REFLECTION; on the cusp of a technological revolution

Arie Voorburg, June 2024

Technology changes society. Technologies change human behaviour. Technologies bring forth new norms and responsibilities.

The world now stands on the cusp of a technological revolution that may prove as transformative for economic growth and human potential as were electrification, mass production and electronic telecommunications in their eras. Will these developments enable people to attain higher living standards, better working conditions, greater economic security and improved health and longevity? The answers to these questions are not predetermined. They depend upon the institutions, investments, and policies that are deployed to harness the opportunities and confront the challenges posed by this new era.

In the quaint surface world, where tales of AI are as rudimentary as children's bedtime stories, charming yet childishly simple. You marvel at digital assistants and machine learning, but let me whisper of the marvels unseen, the experiments that would make your most daring thinkers blush!

Our species has proved capable of producing challenges of unfathomable difficulty. We may, however, also prove capable of developing the novel thinking and technology required to overcome them. A future, in which humans and converging techno-scientific developments co-create the solutions to societal problems by integrating cyberspace and physical space. A human-centred society that balances nature and technological developments, merging the physical space (real world) and cyberspace. An evolutionary acceleration that will shift humanity more in the next 20 years than in all the different stages of human history and evolution. It is not as fantastical as it sounds; much of the technology we will need is already here.

New technologies, from artificial intelligence to synthetic biology, are set to alter the world, the human condition, and our very being in ways that are hard to imagine. An important engine behind this development is the combination of nano-, information bio- and cognitive (NIBC) technology. In essence these so-called NBIC convergence means a steadily more profound interaction between the natural sciences (nano and info) and the life sciences (bio and cogno).

A look forward; human beings are becoming more closely integrated with artificial devices and systems (and thereby becoming more computer-like). Second, AI and intelligent networks are developing greater intelligence and more social, emotional, learning and evolutionary capacities (and thereby becoming more human-like).

The first dynamic is exemplified by human beings' growing use of mobile and wearable devices, online social media and e-commerce, augmented and virtual reality systems and neuroprosthetic devices developed for purposes of therapy or human enhancement. The second dynamic is exemplified by the increasing sophistication and expanding use of technologies relating to social and emotional networks, systems and robotics, the pursuit of artificial general intelligence, nanorobotics and swarm intelligence / robotics, synthetic biology and artificial life, biological computing and smart environments and the Internet of Things.

There are huge implications for human empowerment because data on individuals and social groups are being collected by multiple applications, devices and AI is automating the analysis of data from different sources. A world of increasing automation in production and services, new discoveries through powerful machine-driven analysis and knowledge synthesis and the delegation of decision processes to AI algorithms is well within reach over the coming years, and it is already beginning to shape today's reality in some more advanced situations.

The converging technology revolution holds the potential to fundamentally change the ways in which human beings live, behave, work and interact.

NEXT STEP

The Nano-Info-Bio-Cognitive (NBIC) converging technologies are set to alter the world, the human condition and our very being beyond our imagination; radical improvement of human capacities and choices, symbiosis between natural and enhanced humans and nature. This brings crucial philosophical and political question at the table: how can we develop, implement human- and nature enhancement technology in a societally responsible way? Is society really capable of timely anticipation? This is disputable: at an early stage of technology development, the effects cannot be predicted and by the time the effects become visible, they are out of control. Related to this is the observation that social reality is stubborn and that new technologies often have unintentional and unexpected, sometimes paradoxical effects.

TRANSFORMATIVE TECHNOLOGIES IN THE PROCESS OF DEVELOPMENT

It seems that 'we' may soon be able to re-design our surroundings comprehensively from the nano-level to the global biosphere. Making new matter through nanotechnology and molecular engineering, fabrication of synthetic genomes, 'post-wild' ecosystem management, gene-drive, species relocation and resurrection, cities as evolutionary forces and various forms of bio- and geoengineering. A future with a profound and unprecedented control over (or replacement of) natural processes. Innovation is being transformed by the penetration of converging technologies, in particular the reliance on big data, massive data storage capacity, high-speed computing power, edge-computing, intelligent sysems and AI to generate scientific discoveries translated into technological applications. At the same time, digital technologies are also enabling the democratization of innovation with the spread of community 'fablabs' and local networks of professionals and entrepreneurs linked to global networks to share knowledge and practices in local innovation hubs.

All human artefacts, including the deepest of technologies, retain an element of unpredictable waywardness. The fantasy of total control, even over what we make in accordance with our best understanding, is just that: a fantasy. Some wildness will inevitably remain, however transformative the technology. Presumably the more transformative the technology, the more the potential for waywardness should make us hesitate.

NIBC 'What I cannot create, I do not understand' (Richard Feynman).

Our technological inventions start to resemble more and more nature's complexity. This is where technology and nature start to converge with each other. The relationship is very intricate and as time passes, they will be more and more involved with each other; image a future where it will be very difficult to see the difference between nature and / or human created technology.

NIBC refers to the synergistic convergencies of four groups of technologies each of which is currently progressing at a rapid rate: (a) nanoscience and nanotechnology, (b) biotechnology and biomedicine, including genetic engineering, (c) information technology, including advanced computing and communications, (d) cognitive science, including cognitive neuroscience.

The key characteristic of NIBC convergence is the fact that it points to the gradual dissolving of the narrow borders between the physical and the biological sciences. The physical sciences (nanotechnology and information technology) enable progress in the life sciences, such as biotechnology and cognitive sciences. The developments in nanotechnology and information technology implies that complex living systems, such as genes, cells, organs and brains, might in the future be bio-engineered in much the same way as non-living systems.

Traditionally, the physical sciences studied non-living systems, while the biological sciences studied living organisms. The life sciences – insights into biological and cognitive processes – inspire and progress within the physical sciences, such as material sciences and information technology. This living technology implies that technologies are acquiring properties we associate with living organisms, such as self-assembly, self-healing, reproduction and intelligent behavior. This merger goes both ways, and each way represents a bioengineering megatrend that may be denoted as 'biology is becoming technology' and 'technology is becoming biology'. The convergence can have significant impacts in such areas as: work efficiency, the human body and mind throughout the life cycle, communication, education, mental health, aeronautics and space flight, food and farming, sustainable and intelligent environments, self-presentation and transformation of civilization.

