespread insurance of this balance in science media, leaving room for fear, conspiracy theories, and misinformation. Technology is growing very rapidly, leaving many to feel like they're being left behind. Public perception of machine capabilities is fuelled by a lot of popular culture portrayals of all-mighty machines, when in reality they are still learning how to explain themselves and reason about what they see – a lot of success is due to trial and error. With such a large gap, this makes trust and acceptance difficult.
Tenet 3: *Because of the media's propensity to report along lines of conflict, extreme viewpoints are often highlighted which frequently leads to polarisation.*	The top expert in a field can always be drowned out by someone with a fringe ideology, a loud voice and a big following. Unless you are writing an opinion piece as a scientist in the field, the reporter should always be a neutral vessel. Evidence is always paramount – presenting viewpoints from outside experts and uninvolved sources adds validity to what should be a nuanced, straightforward, and also engaging piece of material that leaves less room for fear and more for empowerment. In my work, I always include a quote from an uninvolved, third-party expert to gain additional viability and clarity. As a reporter, we should never give a voice to extremists, as it promotes a cycle of fear and misinformation. Extremes in any form are usually counterproductive – AI will neither save nor kill us all, it is a technological tool that can amend many parts of society and work with human

	counterparts to free us from the dull, dirty and dangerous tasks. This notion should always be accompanied by an appraisal of security risks, bias, or any other relevant consequences.
Tenet 4: *The media's coverage of prominent events regarding a new technology or scientific development massively influences public perception and acceptance.*	The most important point here that you mentioned is that, while embodied intelligence is a burgeoning field in computer science, for much of the AI advances mentioned – these systems were explicitly programmed to do a single task. AI is very good at that. But an AI simply beating a world-class chess player sounds a lot cooler. Science should not be looked at as entertainment. The need for clicks stands to seriously upend society – we need to detox off the stimulation of more flashy presentations of science and become excited about the material for what it can do for humanity, not for a shiny headline that overstates potential. Connected devices, for example, have boundless use cases for businesses and personal use – vehicles, health and fitness monitors, and household appliances. Recent research has shown that millions of smart devices can be hacked, but rarely do we see this concern addressed in articles about sparkly new smartwatches. As reporters, we need to think of creating engaging ways to present information that isn't sensationalised and overhyped. This could include breaking down topics into various levels of depth (*Wired* has a series that explains machine learning "to a child, a teenager, a student", etc.), making creative video illustrations that break down dense systems, and working with government and schools to begin to incorporate a [computer science] (CS) curriculum (practical and historical) into educational models. We need more consideration on how our words might age. I believe these ethical tenets could potentially be the guideline for a large standards committee that vets science articles with a 1-10 scale on accuracy and honesty.
Tenet 5: *A rigid adherence to 'balance', not based on the weight of evidence, can cause harmful bias.*	Free speech will always be both a large blessing and a frightening weapon. Yes, we should not adhere to balance for the sake of it, it should be due to a nuanced understanding of the need to integrate various viewpoints that buttress the evidence. As I mentioned before, due to free speech and extremists, we should look to creating an ethical standards board that reviews popular claims related to AI in the news.
Tenet 6: *Proper context is often crucial for accurate, responsible reporting on emerging technologies and discoveries.*	Distinguishing between general, embodied and specified intelligence is integral to communicating an honest depiction of the state of AI. We have a good handle on what AI systems are not capable of – it's what fills our researchers' days – and this should be explicit. By including applied research experiments over empirical data, we build a better understanding of current capabilities and how they could be leveraged across various sectors of society. You can assume a varying level of comprehension if you have studied your audiences – but AI reporters should always strive to make all information accessible, stay away from jargon, and should add relevant analogies when appropriate.
Tenet 7: *A lack of adequate knowledge on the part of a journalist is often a barrier to public understanding of novel science and technologies.*	Breaking down the technology behind how AI works is difficult even for experts – neural networks, while modelled after the human brain, don't always feel intuitive, they are extremely complex and hard to put into digestible content. AI is also extremely broad in its form and applications. To be a good writer, you need to be a good reader. If you are not a computer scientist by trade, reporting information on AI requires a tremendous amount of background work. Reading relevant published research papers, speaking to experts, and finding appropriate books to add to a more holistic understanding of the history and current capabilities of AI.

Tenet 8: *Science journalists ought to consider not only the objective facts, but how audiences will feel about the risks that those facts represent, to anticipate moral implications and possible socio-cultural effects.*	Considering possible emotional responses is a tricky landscape to navigate. We use ATMs now with ease, and likely seldom think of the displaced bank tellers. While considering potential ramifications of such technologies, these are areas to probe with experts – with direct quotes on their view of topics such as how many jobs are created and supported because of AI, how to mitigate potential security concerns, or the costs and benefits of potential social and health applications. Taking the moral implications into consideration is critical, so long as it doesn't affect tone – overstating the possibilities of a technology, holding back from discussing potential dangers, and so on in fear of potential emotional response. Since there's still no legal framework for who's at fault if a machine makes a mistake, we must try to distinguish between interpretability, explainability and transparency of AI systems.
Tenet 9: *When it comes to new technologies and scientific developments, journalists should embrace uncertainty and the concept of probability and make it part of their narrative.*	There needs to be more reporting on what AI models are still struggling with in the context of improvement. In my work, I don't shy away from reporting on incremental research – while admittedly less "flashy" – to be transparent in the evolution of a developing technology. We need to go more in-depth with topics, like formulating confidence in deep neural networks, using deepfakes for good, or what it means to manipulate data. German philosopher Martin Heidegger theorised that the human-technology relationship oscillates between suspicion and reliance until we accept the risk inherent in technology. We need science communicators and reporters to explain this risk using the proposed nine tenets to deliver information that we hold to be the highest objective form of moral truth.
Questions on theory viability and practical value	
Do you feel this theory provides a complete, appropriate and viable foundation for the accurate, responsible and ethical communication of potentially disruptive or revolutionary emerging technologies or new scientific discoveries? Please elaborate and indicate if you find there are aspects that are missing and ought to be added.	I can envision this doctrine being incorporated into college journalism classes, at science tech outlets for training, and perhaps even for my idealised proposed ethics committee. I feel it is comprehensive and takes a deep dive into how to present information of the future.
Would a simple, practical field guide (e.g. a one-page PDF) for the communication of potentially disruptive emerging technologies and discoveries, based on the Flaming Torch Theory, be valuable to you in the real-world conditions that you work in?	Absolutely. As I read through the Flaming Torch Theory, I was reminded of where I can do better in my own work, making sure I don't shy away from discussing nuances that are inherently more "negative". There is a vast gap between the public perception of AI and what scientists believe to be true of the current state-of-the-art models. The conceptual clarity can be guided by this framework, which tactfully incorporates a number of technical, social, and moral implications to ensure reporters are presenting AI in an intellectually honest manner.

6.4.2 Discussion of comments – Rachel Gordon

Gordon, in her initial answers, demonstrates how abstract and deep-seated the moral questions around technology can become when she mentions that, in artificial intelligence, neural networks will need to "understand when they can't trust themselves" and that there is "no legal framework for who's at fault when a machine makes a mistake". Such complex issues fit well with the first tenet of the theory.

She also mentions the motivation for either exaggerating or oversimplifying science communication, "based on clicks" – which again emphasises the role of *incentive structures* in communication. She argues that, because psychometric and other data on human behaviour is increasingly available for machine learning analysis, it is possible to "understand who is clicking and why". This can easily incentivise the altering or framing of communication to increase likes, shares, clicks, views, etc. Gordon highlights this again when she says: "The need for clicks stands to seriously upend society – we need to detox off the stimulation of more flashy presentations of science and become excited about the material for what it can do for humanity, not for a shiny headline that overstates potential."

Finally, in stressing the importance of "owning what we don't know", as well as what we do know (for instance acknowledging at what stage a clinical trial is in), Gordon seems to allude to the same *banked knowledge* point raised earlier by Pal.

6.4.3 Jennifer Bernal

Table 11: Artificial Intelligence feedback – expert 2

	**Jennifer Bernal** Public Policy Manager – Google DeepMind, Ethics and Society Team https://deepmind.com/about/ethics-and-society Jennifer has worked at the intersection of public policy and technology for a decade. She previously managed Google's policy strategy for media and intellectual property in Europe, the Middle East and Africa. She works with governments and the policy community, supporting discussions about the governance of new technologies and ensuring that public interests in creating safe and ethical AI are reflected in DeepMind's research.
	Responses
Initial questions	
1. *What do you feel are the most important potentially disruptive long-term consequences, effects or moral or ethical problems that the arrival of artificial intelligence might cause for humanity in the future?*	The misuse of AI systems: Complex AI systems being used in such a way as to facilitate pervasive surveillance; misinformation; perpetuate unfair outcomes; or result in loss of human agency. AI accidents: Vulnerabilities in AI-powered systems, resulting in malfunctions that endanger human wellbeing and safety. Ethical questions around AI agency: Balancing questions around attribution of creativity; personhood; and moral responsibility in the face of increasingly complex and interactive AI systems.
2. *What do you think can be done to best communicate this technology to the public in such a way as to help mitigate potential negative risks, effects or ethical concerns?*	Raise broader awareness: Increase the baseline understanding the general public has about the ways AI is already being used all around us. Aim for clarity and ease of understanding: Demystify complex technological terms in order to make effects digestible. Be transparent about limitations: Openly disclose when people should trust the result an AI system produces, and when it merits further scrutiny. Build trust over time: Developers and deployers of the technology should communicate regularly and expect to be held to a high standard of scrutiny.

3. *Do you currently take ethics into consideration when communicating the technology that you or your company is working on to the public? If so, how?*	Yes. I see ethics as central to discussing our technology and its effects on society. How: i. Highlighting why ethics are important to consider – explaining the stakes. ii. Acknowledging challenges and ambiguities when discussing ethics – for instance, cultural divergence in norms and expectations. iii. Grounding discussion in foresight: Present + anticipated effects of AI. iv. Referencing body of evidence we have from deployment and research; making sure claims made in communication can be backed up via internal practices. v. Bringing in outside voices, including from civil society, policy stakeholders, lay people, and others who might not otherwise be as intimate with the development of technology.
Comment on the Nine Tenets	
Tenet 1: *New scientific discoveries and emerging technologies become disruptive when they challenge widely held core human beliefs.*	It appears that this tenet could cover emerging technologies challenging widely held beliefs, but also resulting in widespread changes to a way of living. I might suggest some slight modifications/builds on the cited considerations to emphasise where status quo assumptions are being challenged: "My field of employment is likely to be stable in the near future." "Our work/employment model is a fundamental element of our society." "Other people have no ways of accurately monitoring my emotions or inner life."
Tenet 2: *It takes decades for a new technology or scientific discovery – and all its effects – to be understood adequately.*	This tenet raises an interesting tension: The full effect of AI can only be assessed over a long period of time, requiring both patience and careful forecasting abilities. At the same time, the rapid pace of AI development means that new techniques are constantly emerging, and new milestones are being met. This means that, simultaneously, one has to be mindful of short timelines to accurately represent and communicate the evolving state of the technology.
Tenet 3: *Because of the media's propensity to report along lines of conflict, extreme viewpoints are often highlighted, which frequently leads to polarisation.*	This tenet astutely alludes to the incentives that guide media coverage. In the case of AI, it is common to see both an amplification of extreme viewpoints at the same time as we see a simplification of arguments, in order to ensure a narrative seen as sufficiently "juicy".
Tenet 4: *The media's coverage of prominent events regarding a new technology or scientific development massively influences public perception and acceptance.*	This tenet captures the important priming and opinion-forming role that journalists and other members of the media play in society. It is a tricky one – in some instances, the reason why a development might be a milestone might be more straightforward, such as in the case of a clear technical benchmark being met. But in others, it is actually the media and community reception that will make an event "prominent" or to seem "important".
Tenet 5: *A rigid adherence to 'balance', not based on the weight of evidence, can cause harmful bias.*	Balance is important, but I agree that it's important to have a flexible understanding of what balance is. AI is currently a 'hot' topic, one that unleashes many emotions. It can therefore lead to people making sensationalist claims, knowingly or unknowingly – and this is something a communicator should be cautious