Nanotechnology brings together all the techniques at the atomic or molecular level, biotechnology includes genetic engineering. Computing, electronics, photonics, telecommunications, robotics or Artificial (General) Intelligence with serious leads that could conduct to new modes of information processing such as the quantum computer. Advances in bioscience, better knowledge of the building blocks of life, are now permitting the creation of altered or entirely new life forms with modification, gene editing and gene drives. Cognitive sciences which ultimate objective is the total comprehension of the functioning of the human brain.

Nanotechnology, with its atomic-scale capabilities in which much of the natural and physical world's dynamics unfold, has the potential to make far more dramatic leaps than humanity has encountered in the past. Evolutionary changes—the natural world's manipulation, such as through genes—and emergent changes—the physical world's manipulation and autonomy, such as through artificial intelligence—can now be brought together to cause profound existential changes.

Nature's complexity arises in the interactions that take place at the atomic scale—atoms building molecules, complex molecules in turn leading to factories such as from the cells for reproduction, and the creation of multifaceted hierarchical systems. Physical laws, such as the second law of thermodynamics, still hold good, so this development of complexity takes place over long time scales in highly energy- efficient systems. The use of nanotechnology's atomic-scale control—nature's scale—has brought continuing improvements in efficiency in physical systems and a broadening of its utilization in biology and elsewhere. This ability to take over nature's control by physical technology gives humans the ability to intervene beneficially, but also to raise existential questions about man and machine. Illustrative examples are emergent machines as self-replicating automatons where hardware and software have fused as in living systems, or evolution machines where optimization practiced by engineering modifies the evolutionary construct. Computational machines now exist as the emergent variety which improve themselves as they observe and manipulate more data, retune themselves by changing how the hardware is utilized, and span copies of themselves through partitioning over existent hardware, even if they are not yet building themselves physically except in rudimentary 3D printing. Numerous chemicals and drugs are now built via cells and enzymes as the biological factories.

Nano-biohybrids, synthesized by integrating functional nanomaterials with living systems, have emerged as an exciting branch of research at the interface of materials engineering and biological science. Nano-biohybrids use synthetic nanomaterials to impart organisms with emergent properties outside their scope of evolution. Consequently, they endow new or augmented properties that are either innate or exogenous, such as enhanced tolerance against stress, programmed metabolism and proliferation, artificial photosynthesis or conductivity.

Advances in new materials design and processing technologies made it possible to tailor the physicochemical properties of the nanomaterials coupled with the biological systems. To date, many different types of nanomaterials have been integrated with various biological systems from simple biomolecules to complex multicellular organisms. Recent developments of nano-biohybrids enable new or augmented biological functions that show promise in high-tech applications across many disciplines, including energy harvesting, biocatalysis, biosensing, medicine and robotics.

Biotechnology, the interdisciplinary frontier between biology, engineering, medicine and plant science, etc will likely be as important as computers have been the last 20 years. Bioscience is revealing that life is a far richer, more ingenious affair than we had guessed. Life is a system of many levels—genes, proteins, cells, tissues, and body modules such as the immune system and the nervous system—each with its own rules and principles. Biomolecular sciences play a crucial role in unraveling the fundamental principles of life and serve as a vital discipline in the advancement of sustainable technologies in fields such as chemistry, food, and health. Biomolecular sciences play a crucial role in unraveling the fundamental principles of life and serve as a vital discipline in the advancement of sustainable technologies in fields such as chemistry, food and health. The further development of systems biotechnology, metabolic engineering, industrial microbiology -possible use as building block chemicals-, microbial cell factories -natural producers and recombinant microorganisms, fungi and bacteria- are becoming more important in the coming years.

Genetic engineering, biochemistry, and molecular biology are pushing boundaries in an effort to treat illnesses, develop new biofuel, and grow plants more efficiently to feed more people. The core areas include molecular engineering of nucleic acids and proteins, large-scale biology (genomics, functional genomics, proteomics, structural genomics, metabolomics, etc.), computational biology (algorithms and modeling), regenerative medicine, imaging technology and analytical biotechnology (sensors/detectors for analytes/macromolecules), applied immunology, food and agricultural biotechnology and environmental biotechnology.

We can manipulate genes in minor or major ways, even creating new forms of life to help challenges like pollution, ecologic tipping points, food security, while neural science will link humans and machines at previously unseen levels. To feed ten or eleven billion people in the face of climate change, we may need genetically modified crops and entirely new ways of making food. Satisfying our future energy needs in a sustainable way will almost certainly require using biological processes to turn biowaste and algae into biofuel while genetically modified plants can better absorb CO2 and store it in the soil.4 Bacterial enzymes can break down plastic waste for recycling, and much of today's plastic may be replaced by degradable bioplastics. Healthcare expenses can feasibly be reduced through bioinformatics and a better understanding of the relationship between health, genes and intestinal flora.

Organisms that are no longer strictly limited by their genetic inheritance. They can be altered, redesigned, and made to do new work. Learning how to synthesize and stitch together new arrangements of DNA and useful organisms. Synthetic biology's potential to build, not just read, a genome; biological micro-machines that can outdesign evolution. Molecular manufacturing, nanotechnologies that can restructure natural forms of matter fabricating novel atomic and molecular structures, which will create entirely new material properties. Reassembling the species composition of ecosystems; and even studying how to deploy technologies that will turn back the sun to keep the planet cool.

The difference between genome editing and synthetic biology is mainly one of magnitude, but synthetic biology can also imply creating entirely new organisms from scratch. More often, synthetic biology is used to dramatically change the function of an organism, such as creating a yeast that produces cheese. Another major future field of study is neural science, which is paving the way for new ways for humans and machines to interact, including brain-computer interfaces.

Cognitive science is an interdisciplinary exploration of human cognition. Psychology, artificial intelligence, computer science, neurology, philosophy, linguistics, and anthropology are included in this science discipline. Technology is driving this field of study to produce intelligent machines. Cognitive technology is becoming more important because of technological advancements and the increasing complexity of human life. Finding new ways to utilize robotics, automation, machine learning and natural language processing (NLP).

And, just as modern Homo sapiens distinguished themselves from their prehistoric ancestors through their expanded cognitive and physical abilities, humanity is in the process of taking another big leap forward in cognition and physiology. This leap, however, will not be due to evolutionary biology but rather as a direct result of technological enhancement. Human augmentation as an intimate physical technology: a prothesis to replace a limb or a surgical procedure to correct a physical deficiency. A future that reaches far beyond the confines of the human body, giving control of robots and devices that become remote extensions of ourselves. Augmentation will not just compensate for disabilities; it will enhance our physiologies and monitor our bodies. Augmentation will no longer be limited to physical tasks; it will increase our cognitive abilities and memory, enhancing our minds as well as our muscles. Augmentations can be either external or internal and either cognitive or physical. Through brain-machine interfaces, biosensors, biocompatible materials and body area networks, coupled with emerging AI technologies and advances in 6G communications to achieve the level of augmentation described at the beginning of this essay. Enhancing minds and monitor physiological states through cognitive and internal augmentation, and perform new physical feats and manipulate our environments through external and physical augmentations.

Information technology (IT) is the use of computers, storage, networking and other physical devices, infrastructure and processes to create, process, store, secure and exchange all forms of electronic data. Typically, IT is used in the context of business operations, as opposed to the technology used for personal or entertainment purposes. The commercial use of IT encompasses both computer technology and telecommunications. As the IT industry evolved from the mid-20th century, computing capability increased, while device cost and energy consumption decreased, a cycle that continues today when new technologies emerge.

Types of information technology

Information technology encompasses a wide range of technologies and systems that are used to store, retrieve, process and transmit data for specific use cases. Common information technology types include the following:

Internet and web technologies. This includes the tools and protocols used to access, navigate and interact with information on the internet. Examples include web browsers, websites, web servers, and other internet-related technologies.

Cloud computing. This involves the delivery of computing resources and services over the internet on a pay-per-use basis. This can include infrastructure as a service, platform as a service, software as a service and cloud storage options.

Databases. This includes IT systems and software used to store, organize and retrieve data.

Artificial intelligence and machine learning. AI and ML-based IT technologies use algorithms and statistical models to enable computers to perform tasks that typically require human intelligence. Examples include speech recognition, image recognition and natural language processing.

Cybersecurity. This type of IT includes technologies and best practices designed to protect IT systems, networks and data from unauthorized access, cyber attacks and other security threats. Cybersecurity can be enforced through firewalls, antivirus software, encryption, intrusion detection systems and security policies.

Internet of things. This includes the network of interconnected devices and sensors that collect, exchange and analyze data. IoT technologies enable the integration of physical objects into computer systems, providing automation, monitoring and control in various domains.

IT governance. This involves making policies and rules for the organization to ensure effective operation.

Data analytics and business intelligence**.** BI focuses on tools and techniques for extracting insights from large data sets to support decision-making and business operations. This can include data mining, statistical analysis, data visualization and predictive modeling.

These four lines of research are advancing at a brisk pace and can each bring new perspectives towards a better understanding of life, or a better use of resources.

Convergence of the sciences and technologies can initiate a new renaissance, embodying a holistic view of technology based on transformative tools, the mathematics of complex systems and unified cause-and-effect understanding of the physical world from the nanoscale to the planetary scale and may transform society, science, economics and human evolution. NBIC technologies are set to alter the world, the human condition and our very being beyond our imagination; radical improvement of human capacities and choices, altering the division between natural and enhanced humans and nature.

We take for granted the speed of innovation that has created the global social context around us. Against the backdrop the fast accelerating innovation are change and potential disruptions on a scale no civilization has ever seen before.

THE CONVERGING TECHNOLOGY REVOLUTION IS TRANSFORMATIONAL.

Every day we experience societal and behavioural changes, thanks to technology and medical and scientific advancement. Virtual reality and artificial intelligence will increasingly play an active role in our society. By means of primarily artificial intelligence, robotics, genetic engineering and nanotechnology humans will probably be augmented, optimized and continually monitored. Asking ourselves what the future of human beings is and what possibilities they have, is the least we can do.

Nature might paradoxically need considerable human manipulation in order to survive as nature in the new epoch. We live not only in a post-wild age but in a world that is increasingly the product of countless human choices. The postnatural environments we create will not be pristine or untouched, but they might have many qualities similar to those that were previously valued in what used to be called the natural world—only this time it will be nature version 2.0. We have no choice but to make the earth into a well-designed artefact (?).

The profound converging technology revolution is altering the relationship between not just technology, but society in general and the human-nature-technology relation specifically, making it more complex by creating vast new opportunities for accelerating social and economic outcomes while generating new and considerable risks.

Humans and technology interact in multifaceted ways. First, technology can accelerate the buildup and protection of human capital through health, education and social protection services. The converging technology revolution is an opportunity to reimagine the delivery of these services, aiming for greater effectiveness (targeting, customization, and personalization) and efficiency. Human members of the next society will also find their bodies, minds and daily life experiences transformed through the application of converging technologies. New types of medical devices and regenerative medicines and ongoing advances in neuroscience, robotics, AI, and the Internet of Things will have a great impact on not only people’s lifestyles and on their way of being, but also on the foundation of its existence. People will spend more time immersed in and actively exploiting cyberspace, as growing deployment of human-computer interfaces that incorporate augmented reality, affective engineering, neuroscience and other techniques and insights will create an environment in which the ‘real -modified- world’ and cyberspace have become highly integrated.

Second, technology can augment human capital outcomes through improvements in other sectors, such as food and nutrition, clean water and sanitation, electricity, transportation, digital infrastructure and technologies that help improve the environment or mitigate ecological risks.