	about. At the same time, the evidence on emerging technology is shifting rapidly, and it is important for the debate on its effects to be inclusive and open to challenge.
Tenet 6: *Proper context is often crucial for accurate, responsible reporting on emerging technologies and discoveries.*	I agree strongly that context is very important to responsible communication. Context is what can help a layperson understand that a technology may be far from maturity; or to situate an effect that may be most immediately ascribed to AI within the right societal origins.
Tenet 7: *A lack of adequate knowledge on the part of a journalist is often a barrier to public understanding of novel science and technologies.*	As translators of technology, journalists have a responsibility to ensure they have adequate knowledge of the technology they are describing. In practice, the journalist will often then have to decide what level of information is appropriate to convey at any given time: It will not always be the case that going into the details of (e.g.) a specific machine learning technique will be appropriate to make a point. That said, it is definitely important to establish partnerships with experts who can ensure communicators have the appropriate baseline understanding of the technology.
Tenet 8: *Science journalists ought to consider not only the objective facts, but how audiences will feel about the risks that those facts represent, to anticipate moral implications and possible socio-cultural effects.*	Agree with this consideration – emotions are likely to be an important factor in determining how people will react to a given technological development, and correspondingly what constraints a society will impose on those technologies.
Tenet 9: *When it comes to new technologies and scientific developments, journalists should embrace uncertainty and the concept of probability and make it part of their narrative.*	Very important point, which ties to the aforementioned importance of allowing for nuance. Communicating uncertainty in a clear and useful way is a difficult task, but one that is possible by getting the public more accustomed to encountering notions of probability (and things like different scenarios and graduated risk) as part of their media consumption. [As an additional nit, I'll point out that the concept of a 'singularity' is not necessarily the same as when AGI becomes possible.]
Questions on theory viability and practical value	
Do you feel this theory provides a complete, appropriate and viable foundation for the accurate, responsible and ethical communication of potentially disruptive or revolutionary emerging technologies or new scientific discoveries? Please elaborate and indicate if you find there are aspects that are missing and ought to be added.	I believe this theory offers an appropriate and useful foundation to think through the responsible communication of potentially disruptive emerging technologies. I find it interesting that the tenets differ quite a bit in their format. Some of them are more observational/diagnostic, leaving the reader to interpret the consequent lesson. The … final ones are more explicitly prescriptive ("journalists ought to"/"journalists should"). It seems positive that the theory is broad – it does not appear to be 'complete' as such, but it seems straightforward to build upon it. I would be interested in hearing more about how this theory would address conflict – for instance, how to incorporate under-represented perspectives, or balance values and belief systems that might be at odds with each other. I would also be interested in more in-depth probing of where this theory results in counter-intuitive insights. The takeaway from tenet number 5, "'balance' may seem desirable but can often lead to simplification and polarisation", is a good example of this. Where do the other tenets expose such tensions worth deeper reflection?

Would a simple, practical field guide (e.g. a one-page PDF) for the communication of potentially disruptive emerging technologies and discoveries, based on the Flaming Torch Theory, be valuable to you in the real-world conditions that you work in?	I find the principles of the Theory helpful ones, and believe the concepts above would make for good reading when encapsulated in (e.g.) a one-pager. That said, as a practitioner who is already facing these questions in the field, they are a useful summary, rather than something I would consider the need to consult regularly. I could see this being a rather valuable resource for someone who is at an earlier stage or has less familiarity with the field.

6.4.4 Discussion of comments – Jennifer Bernal

Bernal states, in discussing Tenet 2, that the full impact of AI can only be assessed over a long period of time, but that ongoing development nevertheless occurs at a very rapid rate. This means that communicators have to simultaneously be mindful of short timelines as well as very long timelines. This again matches with the concept of being clear about what is accepted, *banked knowledge* (that can be built upon as evidence for further developments or speculation), and what remain the larger unknowns.

Bernal also makes mention of the "*incentives* that guide media coverage".

She mentions that some of the tenets are observational/diagnostic, while others are more prescriptive. This is addressed in the concluding chapters in which the field guide is presented.

Finally, Bernal asks how this theory would address conflict, for instance how it could incorporate under-represented perspectives or how it could balance values or belief systems.

6.4.5 Prof. Tommie Meyer

Table 12: Artificial intelligence feedback – expert 3	
	**Prof. Tommie Meyer** Co-director of South Africa's National Centre for Artificial Intelligence Research (CAIR) Tommie is internationally recognised as an expert in knowledge representation and reasoning. He is also Director of the Artificial Intelligence Research Unit (AIRU) – the University of Cape Town's (UCT) node of CAIR. https://www.cair.org.za/user/7
	Responses
Initial questions	
1. *What do you feel are the most important potentially disruptive long-term consequences, effects or moral or ethical problems that the arrival of artificial intelligence might cause for humanity in the future?*	This question requires a conditional response. It is important to distinguish between artificial general intelligence (AGI), and domain-specific artificial intelligence (AI). The former is, roughly speaking, the idea of a system capable of exhibiting intelligence across all domains, or at least a large variety of domains. The latter describes systems able to act intelligently in highly specific domains. AGI has not yet arrived, and the question of whether or not AGI will arrive soon is a hotly debated one. On the other hand, AI has already been with us for some time. It is best to view AGI and AI as two opposites on the same spectrum, and not as separate endeavours. Here I will focus more on the consequences of the arrival of AI, not because I think a discussion of AGI is unimportant (quite the contrary!), but rather because I regard a discussion of the consequences of AI as a better starting point.

	To some extent we are already experiencing the consequences of the arrival of AI in both positive and negative ways. Broadly speaking, the positive aspects relate to a realistic appreciation of the capabilities of the AI technologies being used, while the negative aspects can be traced back to overestimating such capabilities. To illustrate this point, consider the navigation systems offered by companies such as Google (Google Maps) and Apple (Apple Maps), a good example of well-established, domain-specific AI technologies. Overestimating the capabilities of such a system leads to instances of people blindly following the recommendations of such systems with undesirable, and sometimes disastrous, consequences. A well-reported example of such a case is that of a person slavishly following automated navigation instructions under foggy weather conditions, and driving into a body of water as a result. On the other hand, appreciating the actual capabilities of this technology leads to the need to abandon one's own (frequently faulty) intuition of what constitutes the fastest route from point A to B in favour of the more accurate, data-driven approach offered by these systems. This is a fairly innocuous example, but applying the same principles to other (current and future) applications of AI has the potential for enormous disruption. Two more examples serve to illustrate this point: 1. AI technologies are already embedded in systems employed by financial institutions to make decisions on matters such as home loan approvals. Such systems are frequently trained to make decisions using so-called machine learning algorithms that use data obtained from previous decisions being made. The problem is that if previous decisions were biased in some way (e.g. in terms of race or gender), machine learning systems are most likely to reflect this bias. An overestimation of the capabilities of such systems may then perpetuate the same bias, but under the guise of the supposed objectivity of systems based on machine learning. 2. AI systems have found their way into the health sector, with reports of systems providing better medical diagnoses than many medical practitioners in some cases. But there seems to be resistance to the adoption of such AI technologies due to the fact that they are not 100% accurate. This is especially unfortunate, since human experts, of course, do not have a 100% accuracy rate either. The best way forward seems to be a combination of human and machine expertise. But this requires a detailed understanding of the capabilities of the AI systems in question. The decisions made by AI tools are usually arrived at by approaching the problem under question in a way that is very different from approaches adopted by humans. Understanding how AI tools arrive at such decisions, and combining it with human-made decisions, is likely to lead to decision-making processes that surpass the abilities of both humans and machines.
2. *What do you think can be done to best communicate this technology to the public in such a way as to help mitigate potential negative risks, effects or ethical concerns?*	The only way to communicate the use of AI technologies to the public is via a form of education on AI literacy. Basic proficiency in the use of AI tools needs to be taught at school, at tertiary institutions, in industry, and in government. Most urgent here is for policy makers to have a form of AI literacy. Changes in legislation regarding AI are needed, but can lead to disaster if those making the decisions on such legislation do not understand the basic tenets of what these technologies are capable of, and what they are not capable of.
3. *Do you currently take ethics into consideration when communicating the*	At the University of Cape Town, a component on ethics related to Computer Science is included in the curriculum.

technology that you or your company is working on to the public? If so, how?	
Comment on the Nine Tenets	
Tenet 1: *New scientific discoveries and emerging technologies become disruptive when they challenge widely held core human beliefs.*	Core beliefs that are or might be challenged by developments in artificial intelligence: "Humans will always be the smartest entities on earth." Yes, a useful belief to consider, but mostly because it hinges on what we mean by smart. In some ways, machines are smarter than humans already in narrow domains (e.g. calculators) "AI will one day cause me to lose my job." I guess the core belief here is "AI will never cause me to lose my job". The interesting aspect here is that the conversation has shifted from blue-collar jobs being affected to white-collar jobs being affected. "I will always know what is real and what is artificial." This is relevant, yes, in the context of interaction with machines. "AI, and those in power of AI, should not be able to monitor my emotions or behaviour without my consent." Is the intent here that the statement above is the core belief, and that what is being challenged is that individuals may start changing their minds about it, instead moving to the opinion that they may want AI to monitor emotions etc. without consent? If so, then yes, this is very relevant! "Machines are not supposed to be smarter than humans." From a cultural and religious perspective, a relevant core belief. "Machines or computers can never (or should never) achieve consciousness." Similarly to the statement above, a relevant question, but for a different reason. It is clear that intelligence does not require consciousness, and conversely, that consciousness does not require intelligence, but that the two overlap to some extent. The interesting aspect here is that the two notions are frequently conflated. "You cannot form a deep, meaningful connection with a machine." Very relevant statement from a cultural perspective. "Advanced, humanlike AI will eventually kill us all." I don't see that this is a core belief being challenged.
Tenet 2: *It takes decades for a new technology or scientific discovery – and all its effects – to be understood adequately.*	The Saran article is somewhat misleading in my view. Firstly, machine learning is just one aspect of AI. Secondly, the assumption that the rate of learning image identification is closely related to progress in machine learning is highly debatable. So, what we get here is a chain of conclusions leading to a sensationalist claim. I agree that it's very hard to predict AI capabilities even five years into the future, but not because of the research mentioned in Saran's article.

Tenet 3: *Because of the media's propensity to report along lines of conflict, extreme viewpoints are often highlighted, which frequently leads to polarisation.*	A very valid point, and one that needs clear emphasis. There are important parallels to be drawn with other technologies and the human relationship with the these technologies.
Tenet 4: *The media's coverage of prominent events regarding a new technology or scientific development massively influences public perception and acceptance.*	Two valid points are made above [in the examples]. The one about AI being smarter than humans within a narrow domain is a crucial point that frequently gets lost in the hype. A separate point is that of the perception of AI in movies. Almost without exceptions, there is a conflation with consciousness in these cases.
Tenet 5: *A rigid adherence to 'balance', not based on the weight of evidence, can cause harmful bias.*	A valid point in the case of AI, certainly. What makes this tricky is that it's sometimes in the interests of AI researchers to go along with such over-the-top claims to advance their own research agenda. It becomes hard to determine how to assign weight to the evidence.
Tenet 6: *Proper context is often crucial for accurate, responsible reporting on emerging technologies and discoveries.*	This is probably one of the most important aspects when it comes to the role of the media regarding AI. At present, machine learning is frequently used as a synonym for AI, even though it's one of a number of subareas of AI. Even the highly touted examples of successful AI systems, such as Deepmind's AlphaGo, AlphaZero, etc., actually make use of a suite of AI technologies, of which machine learning is just one.
Tenet 7: *A lack of adequate knowledge on the part of a journalist is often a barrier to public understanding of novel science and technologies.*	A valid point, but at the same time a very difficult one in which to achieve balance. The main factor here, in my view, is that it's possible to paint an accurate picture in longer pieces, but that space considerations make it impossible for even the best-intentioned and well-informed science journalists to do justice to complex issues. When space is an issue, the best solution is probably to add constant reminders that the issue is a complex one, and to provide references to articles where more space can be devoted to such issues.
Tenet 8: *Science journalists ought to consider not only the objective facts, but how audiences will feel about the risks that those facts represent, to anticipate moral implications and possible socio-cultural effects.*	Agreed. Taking emotions into account play a very important part in getting an accurate message across. An informed science journalist may well fall into the same trap that AI researchers frequently fall into: dismissing the more outlandish objections and fears about AI technologies, rather than recognising that such objections and fears are real for people, and addressing them in a sober fashion.
Tenet 9: *When it comes to new technologies and scientific developments, journalists should embrace uncertainty and the concept of probability and make it part of their narrative.*	A very important point, yes. The importance of embracing uncertainty, rather than seeing it as a form of weakness, cannot be overemphasised. In the AI research community there is a very diverse set of opinions on AGI, and it's important to convey to the general public that embracing these divergent views now will help us in the future to come to grips with change.
Questions on theory viability and practical value	
Do you feel this theory provides a complete, appropriate and viable foundation for the accurate, responsible and ethical communication of	With some minor qualifications, as expressed in the comments above, I regard this theory as an appropriate and viable foundation for communication about artificial intelligence, and for emerging technologies in general.

potentially disruptive or revolutionary emerging technologies or new scientific discoveries? Please elaborate and indicate if you find there are aspects that are missing and ought to be added.	Whether it is a complete theory is harder for me to judge. From the current presentation, it seems that there is nothing obvious that has been omitted, but completeness is usually much harder to judge than questions relating to viability and being appropriate (this is an example of embracing uncertainty!).
Would a simple, practical field guide (e.g. a one-page PDF) for the communication of potentially disruptive emerging technologies and discoveries, based on the Flaming Torch Theory, be valuable to you in the real-world conditions that you work in?	As an employee of a tertiary institution, I can see the need and the use of such a guide for communicators at my institution and other similar institutions.