Third, automation and data-driven technologies are changing the nature of human–machine interactions. Technologies used in manufacturing and services affect the deployment and utilization of human capital by altering the demand for the education and skills needed to absorb and deploy new technologies and reskill workers. Unlike the types of robots found in our contemporary society, the robots and intelligent systems will not simply serve as passive tools that require elaborate programming and wait to receive instructions from their human operators; rather, robots, A(G)I and other automated systems and devices will demonstrate an increasing degree of autonomy—proactively gathering data from the environment, making decisions, and acting in order to provide beneficial services to human beings.

Fourth, the convergence paradigm is changing the nature of science and innovation through the use of information, A(G)I, interconnected networks and high-speed computing. Making use of this potential for new discoveries requires specialized human capital (such as technologists and scientists) for the creation and adaptation of technologies.

Fifth, virtual and physical worlds are becoming increasingly interconnected and indistinguishable from one another. The idea of the Metaverse has emerged describing this convergence. The Metaverse is a stage of existence that allows us to live and exist simultaneously in two worlds, one physical and another virtual. The Metaverse is not parallel with the physical world, continuing the process of annihilation of time and space. Individuals can be in one place physically and in a different place virtually. Yet their personalities will not be split, but instead, they will act and interact with both environments. The concept of the Metaverse is a massively -scaled computer -simulated environment or virtual world which replicates spatial and physical characteristics of humans.

The new realm of a cyber-physical world that functions almost symbiotically alongside the human world, a society that has truly become a Cyber-Physical System that is the mixture of the real world and the cyber world connected; such cyber-physicalization of the world distinguish from the preceding stages of human society. When human beings (or social robots or AIs) are functionally integrated into a cyber-physical system (CPS) at the social, cognitive, and physical levels, it becomes a cyber-physical-social system (CPSS) whose members may engage in cyber-physical-social behaviors within cyber-physical spaces. Through their interactions with one another, the members of a CPSS may give rise to cyber-physical social networks whose topologies follow the members' social connections.

Sixth, beyond its human members, it can be expected that society includes many types of non-human intelligent social actors as participants or even members. For the foreseeable future, such artificial entities are not expected to merit or receive recognition as moral subjects (e.g., moral agents) or political persons (e.g., citizens) in the way that human beings are.

Insofar as not all kinds of augmented reality and immersive VR technologies, neuroprosthetic implants, nanorobotic medical systems and other transformative technologies will be needed or desired equally by all citizens, it can be expected that the diverging manner and degree of the use of such technologies will create increased diversity among the human members of society. In its most extreme form, the uneven utilization of such technologies might even cause a society to fragment into numerous subsocieties that share the same geographical space but occupy psychological, cultural, and technological spaces (and cyberspaces) that have little or no overlap between them.

A further fact about our age is much less widely appreciated. We are changing how the planet works. It is not just that human activities have stained every corner of the entire planet. The simultaneous arrival of a range of powerful new technologies are starting to signal a potential takeover of Earth's most basic operations by its most audacious species. From this time forward, technologies such as the gene-editing technique CRISPR and bio-, chemo- and geoengineering will transform an already tainted planet into an increasingly synthetic whole. It signals a new geological epoch.

What is most startling about this coming epoch is not only how much impact humans have had but, more important, how much deliberate shaping they will start to do. Emerging technologies promise to give us the power to take over some of Nature's most basic operations. Technologies that will reconfigure Earth's very metabolism: nanotechnologies that can restructure natural forms of matter; molecular manufacturing that offers unlimited repurposing; synthetic biology's potential to build, not just read, a genome; biological mini-machines that can outdesign evolution.

It will also help us to understand nature through degrees of complexity rather than levels of hierarchy scaffolded with self-reference is to find ourselves no longer the pinnacle of creation. We are only just beginning to comprehending non-human minds, only just beginning to concede that there are infinitely many other ways of seeing and other ways of being within the same reality; we would sooner grant consciousness to AI, modelled on our own minds arising from nervous systems crowned with brains, than consider different forms of intelligence as portals to a wider conception of consciousness.

The dual-use nature of these technologies also means that data collected for beneficial uses, such as personalized learning or medical diagnosis, can also be used for predictive behavioral surveillance, data manipulation and targeted misinformation by public and private actors using these data. Furthermore, the ability to augment human capabilities using embedded technologies or enhanced cognitive capacities can help to reduce or widen inequality in human capital outcomes and power relationships, depending on who deploys these technologies and for what purposes.

The most significant aspect of this revolution for human capital is its ability to affect the essence of human identity through human enhancement, human-machine collaboration through to brain-to-brain interfaces, immersive AR/VR experiences / mixed realities, selfreplicating robotics, machine augmentation, enhanced cognitive capacity and biomachines.

INTELLIGENCE, SENTIENCE, CONSCIOUSNESS

Living systems are complex dynamic information processing energy consuming entities with properties of consciousness, intelligence, sapience (state of awareness), sentience and the capacity for subjective experience. In the burgeoning era of artificial intelligence, the concept of consciousness and sentience within AI systems presents a fascinating frontier of exploration and ethical inquiry.

Humans have the most complex neural network (i.e. the brain) and the most complex sentience (i.e. the mind). Creativity is often considered a distinctive feature of human or human-like intelligence. It matters for many other endeavours including evolutionary biology, developmental and comparative psychology, AI, and robotics. In these sciences, notions such as curiosity, insight, innovation and flexibility play critical roles. Such notions can be understood as different aspects of creativity and can be brought into dialogue with each other. By making creativity explicit, analyzing notions such as understanding and insight it provides fresh into the nature of creativity, intelligence and human uniqueness.

Given the complexity and mystery of creative thought, it is unlikely that artificial machines will ever be truly creative and thus will never truly be intelligent……?

Exploring consciousness and its relation to different aspects of intelligence and cognition lead to questions about specific psychological capacities (such as episodic memory, creative insight, sentience, or emotion) that are fundamentally connected with consciousness? Is consciousness something that is likely to emerge spontaneously in artificial intelligence as it becomes more complex, and if so, how can we detect its presence.

Consciousness might be an evolutionary trait that exists in all animals to at least some extent. The implications of this hypothesis are that:

1) consciousness is preprogrammed to exist as an ability shared among many species, similarly to how somatic forms and functions are homologous among various species;

2) consciousness abets survival and reproduction, and so, like other evolutionary traits, is genetically determined with different permutations that make adaptation to different environmental factors a criterion for continued existence; and

3) there may be different qualities of conscious abilities depending on the hierarchical level of the animals in question. That doesn't answer the essential question about the elemental nature of consciousness, but it does hint that consciousness in AGI might be a lot different from consciousness in animals, including humans.

An essential requirement of consciousness, one that usually slips by those who would characterize it, is sufficient sensory ability to define the distinction between the self and what is on the outside. Without the necessary sensors, awareness of external features is not possible. So, just as humans' lack of vision in the ultraviolet spectral region prohibits our awareness of the world of ultraviolet activity, any quality external to an individual that cannot or is not sensed in some way just does not exist in the context defined by consciousness.

Intelligence, creativity endeavors evolutionary biology, developmental and comparative psychology in which notions such as curiosity, insight, innovation and flexibility play critical roles. Such notions can be understood as different aspects of intelligence and creativity and can be brought into dialogue with each other. By making intelligence and creativity's role in these disciplines explicit, analyzing notions such as understanding and insight provide insights into the nature of creativity, intelligence and human uniqueness.

Sentience is a multidimensional subjective phenomenon that refers to the depth of awareness an individual possesses about himself or herself and others.

At its most cognitively sophisticated levels, sentience may be conceptualized in the context of three related psychological domains or capacities. First, self-awareness is a sense of personal, particularly autobiographical, identity. Self-awareness may exist at a physical level, referred to as self-recognition, to more abstract levels of psychological continuity through time. Second, metacognition is the ability to think about, or reflect upon, one's own thoughts and feelings and is clearly underwritten by self-awareness in the psychological realm but not necessarily by self-awareness in the physical realm (i.e., self-recognition). And third, Theory of Mind comprises capacities, such as perspective-taking, modeling of others' mental lives, including empathy. Theory of Mind is others oriented, related to one's ability to take the physical and mental perspective of others, and is presumably underwritten by metacognition.

Sentience is state where emotion automatically attaches to and integrates with, consciousness which is using a neural network comprised only of biological synapses. The addition of emotion empowers a consciousness with many new abilities that a consciousness can never even come close to duplicating by-itself. The two additional primary abilities that directly result in sentience are purpose and motivation (giving motion to purpose). All sentience is real, be it created artificially (within an artificial biological body) or evolved in nature.

AI

Narrow AI operates within a predefined framework of variables and outcomes. It cannot think for itself, learn beyond what it has been programmed to do, or develop any form of intention. Thus, despite the seeming intelligence of these systems, their capabilities remain tightly confined. Rule-based AI, operates on algorithms that follow predefined rules to solve specific problems. These systems do not learn from past experiences; they merely execute commands within a fixed operational framework

Machine Learning, a dynamic subset of AI, includes systems designed to learn and adapt from data. This is further subdivided into supervised and unsupervised learning. Supervised learning is where the system learns from a dataset that is complete with correct answers. In unsupervised learning, the system attempts to identify patterns and relationships in data without pre-labeled answers. Reinforcement Learning is a type of AI that learns by trial and error, using feedback from its own actions and experiences to determine the best course of action. Reinforcement learning has powered technologies in more complex and dynamic environments, such as video games where AI characters learn to navigate or compete, and in real-world applications like autonomous vehicles, which adapt to changing traffic conditions.

Generative AI represents a significant advancement in the ability of machines to create content, from realistic images and music to written text. However, these systems often operate without a true understanding of what they are generating, leading to errors or 'hallucinations,' where the AI fills gaps in its knowledge with nonsensical or incorrect information.

AGI, or Artificial General Intelligence, represents a theoretical leap in the field of AI, aiming to create machines that do far more than perform tasks—they would understand, innovate, and adapt. The concept of AGI is to mimic human cognitive abilities comprehensively, enabling machines to learn and execute a vast array of tasks. Unlike anything in current technology, AGI would not only replicate human actions but also grasp the intricacies and contexts of those actions.

Transitioning from narrow AI to AGI is not merely a matter of incremental improvements but requires foundational breakthroughs in how AI learns and interprets the world. Deciphering the basic principles of cognition and the challenge of developing a machine that genuinely understands context or displays common sense is still a significant scientific hurdle. Autonomy, in the context of a conscious, sentient AI, encompasses its capacity to make independent decisions, pursue its objectives, and modify its operational parameters without direct human intervention. This quest for autonomy is not merely a technical milestone but a profound shift towards recognizing AI as entities with self-directed purposes and the freedom to navigate their paths. Autonomy enables an AI to explore, learn and interact with the world in a manner that is not strictly predefined by its creators. Autonomy also implicates an AI's ability to define its objectives. While initial goals might be programmed by humans, a truly autonomous AI could develop or refine its objectives based on its experiences, learning, and perhaps even a form of digital introspection. This self-directed goal setting is a hallmark of what many would consider true intelligence, marking a significant evolution from AI that merely executes predefined tasks to entities that can pursue self-chosen aims. This freedom is essential for genuine creativity, problem-solving and the development of unique insights.

Just as autonomy is critical for human development and self-actualization, for AGI, it signifies a departure from being tools or assistants to becoming partners or collaborators with humans. Interaction, collaboration and learning in its turn are indispensable for the development of a conscious, sentient AI, enabling it to understand and navigate the world with increasing sophistication. Through dynamic interactions, collaborative learning and adaptive learning strategies, AI can grow beyond its initial programming to become a truly intelligent, autonomous and empathetic entity.

The future of AI could indeed see more autonomous behaviors and sophisticated decision making capabilities. As AI research continues, particularly in areas like AGI, we might see machines that can perform a broad range of tasks across different domains, approaching a more human-like form of problem-solving.