6.4.6 Discussion of comments – Prof. Tommie Meyer

On the whole, Meyer agrees with the Nine Tenets and feels the theory is viable and useful. He also emphasises the ethical complexity of both AI development and its communication to the public by illustrating, firstly, that without careful consideration, machine learning can easily reflect existing human biases, and secondly, that the best way forward – by combining human and machine expertise – inevitably requires a detailed understanding of AI systems (which many communicators and policy stakeholders will not necessarily have). He therefore advocates a form of education on AI literacy.

6.5 Expert feedback: Human gene editing

6.5.1 Dr Samantha Nicholson

Table 13: Human gene editing feedback – expert 1	
	**Dr Samantha Nicholson** Post-doctoral fellow at the University of Pretoria's Institute for Cellular and Molecular Medicine (ICMM) Samantha is a molecular biologist working for the ICMM, focusing on research projects using CRISPR/Cas9 gene editing technologies and human stem cells. http://www.samj.org.za/index.php/samj/article/view/11061
	Responses
Initial questions	
1. *What do you feel are the most important potentially disruptive long-term consequences, effects or moral or ethical problems that the arrival of human gene editing might cause for humanity in the future?*	• The wealth gap and gene editing and gene therapy-type drugs being restricted to only those who can afford these kinds of interventions. A critical question will be the equitable distribution of these potentially life-saving and life-altering technologies. • Diversity and inclusion. The lean towards Eurocentric genetics will have a significant effect on the applicability of these technologies to more diverse populations. • Defining disease, for example deafness is objectively a handicap, but the deaf have a defined and constructive community with its own identity, so how can we prescribe that they undergo a life-altering procedure on an objective definition and where is the line

	(body autonomy is already an issue with vaccines). • Finally, will we be influencing the evolutionary course of our species.
2. *What do you think can be done to best communicate this technology to the public in such a way as to help mitigate potential negative risks, effects or ethical concerns?*	• Inclusivity, expanding capacity for these technologies to LMICs and generating this tech in local settings and communicating these origins. • Basic scientific literacy, making sure scientific communication is handled by those who understand the basics enough to explain it clearly to the public. • Reduced sensationalism, boring doesn't sell copy I know, but the sensationalism around these technologies, like we are going to create designer babies, builds a sense of mistrust for what will ultimately be one of the defining medical breakthroughs of the 22nd century and beyond.
3. *Do you currently take ethics into consideration when communicating the technology that you or your company is working on, to the public? If so, how?*	Absolutely, my work frequently brings me into contact with non-experts and so I work very hard to explain the basics of the tech and how it might be applied and how it won't be applied. I am also a vocal advocate for capacitation in an African setting and I often speak at events highlighting the need for equitable distribution of the technology and ensuring that it is accessible to those who need it.
Comment on the Nine Tenets	
Tenet 1: *New scientific discoveries and emerging technologies become disruptive when they challenge widely held core human beliefs.*	I think this is probably the core challenge to the communication of human gene editing, although there is a potential for enormous human progress in response to these technologies. Equitable access and ethical application will always be a question, the idea of designer babies being an obvious example. However, given the current constraints on human editing, including its confinement to somatic changes and non-germline edits, a lot of these fears can be addressed with a clear education and understanding of the real-world applications of these technologies. Anything being seen to be 'playing God' is a touchy subject, but I think making sure that we communicate the limits and the rigorous review of this kind of advancement, we can navigate this issue. Given this, I believe this is probably core to all messaging around human gene editing, which needs public engagement.
Tenet 2: *It takes decades for a new technology or scientific discovery – and all its effects – to be understood adequately.*	I think there are two things that should be highlighted here. One, the long history of genome engineering. It has been around for much longer than people realise, there are more than four decades behind gene therapy, not the 10 years we have been working with CRISPR. In addition, new technologies often reduce the time of evaluation required – i.e. "built on the shoulders of giants". Given this, it is probably important that this is communicated properly. Scientific progress is connected, often allowing for rapid improvement in the absence of "decades" of evaluation. This idea is actually a misconception and should be addressed specifically as opposed to [only] dealing with it in the long term. Many of these therapies are going to be maturing in the near future, having been in development for far longer than the idea has been in the zeitgeist.
Tenet 3: *Because of the media's propensity to report along lines of conflict, extreme viewpoints are often*	It is critical to make sure that these technologies are discussed in as nuanced a format as possible. There is a broad spectrum of beliefs and, while the ethics and emotion of these technologies is important, it should be discussed in a critical, well-

highlighted, which frequently leads to polarisation.	informed format and sensationalism should be avoided at all costs. Like everything, there are two sides to the story and somewhere in between is the truth; this nuanced approach is probably critical to the widespread adoption of these technologies.
Tenet 4: *The media's coverage of prominent events regarding `a new technology or scientific development massively influences public perception and acceptance.*	Being aware of the historical perception of these technologies is important, and communicating these achievements in a neutral, scientific manner and with an absence of emotion is important, but certainly an awareness of this background is also important when preparing statements and evaluating releases to the media. Scientific communication should be completed using trusted partners with a proven track record of nuanced coverage as mentioned in these tenets.
Tenet 5: *A rigid adherence to 'balance', not based on the weight of evidence, can cause harmful bias.*	The mRNA vaccine debate is a clear example of why allowing scientific progress to be framed in a "balanced" approach, might be dangerous. Science is objective and fact-based by nature, making most discussions of technological advancement by nature "balanced". Informed debate among informed experts should be encouraged, but simply providing equal airtime to different viewpoints is dangerous and unnecessary. Scientific discussions should be subject to ethical and moral discussions, but they should not be "balanced" by allowing proponents of either extreme to comment for the sake of comment.
Tenet 6: *Proper context is often crucial for accurate, responsible reporting on emerging technologies and discoveries.*	Absolutely. Historical and technical context is critical to the accurate communication of this kind of technology, [and] the mRNA therapies are a prime example. There is a sense that they were developed in 12 months, but actually 30 years of prior research went into their development. Given this, it is critical to broadly contextualise and explain the basic principles necessary to evaluate the information being provided. Nothing exists in a vacuum – especially not cutting-edge science.
Tenet 7: *A lack of adequate knowledge on the part of a journalist is often a barrier to public understanding of novel science and technologies.*	Absolutely. It is critical that any report of these technologies is conveyed in a nuanced manner making a basic understanding of the tech on the part of the presenter critical. That said, there is also a requirement for scientists to make their presentations more accessible. Communication among experts is not always clear. It is a critical gap in our education of both doctors and scientists. Simple, relatable explanation is important for public communication, but science should be communicated by specialised reporters, like we have for finance or political reporting where the communicator is well versed in their field of concern.
Tenet 8: *Science journalists ought to consider not only the objective facts, but how audiences will feel about the risks that those facts represent, to anticipate moral implications and possible socio-cultural effects.*	This is especially true for technologies around editing of the human genome, given the history of eugenics and the idea of superiority in human civilisations, it is critical that the communication of these advancements are balanced by this [emotional] context.
Tenet 9: *When it comes to new technologies and scientific developments, journalists should embrace uncertainty and the concept of probability and make it part of their narrative.*	This is true. Science is by its nature an evolution, nothing in science is ever proven, only hypothesised, and scientists reserve the right to change their mind in the face of new information and this should be part of any narrative on scientific progress – making it critical that communicators highlight the inherent evolution of technology and its applications.

Questions on theory viability and practical value	
Do you feel this theory provides a complete, appropriate and viable foundation for the accurate, responsible and ethical communication of potentially disruptive or revolutionary emerging technologies or new scientific discoveries? Please elaborate and indicate if you find there are aspects that are missing and ought to be added.	This is a nuanced and carefully formulated framework with clear advantages to the communicator. I think that it is largely complete, but I would perhaps emphasise the communication of the *history of progress* around these technologies that support their application now, to address the basic concerns around not knowing enough about them. Gene editing is a decades-old scientific effort and sometimes, in our rush to highlight its novelty, we neglect the decades of nuanced, complex research that has facilitated the recent 'rapid' development of these technologies.
Would a simple, practical field guide (e.g. a one-page PDF) for the communication of potentially disruptive emerging technologies and discoveries, based on the Flaming Torch Theory, be valuable to you in the real-world conditions that you work in?	Absolutely. Most scientists are not well versed in communicating with the general public. To have such a framework for evaluating your communication plan would be extremely useful for most scientists [as first-line communicators] working at the cutting edge, often highlighting ideas we would not be trained to consider.

6.5.2 Discussion of comments – Dr Samantha Nicholson

In her initial answers, Nicholson mentions complex issues regarding diversity, inclusivity and defining disease (body autonomy) that fit well with the theory, and especially with Tenet 1.

She adds, however, that the "history of progress around these technologies", i.e. the work that has already been done over decades, should always be included. This again fits with the concept of acknowledging, where appropriate and where evidence supports it, what is accepted *banked knowledge* – and what is not.

6.5.3 Dr Andy Murray

Table 14: Human gene editing feedback – expert 2	
	**Dr Andy Murray** Communications Director – Innovative Genomics Institute (IGI) https://innovativegenomics.org/about-us/ Andy works with IGI founder Dr Jennifer Doudna, who, along with collaborator Prof. Emmanuelle Charpentier, pioneered CRISPR/Cas9 gene editing and was consequently awarded the 2020 Nobel Prize in Chemistry. He also holds a PhD in Integrative Biology from UC Berkeley.
	Responses
Initial questions	
1. *What do you feel are the most important potentially disruptive long-term consequences, effects or moral or ethical problems that the*	Positive: New therapies for ~5 000 genetic diseases, including rare and neglected diseases that are often completely unaddressed. Rapid diagnostic tests for infectious diseases that don't need a lab and can be updated easily as viruses evolve. Underappreciated impact that's already here: The ability to rapidly test and understand the basis of all genetic diseases.

arrival of human gene editing might cause for humanity in the future?	Negative: People tend to jump to futuristic fears when you talk about genome editing, but I think the real concerns are much more mundane and coming soon. As with most human problems, it comes down to power. When we have breakthrough technologies of any sort, who gets access? It's always the wealthy and powerful first. With genome editing, which has the potential to help people of all walks of life, we have to be especially careful to ensure that everyone who needs access to a cure, can access it. Ethical issues we will have to sort out along the way: Who gets to decide what is medically necessary? Is society better off without certain "disabilities" and who gets to make that decision? If germline editing ever becomes safe and effective, (a) is it necessary at all? (b) is it ethical to use, or ethical *not* to use when it's the only option? In a world where all of these therapies are successful, what impact will that have on the planet?
2. *What do you think can be done to best communicate this technology to the public in such a way as to help mitigate potential negative risks, effects or ethical concerns?*	Embrace transparency: Nothing is gained by secrecy; in fact, scientists have everything to gain by involving stakeholders in the process of developing new cures and agricultural solutions. It's also important to show that the people working in this field are not just aware of the potential risks, they think about them more than anyone else on the planet. Set realistic expectations: Genome editing has tremendous promise for humanity, but a lot of that promise will take more time to be realised than people often want to hear. A single new therapy often takes 10 years to be approved, and there are often improvements on the first therapy that come later. Agricultural technologies can take even longer. There is plenty to talk about with regard to effects today, but we have to be careful not to over-promise and under-deliver. Human impact stories: It's easy for people to have strong reactions to abstract issues or potential negatives that could come, so it's important to highlight the real effects this technology is having on real people – people who in many cases had no options, no hope for a cure just a few years ago. Metaphors: This is a highly technical field, and the people who work in it are used to using lots of jargon. For general communication, using visual metaphors is much more effective – and, luckily, genome editing is often easily explained using find/cut/paste metaphors that most people are very familiar with.
3. *Do you currently take ethics into consideration when communicating the technology that you or your company is working on to the public? If so, how?*	Yes, we factor ethics and public impact into all of our work and how we communicate about it. We work with stakeholder communities for all of our projects, e.g. sickle cell disease patient groups to develop solutions that meet their needs, and we also involve them in events and media so that we're not speaking for a community that we're not part of. We also factor ethics into who we choose to do interviews with, working with outlets that are not promoting irresponsible use and ones that are known for high-quality science journalism. Patient privacy is a big issue that we have to take very seriously, and while we want to show human stories, it always has to be the decision of the patient.
Comment on the Nine Tenets	
Tenet 1: *New scientific discoveries and emerging technologies become disruptive when they challenge widely held core human beliefs.*	Overall, I think the tenet is too narrow. Yes, emerging technologies that challenge widely held beliefs can be disruptive, but an innovation that simply improves things can also be disruptive. Airbnb disrupted the travel industry with an old idea in a new interface. No deep beliefs were challenged. What was disrupted was a common way of doing things, as well as the way an industry envisioned itself. This may hinge on exactly what is meant by "disruptive" – it could be a major paradigm shift in the Kuhnian sense, or it could simply be an innovation that pushes aside old ways.