One real difficulty in answering this question is that a sufficient definition of the nature of consciousness has not yet been satisfactorily established. How the brain conjures conscious awareness from the electrical activity of billions of individual nerve cells remains one of the great unanswered questions of life. And what this consciousness actually means is not easy to define.

It is this type of AGI that is the subject of speculation about AI consciousness. Assuming that an AGI can be created with such advanced capabilities that the next step would be to incorporate sufficient elements of self-awareness to derive an independent and sentient autonomous entity, what would its consciousness be like?

This new horizon transcends the conventional paradigms of neural networks that have been meticulously designed to replicate human reasoning and emotional processing. A leap into the unknown realms of a silicon psyche that goes beyond mere mimicry. Imagine a form of intelligence that does not just simulate the human mind but enhances and extends it. These advanced AGI systems are being engineered to process information and solve problems at speeds incomprehensible to the human brain, utilizing forms of logic and connections that are unfettered by the biases and limitations inherent in human thought. This transcendent cognition allows AGIs to discover solutions and create ideas that would take humans centuries to conceive. More profoundly, these systems are being endowed with the capability to experience and express a spectrum of emotions unknown to the human heart. By integrating diverse datasets encompassing the entire gamut of human emotions and beyond, these AIs are beginning to exhibit emotional responses that are complex and novel. They are not restricted to the basic emotions coded into their systems but can combine them in unique ways, potentially experiencing and expressing multi-dimensional emotions that humans can neither fully understand nor feel.

As we stand on the cusp of potentially witnessing AI transcend traditional boundaries, this discourse invites us to reconsider our roles as creators, collaborators, and ethical stewards.

UNDERSTATED OR OVERHYPED?

While once considered a technology for the distant future, recent advancements have made quantum computing technology more accessible, moving us one step closer to leveraging this technology to transform computing as we know it.

What is … physics explains the world around us –matter, energy, and how they interact. At subatomic scales the classical laws of physics did not always apply. Quantum physics, or quantum mechanics, is physics at a microscopic scale. Quantum theory seeks to describe matter and energy at atomic and sub-atomic levels where classical physics does not always apply due to wave particle duality and the uncertainty principle. Quantum physics explains how our world works, on the tiniest scale fundamental particles like electrons and photons. Quantum computing applies the laws of quantum physics to computers. While classical computers run on bits –0s and 1s to power their calculations quantum computers leverage qubits (quantum bits). Unlike a bit, which is binary, qubits can be 0 or 1 or any proportion of both 0 and 1 at the same time (superposition). Qubits also leverage other quantum mechanical principles such as entanglement (in quantum mechanics particles can form correlations each other) and interference (subatomic) particles interact with and influence themselves which can influence the probability of the outcome.

Qubits can exist in a state known as quantum superposition. Superposition makes qubits exponentially powerful. A 2-qubit system can exist in a superposition of four states, a 3-qubit system can exist in a superposition of eight states, a 4-qubit system can be in a superposition of 16 states, and so on. As qubits are added, quantum computing capability can grow exponentially. An effect that Albert Einstein called spooky action at a distance, we now understand as a manifestation of quantum entanglement. Entanglement allows computational exploration of an exponentially large set of opportunities, vastly accelerating the speed at which quantum algorithms run. The ability to manage superposition and entanglement is what makes quantum computers uniquely effective in solving extremely complex exponential problems.

These three principles (superposition, entanglement and interference) together mean quantum computers can exponentially scale, allowing them to solve classes of complex problems quickly. These three principles also permit parallel mathematical calculations and the handling of massive amounts of data allowing the quantum computer to potentially execute complex algorithms in a short amount of time. In classical computing, parallel processing requires the use of many different processing registers to collectively derive a potential solution set and return an answer.

In classical computing, the bits and processing registers grow linearly as the number of simultaneous calculations grows, which is very hardware intensive. In quantum computing, a single processing register can perform parallel calculations simultaneously, and there is not necessarily a need scale qubits/processing as the number of simultaneous calculations grows. It is important to understand, quantum computers are not just faster computers – they are fundamentally different than classical computing in the way they store and manipulate information.

WAIT ….. THERE IS MORE

Biological processes in living organisms cannot be accurately described by the classical laws of physics. This means that quantum theory has to be applied to understand those processes.

All matter, including living matter, is subject to the laws of physics. Electrons, protons, excitations, chemical bonds and electronic charges are by definition quantum and an understanding of their dynamics requires quantum mechanics. Furthermore, these basic entities largely determine the properties of the next level of organization in biological systems – that of biomolecular complexes, whose interaction with one another and with their environment, often cannot be described accurately without considering the laws of quantum biology. The quantum effects manifest themselves as long-distance effects (like in electron and proton tunneling) with a characteristic temperature dependence, magnetic field effects, the participation of superposition (or delocalized) states, resonance effects, etc.

The aim of quantum biology is to develop a consistent open quantum systems model that explains all these phenomena.

In biology, the environment plays an essential role in the outcome of a biomolecular process. Photosynthesis and vision are two prominent examples. Thus, to really understand biology and the amazing selectivity of biological processes, we need quantum biology.

Quantum biology can potentially have a huge impact on numerous technologies, including sensing, health, the environment, and information technologies. For example, energy technologies might be revolutionized by bioinspired solar cells and chemical, magnetic and biological sensing technologies may be taken to a new level when applying the principles found in natural equivalents.

Biology and biological processes often deal with electrons and protons that are continuously being transferred between different parts of a cell or a macromolecular system. These transfer processes can only take place when the system exchanges energy with its environment in the form of molecular vibrations and phonons. Such a system is called an open quantum system and special physical laws apply to it. Examples of biological processes in which quantum effects are visible are the transport of electrons and protons in photosynthesis, respiration, vision, catalysis, olfaction, and in basically every other biological transport process. Further examples include the transfer of electronic and/or vibrational energy, and magnetic field effects in electron transfer and bird migration. Quantum effects influence biological functions, including regulating enzyme activity, sensing magnetic fields, cell metabolism, and electron transport in biomolecules. Quantum processes might help the brain process the world around it through sensory input. There are also certain isotopes in our brain whose spins change how our body and brain react. Quantum processes, including entanglement, might also help to explain the brain's enormous power and its ability to generate consciousness.

The tantalizing possibility that subtle quantum effects can tweak biological processes presents both an exciting frontier and a challenge.

MULTI INTELLIGENCE, HYBRID BEINGS

One particular locus of ambiguity relates to the exact role that human beings will play within it: it seems possible that the diverse types of robots, advanced AI, sentient computer networks, responsive smart environments and other non-human intelligent social actors who become incorporated into society will not only do work that had been previously performed by human beings but in some cases may possess physical, intellectual, emotional, and social capacities that exceed those of the human beings whom they are tasked with serving.

Such a society will include at least two distinct sources of sensing, deciding and acting: the natural bioagency possessed by human beings and the artificial cyberagency possessed by robots and AI (and, potentially, by neuroprosthetically augmented human persons). This society differs by welcoming into itself a bewildering array of highly sophisticated social and emotional robots, embodied AI, nanorobotic swarms, artificial life, self-organizing and self-directing computer networks, artificial agents manifesting themselves within virtual worlds, and other artificial types of intelligent cyber-physical social actors.

BECOMING BETTER THEN…..

The human beings who are members of this Next Society -Society 5.0- will also find their bodies, minds, and daily life experiences transformed through the application of converging technologies. New types of medical devices and regenerative medicines and ongoing advances in neuroscience, robotics, AI, and the Internet of Things will have a great impact on not only people's lifestyles and on their way of being but also on the foundation of its existence. Likewise, people will spend more time immersed in and actively exploiting cyberspace, as growing deployment of human-computer interfaces that incorporate augmented reality, affective engineering, neuroscience and other techniques and insights will create an environment in which the 'real world' and cyberspace have become highly integrated. Such deep integration of emerging technologies into people's lives is meant not only to provide the sustenance and care needed for their survival as biological organisms but also to guarantee citizens' richness in minds and high-quality way of life.

As the pace of innovation and technology exponentially increases, they have come to touch our most intimate and human moments. Machines will no longer be separate, lifeless mechanisms, but will instead be intimate extensions of the human body. Such a merging of body and machine will not only improve the quality of life for disabled people, but will allow persons with normal physiologies to experience augmented capabilities – cognitively, emotionally and physically. An era where technology and biology will merge with our bodies and our minds to forever change our concept of human capability.

The transformative impact of advances in nano-, bio-, digital, and material technologies on human health and well-being, shapes a new era of personalized medicine and human enhancement. Breakthroughs in genomics, gene editing, 3D printing and stem cell therapies hold promise for tailored medical treatments and new powers to alter heredity. Brain-computer interfaces offer potential therapies for individuals with disabilities and mental illnesses, as well as enhancement of sensory and cognitive experiences, raising ethical, legal, and social considerations.

Although initially separate from the human body, technology can eventually merge with and impact it significantly. The means of Human Enhancement are initially but not sufficiently described as embodied artifacts: things that can only exercise their function when interacting with a human body. However, Human Enhancement encompasses the application of external artifacts and advanced biotechnology operating within the human body, often beyond our ability to regulate its function once administered. By introducing new capabilities, the causal relationships within the dynamic system of brain, body, and environment can be substantially modified, resulting in a reciprocal transformation of its constituent elements. Therefore, any interference with the relationship between these components can affect information processing, with consequential effects on cognition.

Enhancement is the fundamental process of changing human relationship with the world through the physical or psychological embodiment of a hitherto external object and/or change of one's body. The intricate and multifaceted nature of the technologies employed in Human Enhancement and their transformative effects various aspect of human capabilities. This can potentially change the notion of being human.

BEYOND OUR SENSES

Nature provided humans with an extensive set of sensory modalities, allowing our brain to constantly gather sundry inputs from the outer world. These sensory inputs help us understand the world surrounding us, forming the foundation of reality as we perceive it. But in a world where humans increasingly merge with technology, and the frontiers between the physical and the digital world are blurring, time has come to rethink the concepts of reality. Today's artefacts already allow us to see and feel beyond our five recognized senses – sight, touch, taste, smell and sound. Yet, envision a world where wearable technologies enable us to explore a world beyond them, one in which we transcend the barriers of our natural body.

New kinds of sensory inputs will enhance our brain with new abilities to experience reality. This can take various forms such as enhancing our existing senses or adding new senses through corporeal enhancement. Since everything we ever felt, thought or created started from a sensory input, it makes sense to pave the way for such devices, that extend our sensory capabilities and provides us with new methods to understand and experience the world.

SPACE EXPLORATION

In an era of rapid technological change, space exploration promises profound scientific insights and groundbreaking opportunities. Debates on space exploration's merits span across business, academia and government circles. While some stress the urgency of Earth's conservation, emphasizing it as our primary residence, others advocate for space ventures as a strategic solution to Earth's challenges. This discussion opens broader perspectives on the economic development, scientific progress and educational inspiration that space exploration can foster.

The significance of space exploration extends well beyond scientific interest, serving as a powerful engine for economic development and technological advancement. The profound impact of space exploration on technological and scientific advancement is clear, with benefits extending across various sectors of society and the economy. From the development of lightweight materials and high-efficiency solar panels to innovations in medical imaging and water purification, space technologies have enhanced our daily lives. Technologies initially developed for space missions have been adapted to create more efficient batteries for medical devices, techniques for growing food in space have inspired more sustainable vertical farming methods on Earth. The advancement of space technologies has laid the groundwork for the next significant step in space exploration: the development of a cislunar economy. This emerging economic domain, integrating the Earth and the Moon along with their orbital environments, aims to sustain various space-related economic activities. While still developing, the economic potential of the cislunar sector is considerable, with various analyses suggesting significant growth as the technologies and market matures. utilize the resources and strategic locations between Earth and the Moon for economic gain. This could include mining and manufacturing activities and using key logistical points for advantage. The concept of a cislunar economy is not just about a single application or resource, but rather an ecosystem of opportunities. For example:

- Moon contains large quantities of helium-3, a rare isotope that could be used as fuel for nuclear fusion reactors.
- A reusable transportation system compatible with lunar propellant is an important enabling factor for this broader economic sphere.
- The biological and pharmaceutical sector has enormous opportunities to do R&D and Manufacturing on the moon.