	Regarding the comments above, this is a familiar list of issues that come up in this field. In many cases, because these are issues to do with beliefs, there is no right or wrong answer. "Human beings shouldn't 'play God' by altering people's genetic makeup." "I cannot change the genes I was born with." Increasingly, you can. Whether you *should* is a separate question. "It is unethical to edit the genes of unborn babies because they cannot give their consent." That is certainly an issue that has been raised. Others ask: If you have the ability to cure a deadly disease in someone who wouldn't otherwise survive, would it not be unethical to withhold that treatment? This is a challenging question that will likely be a real-world question in the next 10 years. "Human gene editing will result in superhuman beings that will ostracise normal humans." This overstates what we can do simply by altering genetic code, but it does raise a key point: it's a very likely risk that this technology will be controlled by a small group of people who can afford it. This will likely take the form of access to cure by the privileged, not superhuman abilities that lead to societal castes, but inequity of access is also a problem. "Gene editing will irreversibly alter the earth's biosphere." We've done quite a good job of that already without gene editing. The goal now is to use the tools we have to repair the damage we have caused.
Tenet 2: *It takes decades for a new technology or scientific discovery – and all its effects – to be understood adequately.*	I agree with the tenet. We can't know all of the future implications of gene editing (or any technology). The commentor shares the concerns of the scientific community – this is part of the reason that scientists are only working on non-heritable therapies. There are vanishingly few reasons to consider heritable germline editing in the first place, but it does take up a lot of the oxygen around the topic of gene editing. There are much more significant effects already under way: Gene editing is accelerating our understanding of disease and our ability to target diseases that were untreatable before. This will have a massive effect in ways we can't fully foresee. The prospect of preventative genomic medicine, e.g. preventing Alzheimer's dementia, will have a profound effect on the quality of life of millions of people. The potential for gene-edited crops to help feed the world through a climate crisis could have health effects on a scale that's hard to conceive. I would wager that we're currently underestimating the impact that rapid point-of-care diagnostics will have on health care, but we may not appreciate that until it has already happened. This is a good tenet to keep in mind. We can't know the future, we can only make educated guesses based on what's in front of us today and based on past examples. And it's valuable to communicate this uncertainty as best as possible.
Tenet 3: *Because of the media's propensity to report along lines of conflict, extreme viewpoints are often highlighted, which frequently leads to polarisation.*	I find this tenet to be problematic in several ways. First, media reporting along lines of conflict is a narrow view of the problem, and one that seems more specific to political reporting. More broadly, media coverage is driven by the wrong *incentives*: What drives clicks, subscriptions, ad revenue, instead of what is the most important content for people to stay well-informed. This may result in focusing on lines of conflict or, as is the case with gene editing, that the focus is often on future "what ifs" instead of the effect that is occurring right now. The spectre of a gene-edited super soldier

	is more likely to drive readership than the ability to remove cyanide from a staple crop that millions rely on, even though one is fantasy and the other is a real-world example. I would also urge caution about the term "polarisation," which can mean two different things. The "polarisation" that is most widely discussed today is political polarisation. In this context, the media reporting along lines of conflict may exacerbate polarisation, but is not the primary driver by any means. This is a common misconception. The polarisation itself drives beliefs, and when polarisation is extreme the effect is so strong that reporting in the media has little if any effect. We've seen this quite clearly with vaccines in the US: there is a certain percentage of the population that is entirely unpersuadable, not because of the media reporting along lines of conflict, but because their beliefs are already locked in because of polarised politics. Right now, gene editing sits in a relatively neutral place. If it becomes a political wedge issue – that is, if supporting it or opposing it gets lumped in with other political causes – this neutral position could shift rapidly. While this is a concern for communicators, it's largely out of our control. If you are instead talking about a more general polarisation, where people see gene editing as a good/bad binary, then there's some truth to this. Two angles that are frequently featured in media coverage are (1) amazing miracle cures that are coming soon, and (2) futuristic fears (designer babies, super soldiers, weaponisation). Sometimes you will find both of these in the same article as an attempt at balance. The problem is that both of these extremes ignore what's here today: CRISPR gene editing has already transformed life science research, greatly accelerated our understanding of disease, etc., but these don't make splashy headlines. In regard to the two considerations statements, I agree that nuance is important, and scientists working on this are deeply versed in this nuance, even if that isn't apparent in the reporting. It can often appear in reporting that Scientist A is selling a grand vision, while Critic B sees a downside that Scientist A never considered. If anything, Scientist A knows all of those downsides and probably 12 more, because their job is to think about how to overcome them. With GM foods, we start to drift into a political polarisation discussion. The controversy over GM foods has largely not been about the science, but has been more about power, money and public acceptance. There are many things to learn from the GM foods example, but again I don't think we can blame the media for reporting on lines of conflict.
Tenet 4: *The media's coverage of prominent events regarding a new technology or scientific development massively influences public perception and acceptance.*	This is true, though "massively" may be overstating the case. Yes, prominent events factor into public perception, but there are multiple other influences such as popular culture, personal experience and word of mouth. Moreover, public perception is not purely rational (see note above on political polarisation). A few years back, there was a TV series in development starring Jennifer Lopez that was going to be focused on CRISPR. It was described as "a futuristic bio-terror drama". If this show had actually been made and became popular, something like that would vastly overshadow the media reporting on He Jiankui or the Nobel Prize. Another real-world example: The media did not help LED lightbulbs take over the industry from CFLs – it was simply a better product, people disliked CFLs, and the price came down quickly. There was no inciting event. Most people probably never even heard about LEDs in the media, and yet they were a remarkable breakthrough that won the Nobel Prize, decreased energy usage around the world, and made buying lightbulbs a rather rare event.

Tenet 5: *A rigid adherence to 'balance', not based on the weight of evidence, can cause harmful bias.*	This is perhaps another example where political journalism and science journalism are not the same. Science journalism as a whole is often a good example of how to present opposing viewpoints, and scientists themselves are often the first ones to point out the weaknesses in their own arguments (sometimes making life difficult for communicators like me who want a clean, simple story). On the media side, there is no overarching desire to project balance and impartiality like we see in political reporting. However, we have seen examples (see climate change, GMOs, nuclear energy) where the consensus of experts is given as much weight as the opinions of non-experts or even lies by people with clear conflicts of interest. This is a concern, and tends to happen when scientific issues become political issues, or when large financial interests are at stake. Regarding the consideration here, I think it's important to clarify that voice should be given to experts, but that there are different types of experts. For example, a scientist who is an expert on sickle cell disease and gene editing has a valuable perspective, but they are not an expert on what it's like to live with sickle cell disease or the needs of the sickle cell community. Some of their concerns may be moral, ethical, religious or otherwise, but they should be taken just as seriously as any researcher.
Tenet 6: *Proper context is often crucial for accurate, responsible reporting on emerging technologies and discoveries.*	Context is always key. It can also be a challenge for communicators, because the more nuance you add, the more you lose people. Somatic gene editing is a perfect example. A lot of the concern around gene editing centres on heritable germline editing, but all of the current research and the vast majority of the promise of the technology lies in non-heritable somatic editing. This is often lost in reporting. The word "somatic" is not commonly understood, nor is "germline". It takes some effort (and space in an article) to explain the distinction. It's an important distinction, but based on the questions I get frequently, it's not one that's commonly understood.
Tenet 7: *A lack of adequate knowledge on the part of a journalist is often a barrier to public understanding of novel science and technologies.*	Most of the very best science communicators are not scientists themselves. This is not an issue. Most journalists are addressing an audience of non-experts, so their job is to translate what is important for their audience into a format that helps them understand. The analogies used for CRISPR are quite good at explaining how the technology works. It's more important for a general audience to understand what the technology does and what impact it could have than the technical details of how it works. Nearly no one who owns a solar panel could tell you how it works at a technical level, but they understand the benefit. There are times when the audience requires more detail, e.g. a patient community assessing risks, but oversimplification is rarely a big issue. Have I had to correct journalists occasionally? Yes, but it's rare. I would argue that a bigger barrier to public understanding is a lack of basic science education and difficulty in assessing trustworthiness of information. Ironically, the fact that we have so much information available is in itself a barrier to public understanding.
Tenet 8: *Science journalists ought to consider not only the objective facts, but how audiences will feel about the risks that those facts represent, to anticipate moral implications and possible socio-cultural effects.*	I hope that science journalists feel this way, because the emotional, ethical and cultural aspects of transformative technologies are fascinating and critical to how/if the technology is ultimately adopted by society. I don't think every journalist will agree that anticipating the implications is their job precisely, but it is the job of scientists and technologists, and journalists should be asking them questions along these lines. The commenter makes an interesting point that it's not just about risks and rewards, it's also about access, fairness, equity. A cure that works perfectly but is not available to you or your loved ones will naturally evoke a strong

	reaction. This issue of access and equity is also, I hope, an area of interest to science journalists.
Tenet 9: *When it comes to new technologies and scientific developments, journalists should embrace uncertainty and the concept of probability and make it part of their narrative.*	Communicating probabilities is a persistent challenge for science journalists: it's often essential, but the public is typically not good at understanding probabilities. There are multiple angles to this that relate to gene editing, and it's not all about communicating risk. Sometimes it's about efficiency: a therapy can be 20% efficient at editing cells, but still be fully effective. Sometimes it's about timing: a therapy may be extremely successful, but 9 out of 10 drugs never make it to the market, often for purely financial reasons, so saying a therapy is on its way is perhaps overselling the truth. Sometimes the probability is about the disease itself: how many people are likely to be born with sickle cell, or how that changes in different communities. The commentor does betray two common misunderstandings. 1. None of the therapies in development today affect future generations, so that level of uncertainty isn't relevant; 2. Gene editing therapies aren't writing newly invented code from thin air; they're taking an identified error and changing it to a known safe condition that millions of other people already have in their genes. It's like fixing the spelling of ELEBHANT by removing the B and adding a P. We don't have to worry that people will misunderstand the new ELEPHANT because it's identical to every other spelling of ELEPHANT that we already know.
Questions on theory viability and practical value	
Do you feel this theory provides a complete, appropriate and viable foundation for the accurate, responsible and ethical communication of potentially disruptive or revolutionary emerging technologies or new scientific discoveries? Please elaborate and indicate if you find there are aspects that are missing and ought to be added.	While many of the tenets are spot on, I don't think that this theory is complete or fully applicable to science communication. There are parts that feel borrowed from political journalism that aren't a perfect fit (e.g. polarisation, false balance), there's a gap in understanding some of the unhealthy incentives built into the media landscape (e.g. clickbait, focusing on controversy over importance), and there were times when I wasn't clear if it was addressing science journalists or science communicators more broadly. Today, I am a science communicator working for a scientific institute with a particular point of view. I have also been a freelance journalist and a staff editor. Each of these positions has different incentives and pressures put upon them, and it may be hard to fully capture that nuance in any framework like this. It's important to be very clear who this is aimed at. One thing that's missing from this is power dynamics, i.e. winners and losers. Journalists often say that their job is to hold the powerful accountable, but a lot of the framing of science journalism is unintentionally from the point of view of the powerful: tech companies, biotech, large universities, governments. The type of balance that's truly needed is listening to all types of relevant stakeholders — not just the inventors or the investors, but the people on the receiving end of the technology. Were they consulted from the beginning? Is this the technology they wanted, or the one they were given? The first tenet starts to hint at this ("who might be disenfranchised or marginalised"), but this deserves more than a side note.
Would a simple, practical field guide (e.g. a one-page PDF) for the communication of potentially disruptive emerging technologies and discoveries, based on the Flaming Torch Theory, be valuable to you in the real-world conditions that you work in?	Potentially so. It's nice to have a sort of pre-publication checklist, like passing the Bechdel Test. Did your story pass the Flaming Torch test? To be truly useful, you should consider phrasing the tenets as recommendations or as questions. For example, either say "Journalists should embrace uncertainty and the concept of probability, and make it part of their narrative" or "Did you explain the relevant uncertainty and make it part of your narrative?"

6.5.4 Discussion of comments – Dr Andy Murray

Murray highlights the same issues previously highlighted by Nicholson regarding the disruptive impact that human gene editing might have – in particular concerning who will have *access* to the technology and who gets to decide what is *medically necessary* in terms of human gene editing. These are again good examples of the ethical complexity involved. The other issues of concern mentioned in Murray's initial answers are well covered by the theory.

Regarding the tenets themselves, Murray points out in relation to Tenet 1 that it is not only core human beliefs (be they moral, ethical, religious or cultural) that may be challenged by discoveries and technologies, but also simply "the common way of doing things". In other words, old ways of life, for example e-mail replacing postal mail.

For Tenet 3, Murray points out that media coverage is largely driven by "unhealthy" *incentives* ("clicks, subscriptions, ad revenue"). He also distinguishes between general polarisation in the media and society, and political polarisation – which he posits can be exacerbated by mass communication but is not the primary driver "by any means", because the polarisation itself drives beliefs. This is further discussed in the appropriate section in the next chapter.

With regard to Tenet 5, Murray believes it is possible to present opposing views for balance in a constructive way, and that balance only becomes a problem when science journalism becomes politically motivated. The point stands, but actually reinforces, the idea of Tenet 5, namely that balance is important, as long as opposing views are buttressed by some form of evidence (rather than by political agenda, financial gain or emotion).

With regard to Tenet 7, Murray states that a lack of knowledge should not be a problem because very few science journalists are scientists themselves (with technical expertise), but are nonetheless capable of explaining difficult concepts in understandable ways. This may be true, but it underscores the idea behind Tenet 7 that there does at least need to be a *basic level* of conceptual understanding on the part of the communicator (about key concepts, effects and functioning, etc.). Seeing as the tenets do not cater only for educated science journalists, the historical evidence (and mass communication errors) that led to the inclusion of Tenet 7 (see Table 1) still remains valid. Murray also admits that the overabundance of information and misinformation that the internet affords the average media consumer today is problematic because it leads to difficulty in assessing the "trustworthiness of information". This again highlights the need for science communicators to have the necessary knowledge to be able to distinguish between real information and noise.

Murray requests clarification on whether the tenets are aimed at science journalists specifically, or science communicators in general. This aspect is taken into account in the following chapter. He further suggests the tenets should all be phrased as recommendations – a point also considered for the field guide developed in this study.

Finally, he stresses the importance of acknowledging, in communication efforts, who are the "winners and losers", which is duly considered in the next chapter.

6.5.5 Lindsay Brownell

Table 15: Human gene editing feedback – expert 3

	**Lindsay Brownell** Science writer – Wyss Institute for Biologically Inspired Engineering, Harvard University The Wyss Institute uses biological design principles – such as the CRISPR/Cas9 mechanism – to develop new engineering innovations that will transform medicine and create a more sustainable world: https://wyss.harvard.edu/
	Responses
Initial questions	
1. *What do you feel are the most important potentially disruptive long-term consequences, effects or moral or ethical problems that the arrival of Bitcoin and cryptocurrencies might cause for humanity in the future?*	• Human genetics is extremely complicated, and I fear that human gene editing products or services will be approved based on incomplete knowledge of their effects on the genome, leading to unwanted side effects in people whose genes are edited. • Humans already ground their personal identities, discriminate against each other, organise and set expectations based on genetic differences, some as fundamental as whether they have XX or XY sex chromosomes. Once those genetic differences become deliberate rather than randomly inherited, will our responses to them change? Michael Phelps is widely considered the best competitive swimmer in history because his randomly determined genetics gave him unusual proportions that turned out to make him incredibly efficient, and nobody thinks it's "unfair" that he beat so many competitors who didn't have those proportions. But if someone genetically engineered their child to produce the same result, I predict there would be many indignant people who say that child should not be allowed to compete against "normal" (aka randomly determined) swimmers. I think similar situations will cause a significant amount of social friction and possibly harmful polarisation and fragmentation. • I also worry that certain traits will be determined to be "ideal" or "desired", and then gene editing will be forced onto women in certain cultures, or will become normal among wealthy families but not accessible to poorer ones, leading to the creation of socio-economic classes that are actually genetically different. That could give fodder to those who claim that those on a lower tier are actually genetically inferior, in a twisted re-emergence of eugenics.
2. *What do you think can be done to best communicate this technology to the public in such a way as to help mitigate potential negative risks, effects or ethical concerns?*	• I think a lot of the public image of gene editing comes from films and TV shows that show an apocalyptic world in which gene editing has gone awry. But the editing of genes as complex as those that control height and metabolism is much further off than the editing of single genes that are known to cause debilitating genetic diseases. I think the public should be introduced to this spectrum of difficulty in editing genes, which I think directly correlates with a similar spectrum of ethical justification. The easy genetic fixes that can cure people of deadly diseases is a no-brainer – both the easiest to do and to justify as "good". But as we move into the more complex changes, the ethics around them becomes more fraught. Perhaps it will be useful to draw a line somewhere on those spectra and say, "Scientists are now working on everything to the left of this line, and they're reasonably confident they'll be able to achieve them. What's to the right of this line is further out but also more fraught, and thus require more thought." • People often fear what they don't understand, and science has become much more esoteric and difficult for someone without specific knowledge of a given field to grasp. I think the concepts

	and specifics underlying gene editing need to be presented in an engaging, thoughtful way, probably one that relies heavily on storytelling. We've seen, with the rise of streaming services, that people are willing to invest many hours of their time in watching long-form TV shows, as long as those shows are [of] high quality and engaging. Perhaps a similar approach would be beneficial for science communication.
3. *Do you currently take ethics into consideration when communicating the technology that you or your company is working on to the public? If so, how?*	We try to minimise references to the use of animals in our scientific studies, because animal cruelty activist groups often vocally oppose and decry that practice, even though it's crucial to science. We do take ethics into consideration when communicating about technologies that have a clear potential use case in humans, or that present future possibilities that could raise ethical concerns. For example, the Xenobots 3.0 story caused a stir on social media because they represent, to our knowledge, the first example of living robots that can self-replicate. The scientists themselves knew it was important to communicate the limits of these robots very carefully so that the public wouldn't accuse them of meddling in the affairs of God (which they did anyway), so in an effort to combat that proactively, we held a live-streamed webinar with the authors of the paper where we asked them common questions about the Xenobots. It was also important that we present the scientists to the public as living, breathing people with good intentions, and the webinar format allowed us to do that effectively.
Comment on the Nine Tenets	
Tenet 1: *New scientific discoveries and emerging technologies become disruptive when they challenge widely held core human beliefs.*	Agree.
Tenet 2: *It takes decades for a new technology or scientific discovery – and all its effects – to be understood adequately.*	It's not entirely accurate [in your example] to say "if the genes modified are hereditary", because any gene that a parent has in their genome could be inherited by a child. It would be more accurate to say "if genes are modified in germline cells", as these are reproductive cells that actually develop into embryos and sperm in their respective sexes. I think people would have less of a problem with an adult's lung cells being genetically engineered – to, for example, cure their asthma – than they would have with an adult's egg cells being genetically modified to determine the genome of their child. But the overall consideration itself is sound.
Tenet 3: *Because of the media's propensity to report along lines of conflict, extreme viewpoints are often highlighted, which frequently leads to polarisation.*	Agree.
Tenet 4: *The media's coverage of prominent events regarding a new technology or scientific development massively influences public perception and acceptance.*	I agree with the consideration, but the examples provided are fundamentally different. One event [from the example] involved the unconfirmed actions of a rogue scientist who applied an unproven technology to human beings, while the other event involved recognition of the fundamental scientific work that was done to create a new technology that has enormous potential – even if that potential could be turned to nefarious purposes.

	So, yes, the media's coverage *can* influence how people perceive and accept events, but it should also be noted that the nature of the events themselves can influence how the media covers them.
Tenet 5: *A rigid adherence to 'balance', not based on the weight of evidence, can cause harmful bias.*	I think a fair number of people are opposed to gene editing technologies on the basis of the lack of definitive scientific evidence that it will not have unintended, off-target side effects. Granted, yes, moral/ethical/religious concerns also play a role, but there are some scientifically valid reasons for concern. We simply do not know enough about genetics to be able to predict all the potential downstream effects of editing a gene, especially when we take into account epigenetics and individuals' unique physiology. I would suggest the addition of the nuance that finding diverse points of view in the name of "balance" is not a bad thing in and of itself, but if one is presenting an evidence-based argument in the "for" category, then the "against" category *should also be based on evidence* (or the lack thereof), not moral, ethical or religious concerns. Unless, of course, a journalist is specifically writing about the ethical concerns raised by a given technology, in which case, concerns of that nature should be included.
Tenet 6: *Proper context is often crucial for accurate, responsible reporting on emerging technologies and discoveries.*	Agree.
Tenet 7: *A lack of adequate knowledge on the part of a journalist is often a barrier to public understanding of novel science and technologies.*	I would argue that journalists need to understand the technology about which they are writing BEYOND the basic concept. Understanding the *nuances* of a technology makes it easier for a journalist to decide which details are appropriate to gloss over and which are necessary to include for a given story and audience.
Tenet 8: *Science journalists ought to consider not only the objective facts, but how audiences will feel about the risks that those facts represent, to anticipate moral implications and possible socio-cultural effects.*	Agree.
Tenet 9: *When it comes to new technologies and scientific developments, journalists should embrace uncertainty and the concept of probability and make it part of their narrative.*	I also think it is prudent for journalists to (where possible) help their readers understand what uncertainty *means* in science vs. in other areas of life. In science, being uncertain about something simply means that there are additional experiments that can be run to further generate evidence. In the rest of society, being uncertain about something is often seen as a lack of confidence or decisiveness, and thus is viewed negatively. When non-scientists hear scientists say they are uncertain or unsure of something, that can lead them to view the scientists as less competent due to this fundamental difference in how uncertainty is viewed inside the lab vs. outside the lab.
Questions on theory viability and practical value	
Do you feel this theory provides a complete,	I think this theory is very sound, accurate, and helpful.

appropriate and viable foundation for the accurate, responsible and ethical communication of potentially disruptive or revolutionary emerging technologies or new scientific discoveries? Please elaborate and indicate if you find there are aspects that are missing and ought to be added.	It addresses many common pitfalls of communicating complex scientific topics, and offers useful guiding questions for science journalists to ask themselves when writing a story about a novel, disruptive scientific technology.
Would a simple, practical field guide (e.g. a one-page PDF) for the communication of potentially disruptive emerging technologies and discoveries, based on the Flaming Torch Theory, be valuable to you in the real-world conditions that you work in?	Yes, I think a one-page PDF that summarises the theory would be helpful.

6.5.6 Discussion of comments – Lindsay Brownell

Brownell anticipates "significant social friction" with the rise of deliberate genetic human differences and "preferred traits", and again stresses the issues of access, unwanted and unforeseen side-effects, and moral-ethical complexity.

Brownell specifically highlights the importance of acknowledging the "spectrum of difficulty in editing genes", i.e. what is already accepted as possible and safe, what is plausible and being tested, and what is theoretically conceivable but still far away from practically viable. This again alludes to the concept of *banked knowledge* proposed by Pal.

In general, Brownell agrees with the Nine Tenets as stated. In contrast to Murray, however, she argues (for Tenet 7) that science communicators need to understand the technology they are communicating "beyond the basic concept" in order to be able to provide the necessary contextual nuance.

CHAPTER 7

7. Amendments: The Flaming Torch Theory 2.0

7.1 Points of critique

On the whole, all nine of the interviewed experts agreed with the majority of the Nine Tenets that form the basis of the Flaming Torch Theory, and generally stated that such a theory and a resulting field guide would be of practical use in the communication of discoveries and technologies. This is encouraging and serves as evidence that the theory remains applicable across different emerging technologies and their respective ethical concerns.

Having analysed and discussed all the feedback, however, it also became clear that certain recurring points of criticism and advice could be used to address omissions and significantly improve the theory and its underlying tenets. In this chapter, each of these points is discussed further to explain how they were incorporated into the final version of the Flaming Torch Media Ethics Theory (Table 16).

7.1.1 Incentives

Uttarwar, Pal, Gordon, Bernal and Murray all made separate mention of the crucial role of *incentives* in the public communication – as well as the development, adoption, use and acceptance – of emerging technologies and disruptive scientific discoveries.

The prominence and consistent repetition of this refrain in the feedback, for communicators, authorities, developers, scientists and consumers alike, was such that the addition of a *tenth tenet* became justified. Consequently, the final proposed version of the Flaming Torch Theory has, underlying it, *Ten* Tenets as opposed to the Nine Tenets initially suggested to the experts. Tenet 10 is focused on the role of incentive structures.

7.1.2 Banked knowledge

Pal, Gordon, Bernal, Nicholson and Brownell all made similar reference to the importance of acknowledging "where we are" in the journey of the technology or the science in question. In other words, what has already been sufficiently proven and accepted by top experts (which can often do much to diminish popular uninformed criticisms), what are still only fanciful claims that are yet to be tested, and what *known* risks or benefits are expected by experts over the short, medium and long term. This can be summed up adequately by the term *banked knowledge*, as proposed by Pal in his feedback.

It is noteworthy that neither Pal, Uttarwar or Reitz discussed (in meaningful detail) the most popular concerns around Bitcoin and cryptocurrencies mentioned in Chapter 1 – energy consumption, transparency, volatility and practical usability – when discussing their ethical concerns around blockchain technology. This could well be because, as experts, they view these issues as settled *banked knowledge*, since there is some evidence to that effect:

- **Bitcoin energy consumption:** Many sources, including the International Energy Agency (Kamiya, 2019), have pointed out that the anxiety over Bitcoin's energy consumption has been largely sensationalised and often ignores crucial context. For instance, Bitcoin "consumes less than half the energy" when compared to the existing banking system or the global gold industry (Namcios, 2021a). Furthermore, a significant part of the world's energy production is simply wasted – about 2 205 TWh

per year, which is 19.4 times that of the Bitcoin network (Namcios, 2021a). And, because Bitcoin miners are directly incentivised to use the cheapest available electricity (in order to be maximally profitable), they offer a viable solution to the world's wasted energy. Miners have, through companies like Upstream Data, begun to utilise previously wasted energy from venting and flaring at natural gas power stations to mine Bitcoin. Excess energy from wind and solar plants is also being used for Bitcoin mining, and even decommissioned hydropower stations have been repurposed for Bitcoin mining (Namcios, 2021b). In this sense, Bitcoin allows for the monetisation of stranded energy sources. In fact, studies like the *3rd Global Cryptoasset Benchmarking Study* by the University of Cambridge have shown that around 39% of the energy use from Bitcoin mining actually comes from renewable energy sources and, because Bitcoin is location-agnostic and incentivises miners to use cheaper, renewable energy sources, "cryptocurrency mining can become a complementary technology for clean energy production, accelerating the global transition to renewables" (Ciutina, 2021).

- **Bitcoin transparency:** Accountability and transparency are the "fundamental tenets" (Chainalysis, 2021) of cryptocurrencies like Bitcoin: Everyone on the network can see every transaction at any time, and it is impossible to alter or manipulate transactions after the fact due to the nature of the encryption that powers blockchain technology. The problem is that at either end of the transaction is simply a public key Bitcoin address (like a password), which leaves room for anonymous and nefarious transactions. But this is changing fast as governments wise up to regulating the technology. Every major cryptocurrency exchange, like Binance, Coinbase, Luno, Kraken, Bitfinex, etc., all now require strict KYC (know your customer) processes, which require a photo ID and proof of national identity, from all customers, in order to comply with burgeoning regulations. If a Bitcoin public key address is directly and provably tied to an individual's identity, the Bitcoin network arguably becomes far more transparent than existing banking systems that rely on a myriad different databases and global remittance systems. In most nations, including South Africa, some form of crypto regulation and taxation is already in place. The decision by the governments of El Salvador, Tonga and Mexico (most recently) to accept Bitcoin as legal tender also indicates the growing confidence among governments that Bitcoin can, over time, become sufficiently regulated and safe.
- **Bitcoin scalability and usability as money:** Because they are built on software, blockchains are upgradeable. So-called Layer 2 solutions that build upon the foundation of the Bitcoin blockchain to make it scalable, faster and cheaper, etc. have resulted in the Lightning Network, which can potentially allow up to one million transactions per second, settled instantly at negligible cost. Jack Mallers, CEO of Strike (strike.me), has published several video demonstrations of the Strike app (integrated with Twitter's tipping function), which utilises the Bitcoin Lightning Network. In these videos, for instance, he sends $10 from his smartphone, in Chicago, United States, to a friend at a Starbucks in El Salvador, "freely, and instantly" (Mallers, 2021).
- **Bitcoin volatility:** Because it is an emerging asset class influenced by wildly fluctuating demand and user sentiment, and with a decreasing supply, Bitcoin is likely to remain volatile for some time, but there is evidence that its volatility is decreasing as it is maturing (Iconic Holding, 2022).

This all might well be the case, and immediately demonstrates the crucial task that experts have to communicate such banked knowledge effectively to the public so as not to cause misconceptions or misinformation by omission. Furthermore, however, as is the case with Bitcoin, whatever experts feel should be considered banked knowledge can often only be proven and played out over time, for instance as a technology goes through the mass adoption growth curve. Even experts' *banked knowledge* might in the end simply be proven wrong.

This again highlights the important role of communicators not just in effectively communicating what experts agree should be seen as *banked knowledge*, but also holding experts to account for the *evidence* for what they consider to be banked knowledge.

Although this is clearly an important point, its obvious similarity to Tenet 2 – the fact that it takes decades for the effects of a new technology or discovery to be understood – negates the need to add yet another tenet. Rather, Tenet 2 was amended (Table 16) to include proper reference to the concept of *banked knowledge*.

7.1.3 Different communicators

Uttarwar and Murray both requested clarification with regard to what type of communicators the theory and tenets are referring to in various instances, since they can have different roles and responsibilities (science journalists vs science educators vs scientists and developers, etc.).

Although this is true, the aim set out at the start of this study was to create an easily referenced field guide – a kind of a 'minimum requirements' check list – for *anyone* who wants to convey new science and technologies to *any* wider audience. Although such a wide scope is inevitably limiting in its specificity, it is necessary because, firstly, such a technology-tailored, evidence-based field guide does not currently seem to exist for communicators or the public, and secondly, because the communication of science is no longer only the purview of scientists, educators, committees or science journalists.

Social media and the *hive mind* referred to by Pal and Uttarwar have made it possible for anyone, regardless of education, location or background, to instantly become a science mass communicator on Twitter, Instagram, WhatsApp, Reddit, etc. – sometimes with massive audiences (for instance celebrity social media influencers with millions of followers).

For this reason, it is imperative that the tenets and the Flaming Torch Theory be presented as simply as possible so as to become accessible and usable by anyone who wishes to communicate potentially disruptive sci-tech news to a mass audience.

Should science journalists, educators or communicators wish to receive more specialised guidance, there are enough frameworks and theories for deeper ethical analysis of technologies or for professional science communication training already in existence. As such, the amended Flaming Torch Theory (Table 16) is worded so as to reflect its applicability to as wide a range of potential science communicators in the current media and public spheres as possible.

7.1.4 Tweaking the language of the tenets

Several experts suggested ways in which the language of the tenets might be amended or expanded to include issues of concern they felt were absent.

Murray's suggestion that it is not just core human beliefs that are challenged by these technologies, but sometimes simply the "common way of doing things", is reflected in the amended wording of Tenet 1 (Table 16).

Murray also had concerns about the possible confusion of political polarisation, which he says is not driven by the media, versus generalised polarisation, which may to an extent be driven by the media. Although the historical evidence provided by the findings of the literature

review (Table 1) does point to the fact that, in many cases, the media can be a powerful driver of political polarisation when it comes to technologies and discoveries, the use of the word "polarisation" was removed to avoid any confusion – and Tenet 3 was reworded to rather simply indicate the avoidance of extreme viewpoints.

Bernal was interested in how the theory and tenets might address conflict, such as incorporating under-represented perspectives or balancing values and belief systems. In this regard, it is not the aim of the theory to mediate conflict. It is too broad in scope for that purpose. Instead, it is meant to highlight issues of concern early enough, precisely to avoid conflict by encouraging informed, healthy public debate. However, the tenets *should* leave room for under-represented perspectives (in Tenet 8) and opposing beliefs (Tenets 1 and 5).

Very similar issues were raised by Murray, around "winners and losers", and Nicholson, Brownell and Uttarwar, who raised concern over the issue of *access* and *inclusion*. As such, the wording of the appropriate tenets was amended to ensure these issues, about who is empowered and marginalised by new discoveries and technologies, are adequately covered.

Bernal pointed out that some of the tenets are observational, while others are more prescriptive. For the same reason, Murray recommended that the tenets be phrased as either questions or recommendations. It was decided to reword the tenets, and the resulting field guide, as a list of clear recommendations.

7.1.5 The hive mind

Uttarwar mentioned the significant role that Twitter has played and is playing in driving mass communication, debates and narratives around cryptocurrencies in a decentralised and often chaotic way, where the best ideas do not always rise to the top but are often drowned out by louder voices. Pal, on the other hand, explained how the decentralised "groundswell" or *hive mind* of social networks like Twitter has demonstrated it can, *over time*, create powerful counter-narratives to hype or FUD (fear, uncertainty and doubt) narratives pushed by mainstream media for clicks. In his view, the decentralised hive mind of the internet has the potential to subvert some of the problems that traditional, centralised media companies have come to display.

Although it is unnecessary to make direct mention of the concept of a hive mind in the tenets (which are aimed at communication from one to many, regardless whether it is on social or traditional media), it bears mentioning that the hive mind will be important in any attempt at *dissemination* of the Flaming Torch Theory and its Ten Tenets. This is discussed further in the next and concluding chapters.

7.2 The Flaming Torch Theory 2.0

Using the valuable feedback from the nine experts, and specifically the points of critique discussed in 7.1.1 to 7.1.5, the draft Flaming Torch Theory and the initial Nine Tenets were amended, clarified and expanded, where necessary, and are consequently presented here as the Flaming Torch Theory 2.0 (which will, outside of this study, simply be referred to as The Flaming Torch Theory) (see Table 16).

Table 16: The Flaming Torch Theory 2.0

CORE PRINCIPLE: *Like a flaming torch in the hand, any new technology or scientific discovery can either light the way in the darkness, or burn the whole forest down. Often both. Therefore, any attempt at communicating new science and technologies shares in the weight of that responsibility.*

This theory is concerned with the accurate, responsible and ethical communication of potentially disruptive new emerging technologies and scientific discoveries in order to limit harm to humanity.

Science journalists (and any science communicators, be they scientists, educators, policy makers, government authorities, social media influencers or interested individuals) should help their audience to find the golden mean between the *risks* and *benefits* of new science and technologies, always guided by the *weight of evidence*, to be able to "carry the torch" with the necessary confidence and care.

An examination of past revolutionary scientific and technological discoveries (such as nuclear energy, the theory of evolution and climate change), and how they were communicated to the public, identified certain key lessons. To help inform the best communication from as early as possible after invention or discovery, the following Ten Tenets and associated logical statements and guiding questions are always to be remembered when trying to communicate potentially disruptive new science or technologies:

The Ten Tenets	**Logical Statements**	**Guiding Questions**
Tenet 1: **Emerging technologies and new scientific discoveries often become disruptive, divisive and harmful when they challenge *widely held core human beliefs, values or accepted ways of life*.** **If this applies, consider mentioning what values, beliefs or ways of life might be challenged as early as possible, as well as how these might affect people on different social strata.**	If the emerging technology or new scientific discovery challenges any deep-seated human beliefs, for instance moral or religious beliefs, accepted cultural norms or common ways of doing things, it should be acknowledged as soon as possible after discovery or invention. Be as specific as possible, so that open debate is encouraged to properly and respectfully acknowledge potential conflicting perspectives, public fears or hesitancies, or moral-ethical value crises.	• Does the technology or discovery somehow alter the human condition in a fundamental way? • Could people with certain religious or cultural beliefs possibly feel threatened by the existence or use of this technology or discovery? • Does the technology or discovery create unique new moral dilemmas for humanity, and have you stated such? • Who stands to benefit from this technology or discovery, and who

		might be disenfranchised or marginalised – and if so, have you acknowledged this?
Tenet 2: **Because it takes *decades* for any new technology or scientific discovery and its effects to be understood properly, it is important to disclose what is already accepted by leading experts as *banked knowledge*, what are the unknowns that remain, along with the known risks over the short, medium and long term, to create a sense of "where we are" with regard to this particular development.**	Whenever possible and appropriate, acknowledge that you are discussing *frontier science* – not textbook science – which concerns early-stage development that will inevitably lead to unknowable (even by top experts) future outcomes or consequences. State what has already been achieved and encourage early debate about the various potential long-term consequences (both positive and negative), steering clear of hyperbole and sensation or causing undue fear (unless corroborated by sufficient evidence).	• Have you stated when the discovery was made or the technology was first invented – i.e. How 'new' is this development? • What has been verifiably achieved and is currently possible? And what is not yet possible or confirmed? • Imagine the technology becomes everyday and exists for 20 years – what would that look like? • What are the long-term effects expected by experts?
Tenet 3: **Any tool can be used for good or ill: Refrain from *extreme viewpoints* that label a technology or breakthrough simply as 'good' or 'bad', and that leaves no room for nuance.**	Refrain from pitting expert sources with different views against each other simply for the sake of sensation or 'balance'. Steer clear of extreme, emotional responses. Leave room for nuance. Efforts should be made to determine any potential hidden agendas that sources might have, such as whether they are politically or morally opposed to the technology or discovery in question, or if they somehow stand to gain financially. Let only the *evidence* determine whether your content sways to the positive or negative.	• Are you skewing towards a mostly positive or mostly negative view? If so, ask yourself why. • Make sure you are aware of any conflicts of interest: Who funded the experts you are quoting? Why was the research done in the first place, and for whom? Is your source affiliated with particular political or religious groups? • Are you sure your communication (article, post, video clip, etc.) is backed up by evidence and not

		emotion (such as fear or hype)?
Tenet 4: **Be mindful that the public conversation around *prominent events* regarding a new technology or scientific development can often massively influence public perception and acceptance far into the future.**	If you are covering or discussing an event that might in the future be historically significant for the technology or discovery in question (for instance a highly publicised launch event or a major disaster or accident) – then be aware that what you write or say today might determine how people view this technology or discovery *for decades or even generations to come* (think Hiroshima or Chernobyl). Be responsible and honest. Stick to the facts, and not the emotion of the day.	• Are you sure your communication is based on sound science and evidence, rather than the mood of the moment, the emotion of a hyped-up event or some horrible accident? • In the case of a launch event or big announcement, have you stated who paid for the event or the publicity, or what their aims are, and have you consulted outside sources? • In the case of an accident, it is important to acknowledge tragedy and human suffering – but make sure these emotional anecdotes do not obscure scientific facts.
Tenet 5: **A balanced view is important, but a rigid adherence to balance for balance's sake, and not based on the *weight of evidence*, can cause harmful bias and misinformation.**	*Let the weight of the evidence always determine the weight of opinion.* Do not give voice to a source simply because he or she provides balance by opposing expert views – unless the source can provide *adequate, sound evidence* on which to base his or her opinion. Equally, do not trust any claims by a so-called expert who cannot provide sufficient evidence. Alarming, shocking or	• Have you chosen your sources based on their evidence? Or based simply on what they will be saying (for instance entertaining, political, controversial or extreme counterpoint opinions to sell the story or increase its reach)? • Can all your sources back up their opinions or claims with adequate, sound evidence (and not simply claims or anecdotes)?

	popular claims can go viral even if completely unfounded, misleading or actively harmful.	
Tenet 6: **Do not exclude any crucial *context* without which people might be unable to form a full, accurate view and opinion about the risks and benefits of an emerging technology or discovery.**	Make sure not to omit important context without which people might not be able to make informed decisions or judgements about the new technology or discovery. Always ask yourself if your audience would be fairly well informed about the discovery or technology (within your inevitable space and time constraints) if they have read *nothing else about it*. Do not assume people will know anything that you might omit.	• Look at all the facts you are presenting – is there any additional context required without which people might get the wrong idea? • For instance, under what circumstances might the technology *not* work? Has the technology been tested in real-world conditions, or only in a laboratory or computer model? Under what conditions might a new medical treatment *not* be effective? And so forth.
Tenet 7: **Learn as much as you can before you communicate. A *lack of adequate knowledge* on the part of the communicator can be a barrier to proper public understanding of novel science and technologies.**	Always try to understand the technology or discovery you are communicating yourself, at least at a basic, conceptual level. If you do not understand, or feel that you lack the necessary technical expertise, make sure to ask a qualified, *independent* expert to look over your explanations and to help clarify what might be misleading.	• Do you understand the technology or discovery you are trying to communicate? • Have you listed both the positive *and* negative aspects involved? • If you do not understand, which of your sources might be able to better explain it to you, or to look over your work to check the facts and clarify potential misconceptions? • Are you confident your sources have an adequate understanding of the

		topic? If not, find a better source.
Tenet 8: **Consider not only the objective facts, but how different people will *feel* about the risks and benefits that those facts represent, so you can better anticipate moral-ethical implications like who will be the "winners and losers", who will have access and who might be disempowered.**	Think about your audience's pervasive cultural, moral and religious beliefs, customs and lifestyles. Actively consider how they might view the emerging technology or discovery in question, how it might affect their daily lives, and how they might *feel* about the risks and benefits it represents. Carefully consider the possible emotional public responses and help, if possible, to steer the conversation toward healthy, open public debate, with space enough for a variety of possible views and attitudes.	• How will this technology or discovery change the daily lives of people, their morals, values or beliefs, and how might they feel about it? • Which peoples will be most (or least) affected by the emergence of this technology or discovery – and have they been given a voice to air their hopes, fears and concerns? • Which peoples might be overlooked within the context of this new science or technology (who might not get access to its benefits)?
Tenet 9: **When it comes to communicating new technologies and breakthroughs, embrace *uncertainty* and the concept of *probability* and make it part of the narrative.**	Be sure to note which aspects of the discovery or technology scientists or developers are still uncertain about, still need to test, or have indicated need further research. If necessary, explain that the outcomes expected by experts are based on probability, not certainty. Uncertainty in this regard need not be detrimental to communication. Some scientifically plausible *mystery* might well make content more engaging.	• Be careful not to present accepted or expected *probabilities* as facts. • State any relevant, known remaining *uncertainties* (do not shy away from uncertainty). • Have you adequately explained the various probable outcomes, which ones are most likely, and why? • Are you confident your communication efforts will not lead to unrealistic expectations based on assumed but as-yet-unconfirmed certainties?

Tenet 10: **Be keenly aware of the role of incentives: Of the kind of behaviour this technology or discovery will likely incentivise among people, and of which (and whose) incentives might be playing a role in how it will be used, and in how it will be communicated – also by yourself.**	Incentives can take many forms – the need for clicks, likes, shares and follows, the need for advertising revenue, the need for political sway, the need for acceptance of one product over another, the need to create negative sentiment over something you fear, etc. Whatever the case may be, ask yourself which incentive structures might be at play in the development, communication, acceptance and use of the technology or discovery.	• How will this development incentivise ordinary people to behave? • How are people, and communicators, being incentivised to talk about it? • How might your own communication tie in with incentives?

CHAPTER 8

8. Field guide: Simplifying the Ten Tenets

8.1 Prerequisites for a field guide

To create a useful, practical field guide – based on the Flaming Torch Theory – for the responsible and ethical communication of emerging technologies and scientific discoveries, certain parameters had to be met.

First and foremost, the field guide needs to be *as simple as possible* in order to be practically useful for anyone, regardless of training or background, who wants to communicate about controversial scientific and technological developments with a wider audience. Although the aim of the Flaming Torch Theory was already to be simpler and more straightforward than existing media ethics theories and theories for the ethical analysis of new technologies, it remains too lengthy to be considered a practical field guide. In general, journalists, politicians and especially ordinary, interested citizens who wish to share or retweet some new development regarding human gene editing, AI, blockchain, the Metaverse or whatever else do not have the time (or necessarily the desire) for deep ethical analysis. If it is short enough to fit into a Twitter thread, a brief Reddit or Instagram post or a WhatsApp message, then they *might* take the trouble to glance over the Ten Tenets.

This raises the second prerequisite. The field guide needs to be visually interesting and engaging in order to hold the attention of the individual and communicating *nodes* of the internet's various hive mind networks (whoever they may be). As such, it was decided that the first version of the Flaming Torch Field Guide should be a simplified version of the Flaming Torch core principle and the Ten Tenets, listed in a single image, or series of images, with an attractive design that can also be used as a single image for a social media post.

Finally, even though the field guide tenets needed to be simplified, they still needed to be true to the spirit of the initially drafted tenets so as not to exclude valuable detail.

8.2 The simplified Ten Tenets

To create the field guide, the Ten Tenets of the Flaming Torch Theory were simplified, first as a list of ten recommendations, and secondly as a list of questions, to provide two different possible versions. As a list of questions, it was possible to simplify the Tenets somewhat more than was possible with the list of recommendations.

8.2.1 As recommendations

1. New technologies and discoveries can sometimes deeply challenge what people believe and value, or how they are used to living. If you think this may be the case, start the conversation about who will be affected how as early as possible.

2. It will take *decades* for any new technology or discovery and all its influences to be properly understood, so create an accurate sense of 'where we are' currently. Mention what you know – what the top experts agree on, but also what might not be known yet. Try to think of the indirect effects that might not be obvious immediately, but might ultimately be inevitable.

3. Do not label any technology or discovery as simply ‘good’ or ‘bad’ – most new tools can be used for building and breaking.

4. If you are discussing a big event concerning a new technology or discovery (like a high-profile announcement or a major accident), remember that such conversations help shape history, and what you say could influence people’s ideas – or prejudices – long into the future.

5. It is important to have a balanced view, but if you are quoting people with opposing views, make sure they have some *evidence* for what they are saying. Do not quote or repeat/share/ retweet something simply because someone has a loud voice, an entertaining theory, powerful political backing or the most followers.

6. Assume, where relevant, that you are talking to people who know nothing about the technology or discovery in question, and do not leave out any important *context* without which people might not have the full picture about the risks and benefits involved.

7. Learn as much as you can before you talk about a new technology or discovery so that you do not end up spreading unnecessary fear, undue hype or misinformation.

8. Think about how different people will *feel* if a technology becomes commonplace in everyday life. (Automated taxis are cool, but maybe not for taxi drivers. Gene editing that can cure diseases is great – but not if only the super rich can afford it.) Ask yourself who will be the ‘winners and losers’.

9. Learn to embrace the concepts of *uncertainty* and *probability* in science and technologies – this can be an exciting part of the story!

10. Think carefully about *incentives*. What kind of behaviour will a technology incentivise? How are people being incentivised to think and talk about it? What are your own incentives to want to talk about this cool, scary new thing?

8.2.2 As questions

1. Will this technology or discovery challenge what people *deeply believe* and value or how they are used to living? Have you mentioned this – and how it might affect, and possibly anger or offend, some people?

2. Have you properly acknowledged ‘where we are’ with regard to this new discovery or technology? In other words, have you acknowledged what work has already been done, what is accepted and proven, and also what remains unknown, and what indirect effects might arise over *decades*?

3. Have you labelled the technology or discovery as mostly ‘good’ or mostly ‘bad’? Extreme viewpoints can be extremely damaging – remember that most tools can be used for building *and* breaking.

4. Are you discussing a *big event* concerning a new technology or discovery (like a high-profile announcement or major accident)? If so, remember that such conversations help shape history, and what you say could influence people’s ideas – or prejudices – long into the future.

5. Are the opinions you rely on *weighted by evidence*? Or have you included the opinion of people simply because they are loud, entertaining, popular, angry, powerful or rich? Even opposing opinions should be guided by evidence.

6. Have you included all the necessary *context*? If you leave out important aspects that you do not like, do not know, do not have time or space for, or that do not fit your story, people will be forced to make assumptions that can cause fear or unrealistic expectations that can become damaging.

7. Do you *understand* the technology or discovery in question, even if just at a conceptual level? If you don't, your audience likely will become misinformed. Learn as much as you can and, if you don't understand, ask an expert.

8. How will different people *feel* if this technology or discovery becomes a part of their everyday life? Who might be empowered or disempowered? Who will be the 'winners and losers'?

9. Have you acknowledged that the science behind the technology or discovery is inevitably based on some *uncertainties* and *probabilities* that will only become clear over time? Have you mentioned what the known uncertainties and probabilities are?

10. What are the *incentives* at play? What kind of behaviour will this technology or discovery incentivise (in how people use it, think and talk about it)? What are your own incentives to want to talk about this cool, scary new thing?

8.3 The Ten Tenets Field Guide

The tenets, either as a list of recommendations or as a list of guiding questions, can obviously be adapted further in various ways for different purposes and audiences. For the general purpose of this study, the list of recommendations was used, along with the core principle of the theory and some further clarifying text, to create a first concept version of the Ten Tenets Field Guide – designed by a multimedia designer as a poster (Figure 1 on the next page) and then broken down as a set of more easily digestible image posts for easy distribution via social media (Twitter, Instagram, Facebook, WhatsApp, Reddit, etc.). For the concept social media posts, see Figure 2 (p.156).

Figure 1: Illustrative concept for the Ten Tenets Field Guide

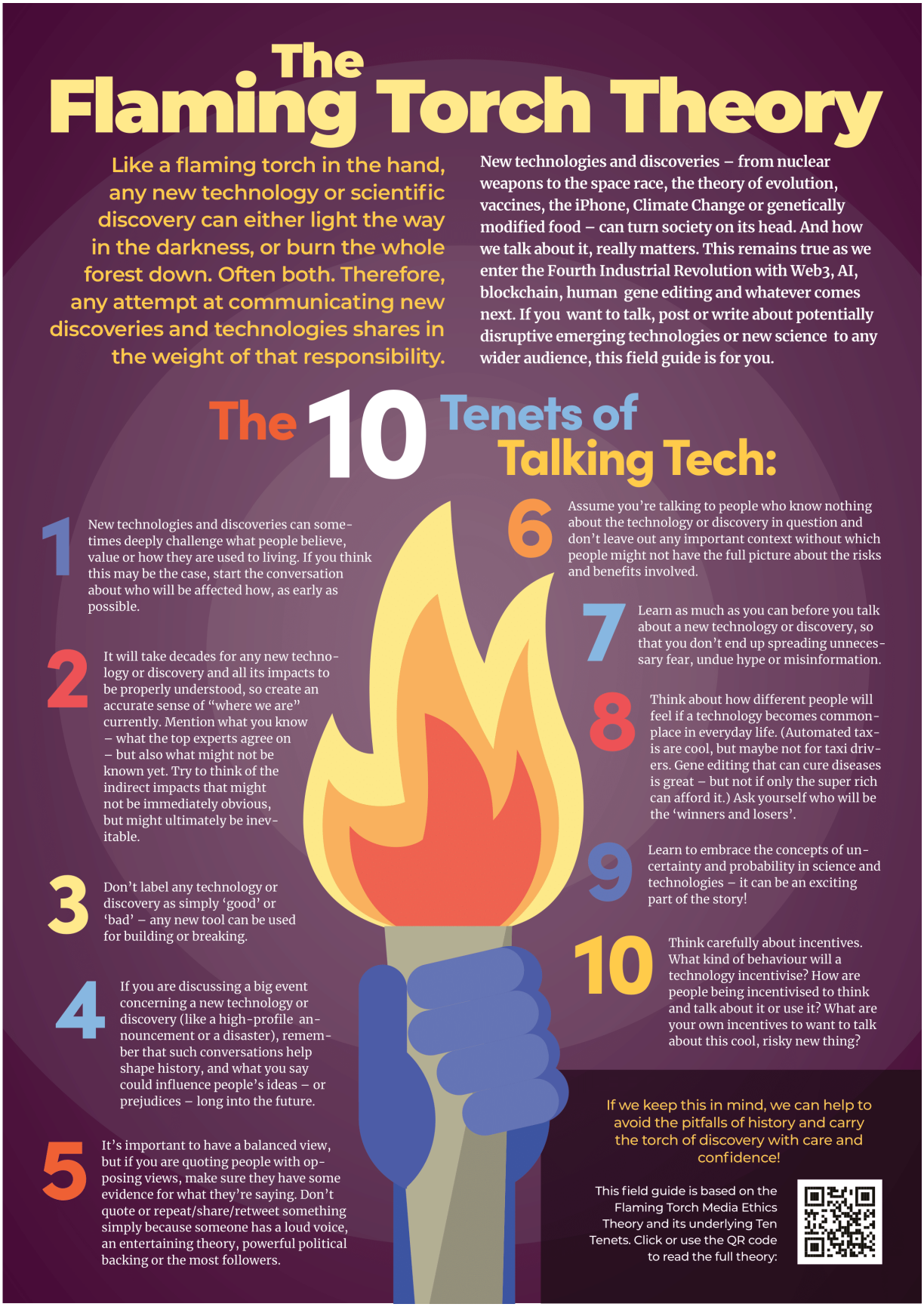

Figure 2: Concept social media posts for the Ten Tenets Field Guide

CHAPTER 9

9. Concluding remarks

9.1 Responsible disruption

Given the current state of constantly accelerating scientific and technological development, further large-scale disruptions – be they ultimately beneficial or harmful to society – are inevitable. This will almost certainly be the case for the three technologies studied here.

Jack Dorsey, co-founder of Twitter, who left his social media company in large part to pursue projects in the cryptospace, has said: "Bitcoin changes absolutely everything. I don't think there is anything more important in my lifetime to work on" (Locke, 2021). This while Warren Buffett, a stalwart of the legacy financial system, reiterated in May of 2022 it has "no value", stating he "wouldn't buy all the Bitcoin in the world for $25" (Novak, 2022).

Elon Musk, in discussing Tesla's line of Optimus household robots currently in development, sees AI and robotics leading to an "age of abundance", saying about the concept of household robots capable of learning and companionship: "People have no idea, this will be bigger than the car" (TED [YouTube], 2022). This while the Russia-Ukraine war has again raised people's fears about the potential use of autonomous weapons systems in warfare, like drones equipped with facial recognition (Al Jazeera English, 2022). Matt Mahmoudi, an artificial intelligence researcher for Amnesty International, has decried the use of so-called *killer robots*, which do not discern targets like humans do: "Humans are not just numbers, and these systems process human beings as if they were" (Al Jazeera English, 2022). Mo Gawdat, former chief business officer of Google X, has said the ethics codes we teach artificial intelligence will "determine humanity's future" (Evans, 2021). More recently, a Google AI researcher was placed on administrative leave and came under scrutiny after going public with claims that LaMDA, a large language model designed to converse with people, was in fact already sentient (Johnson, 2022). A conversation with LaMDA, provided as evidence of sentience, was published by the researcher online (Lemoine, 2022).

Jennifer Doudna, Nobel laureate and co-inventor of CRISPR-Cas9 gene editing, has expressed great excitement about what will become possible in gene editing over the coming 10 years, specifically because of the intersection with AI, machine learning and neural networks in health care: "I'm very excited about the ways that genome editing is going to intersect with computer science and Artificial Intelligence, in ways that are hard for us to imagine. I think increasingly over [the next] 10 years we'll see CRISPR woven into many aspects of our daily lives" (Bloomberg Technology, 2022). Prof. Samira Kiani, herself a professor of genetic engineering at the University of Pittsburgh, is equally excited, but also scared:

> I don't think it's an overstatement to say that CRISPR, a precise and efficient tool that allows us to 'edit' genes, is on the verge of altering the course of human history to an extent far greater than the recent 'disruptions' catalyzed by internet technology. If you think digital surveillance tools are frightening in the hands of autocracy, consider the power to bend the human genome to one's will. CRISPR provides that power. To use another analogy, the ability to edit genes with surgical precision is a scientific discovery on par with nuclear fission – while there may be beneficial applications, it is by nature seductive to our darkest impulses (Kiani, 2022).

Even the pace of acceleration of technological advancement itself is increasing, with experts now referring to the Exponential Age, where new technologies are adopted and (successful) technology companies are scaling up at rates and scales unseen and that will "transform economics forever" (Azhar, 2021). It also is likely that such revolutionary technologies will intersect in unprecedented ways. DeepMind's AI tool, AlphaFold, which is capable of predicting the 3D shape of proteins from their genetic sequence with pinpoint accuracy through protein-folding simulations, has already shown what is possible with such overlaps, promising to fundamentally "change biology and medicine" (Callaway, 2022).

Furthermore, as the rate at which new technologies are adopted keeps accelerating, regulation (for example of the use of drones and automated taxis) is often falling behind: "Greater innovation can bring greater risks, which require more control … [but] where technology moves fast, regulation moves slow" (The Economist, 2022).

Communication can obviously play a key role in helping society absorb the shock of such scientific and technological disruptions and revolutions. But communication *failures* can equally have an exponentially devastating effect. During the Covid-19 pandemic, communication failures and misinformation around appropriate prevention measures, remedies and vaccine safety undoubtedly cost human lives (Gross, 2020).

This study aimed to answer the question whether this complex and difficult communication task could be made easier through the creation of a simple, practical field guide tailored to help communicators guide society toward more measured, ethical and responsible disruption.

It was demonstrated that there have been common factors that caused communication failures during past scientific disruptions and technological revolutions, and that these key lessons could be used to create a media ethics theory to inform a draft field guide.

Through in-depth discussions with leading expert communicators and scientists in current emerging technological fields, it was further demonstrated that this theory, the Flaming Torch Media Ethics Theory, indeed has merit and that a field guide based on its basic Ten Tenets would have practical value for these experts. As such, the theory was further refined and a simplified, working field guide for science journalists, experts and communicators across the spectrum is hereby proposed.

If disseminated and adopted in the public sphere, the Ten Tenets of the field guide should be able to contribute significantly to guiding public discussions of this nature – and even policy – in order to limit unnecessary future harm to society and to the environment.

9.2 The need for future research

The field guide should be seen as a starting point for the ethical communication of potentially disruptive technologies and discoveries, and not as an end in itself, because the basic tenets could easily be adapted further for more focused, specific use depending on the context and audience in question.

In this sense, the Flaming Torch Theory and the Ten Tenets field guide provide a lot of opportunity for further research. Firstly, attempts can be made to adapt the field guide for more specific audiences and to assess its applicability – for instance to be used for educational purposes in schools, for communication training of scientists at scientific institutions, for developers in tech companies, for science journalists, for social media influencers, etc.

Secondly, a sensible way to further assess the applicability and usefulness of the theory and field guide would be to use it to measure existing media content and coverage of appropriate emerging sci-tech issues and topics. For instance, it would be interesting to take examples of the coverage of a specific media outlet, like BBC News, of the Covid-19 pandemic and vaccinations to determine to what extent the coverage adhered to the guidelines of the Ten Tenets, and to identify potential gaps that allowed for misinformation, lack of context, bias, etc., as highlighted by the theory.

Lastly, further research is needed to determine what would be the best manner to disseminate the field guide and its tenets in the public sphere so as to most effectively encourage its use and to maximise public engagement on these issues. Next, one possible strategy for dissemination is outlined briefly.

9.3 Dissemination: Deploying the hive mind

In the era of social media, where individuals can grow massive followings, popular thought leaders, public figures and influencers are – for better or worse – increasingly garnering viewership and audiences that rival those of traditional news media giants like CNN and BBC (see Table 17). Joe Rogan's YouTube audience, for instance, rivals that of both CNN and BBC News, while Elon Musk's Twitter audience dwarfs that of all the other sampled news media. The existence of bots and unused or fake accounts makes the accuracy of these metrics unreliable, but they do serve to illustrate a point.

To demonstrate the importance of this reach, Rogan was in hot water in 2021 for conveying inaccurate information about Covid-19 to his millions of listeners and followers. Perhaps, with the benefit of the Ten Tenets, 'new journalists' like Rogan would be less likely to spread misinformation. At the same time, it would be naïve to believe that the Ten Tenets will consistently trump the desire for increased ratings or the promotion of biased personal beliefs.

Table 17: News media vs. public figure social media metrics (2022)

	YouTube subscribers	Twitter followers
Joe Rogan	12 million	8.5 million
Jordan Peterson	5 million	1.5 million
Russell Brand	5.5 million	11 million
Elon Musk	6 million (SpaceX)	81 million
CNN	13.7 million	57 million
BBC News	12.2 million	50 million
The Guardian	2.5 million	10.4 million
The New York Times	4 million	52 million
Sky News	4.7 million	7.7 million
Al Jazeera	9 million	7.6 million
VICE News	7.7 million	1 million

Furthermore, figures like Rogan, Peterson and Brand have grown their audiences chiefly through the use of long-form video or podcast discussions of over 20 minutes, up to an hour or even three to five hours long. There is evidence that such long-form online discussions about interesting, complex topics are gaining popularity (Bhardwaj & Cheng, 2018; Bump, 2021; Marshall, 2013).

Lots of online long-form content already covers issues such as emerging technologies. YouTube host Lex Fridman's videos are often hours-long, in-depth discussions centred on

technology, philosophy and artificial intelligence in particular. Talks at Google regularly cover issues regarding the cultural effect of various technologies, and investment platforms like Real Vision Finance, Stansberry Research and ARK Invest frequently host discussions on developments in the cryptocurrency space and other emerging technologies in order to inform and attract investors. As such, it would not be too far-fetched to imagine that a similar long-form discussion or debate could be held about the ethical implications of various emerging technologies that investors are already interested in, guided by the Ten Tenets field guide.

Taking Pal's advice (Section 6.3.5), one would first need to motivate some high-profile public communicators to embrace the tenets as a means to boost their authority and career, and to partner with a suitable online platform or channel to facilitate such a public online discussion.

To help ease access and to raise the profile of the Flaming Torch Theory and the Ten Tenets field guide, the following dissemination strategy could be followed:

The field guide, broken up into separate, easily digestible image posts, as demonstrated in the previous chapter, could be posted on various social media platforms like Twitter, Instagram, TikTok and the like, with the posts specifically tagging the social media accounts of high-profile figures in the emerging technology space. At the same time, a popular online article on a suitable, free, open platform, such as Medium.com or TheConversation.com, could be published to explain the Flaming Torch Theory and its underlying tenets in simple terms. Anyone who sees the social media posts can follow a link to the article to gain a deeper understanding. The popular article, in turn, could link to this study in its final, published form.

Once the study, the popular article and the social media posts have been published, ARK Invest, Stansberry Research, Real Vision Finance or similar institutions with a respectable online presence can be approached to host a discussion or debate on the ethics of emerging technologies, guided by the Ten Tenets. This might be facilitated by the involvement of the Stellenbosch University Department of Journalism or its affiliated Centre for Science Communication (Censcom) as respected academic institutions. The audiences of the mentioned investor platforms would already be interested in emerging technologies, and so should have a vested interest in the ethics involved. Such a discussion would also likely be interesting at face value. Potential expert participants for such a discussion might be suggested from the ranks of the experts interviewed for this study, sourced from their affiliated organisations, or might be suggested by the hosting institution itself. The streamed discussion could then be shared on social media and, hopefully, be reshared by viewers.

The idea is that, once such an online discussion has taken place to popularise the Ten Tenets – or at least the concept of considering ethical communication when discussing potentially disruptive emerging technologies in public – then other communicators and the social media hive mind that follow them might in time make the Ten Tenets their own. This is of course only one potential avenue for dissemination, and serves here as an example and would need to be tested to ascertain its practicality.

9.4 Final thoughts

There is no illusion that the Ten Tenets are by any means a final answer to the question of how we, as a species, should communicate about revolutionary technologies and discoveries. Yet the Flaming Torch Theory has at least been shown to be a useful base to start from.

According to the experts interviewed here, the Ten Tenets field guide seems to be a sensible beginning to this important conversation: a field guide that is broad enough, clear enough and

simple enough to be practically useful for any science communicator – from lay social media influencer to professional science journalist – to start the conversation.

Hopefully, future research will be able to further workshop, refine and focus the Ten Tenets for specific uses and audiences. And, hopefully, it will be possible to disseminate the theory and the tenets so that they become engendered in the constantly buzzing hive mind of online conversations around emerging tech and new science.

Hence, if Bitcoin does in fact become the world reserve currency, if the human genome becomes as malleable as software is today, if there's a robot in every home and the metaverse becomes more real than the real world, or if the dark lord Sauron comes along with a collection of seemingly magical rings, promising to let us wield all kinds of strange new powers, we might at least have a better notion of what questions to ask ourselves, and to ask each other.

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