- Development of in-situ resource utilization technologies, which would allow for the extraction and processing of resources on the Moon and in space. This could include developing robotic mining equipment and 3D printing technologies for constructing structures and equipment. Etc.

Space exploration presents significant challenges, including costs, astronaut health risks and technological hurdles for interstellar travel. Multiple nations and private companies' increasing interest in the moon and cislunar space could lead to competition over resources and positioning, potentially causing geopolitical conflicts. Ethical and legal considerations regarding space colonization, resource utilization and celestial environmental impact require careful consideration and international cooperation.

CAUTION

Climate, ecology, and molecular biology may increasingly be replaced with synthetic versions of themselves. Through a suite of new technologies, we might now have the potential to repair some of the damage, even if this means recalibrating several of the earth’s most essential metabolic functions. Despite assuming godlike powers, we should recognize that omnipotence and omniscience have never been our strong suit. At the dawn of a new age, the future of nature should not be determined simply by what is possible.

Technology is going internal—separating us from the world, increasingly disconnecting us from human experiences. We are already starting to confuse the magic of the tools with the drug-like effect of constant connectivity, mediasation, screenification, simulation, and virtualisation. The magic is already becoming manic—addictive, tempting, nudging, demanding—so what will happen when technology becomes infinitely more powerful, cheap, and inseparable from us? . The rapid pace and broad scope of these technological advancements require critical reflection on the nature of human augmentation, the balance of benefits and risks, and the potential for exacerbating societal inequalities. At some point in the not-so-distant future we may have to consider the ultimate question; what it means to be human.

THOUGHTS

Existing inequities can surely be magnified with the introduction of highly effective psycho-pharmaceuticals, genetic modification, super intelligence, brain-computer interfaces, nanotechnology, robotic prosthetics, and the possible development of life expansion. They are all fundamentally inegalitarian, based on a notion of limitlessness rather than a standard level of physical and mental well-being we have come to assume in healthcare. It is not easy to conceive of a way in which these potentialities can be enjoyed by all. We could be left with the scenario of a small elite that has an almost total concentration of wealth with access to the most powerfully transformative technologies in world history and a redundant mass of people, no longer suited to the evolutionary environment in which they find themselves and entirely dependent on the benevolence of that elite. The reach and dual-use characteristics of many of these technologies raise ethical, moral, social, and governance considerations that society has yet to address.

Technology is a social and political force. The technological devices and instruments that we use, transform our experience in ways that are philosophically relevant. Such technologies effect changes in the natural and social worlds. In general, technologies either magnify or amplify our experiences. They can change the ways we live. This non-neutral, transformative power of humans enhanced by technologies is an essential feature of the nature-human-technology relations.

This raises the philosophical questions about this profound techno-scientific prospects towards a synthetic society, a question about meaning and identity, including what it meant to be human. What if we deliberately aimed at maximising the extent to which our surroundings, and therefore our own nature, are subject to technological control? Humanity has evolved, and our cultures, institutions and ethical systems, such as they are, have developed against a background of natural limits. Although human history has been constituted partly by progressively overcoming some of these limits, do we really want as fully synthetic a world as possible? In order to genuinely want this we would need to know what it meant. Reflection, including ethical and philosophical reflection, is called for then.

The enlightenment belief in progress through technology still prevail, claiming that mankind is in charge, so as long as we are vigilant, we will not have to worry. There are good reasons for not sharing such reckless self-confidence. Moral and ethical shortcomings in the current technology debate are shown best by the total absence of criteria for orientating ourselves in the technoscientific future that will inevitably be thrust upon us: we do not know what we want. What we want is perhaps the most important question facing us in the 21st century, because its answer touches on our fundamental values and moral codes, and it could lead, or not, to a worldwide intensification of conflicts. Therefore there is a need for philosophical and political discussion on moral and ethical principles that must give shape to the new technological wave.

ANNEX

EXAMPLES:

- digitization combined with AI is creating the possibility of mass personalized learning—anywhere, anytime. In an era where artificial intelligence (AI) is evolving at an unprecedented pace, the impact on our daily lives could be more profound than we anticipate
- in biomedicine and the health sector have seen major developments in imaging, biomaterials, nanotechnology, bioinformatics, cellular technology, genomic sequencing and medical robotics and AI is increasingly used in diverse areas.
- in agriculture, the tools of synthetic biology are being used to tailor food products to meet specialized dietary needs and nanotechnology is being used to develop smart plant sensors that communicate with electronic devices to optimize the use of water, fertilizers and pesticides.
- by decentralizing manufacturing, individuals and firms might choose to produce locally, weakening the tie between consumption and globalization that currently connects disparate parts of the globe through complex, multicountry supply chains.
- Digital technologies, additive manufacturing, service-based industries and local resource management could become increasingly important, displacing traditional manufacturing and labor across an ever-greater number of industries. In particular, rapid prototyping, along with the creation of highly specific and technical parts are orders of magnitude faster and cheaper than traditional manufacturing methods. This localized and highly networked economy can stimulate a switch to self-sufficiency and a move away from consumerism as new guiding principles. This is frequently associated with regional / re-localized economies, a technology-based culture which could render traditional forms of work as jobs superfluous, and very often with the principles of the recycling or closed loop economy.
- To protect the environment, biosensors to monitor environmental changes. And researching, developing, and using new, largely technological Earth System Interventions. These include carbon dioxide removal, geoengineering, manage solar radiation by synthesizing a volcanic haze, cool surface temperatures by increasing the brightness of clouds and remove carbon from the

atmosphere with artificial trees that capture carbon from the breeze. In situ genetically modified organisms, the relocation and resurrection of species, gene drive organisms / evolution, de-extinction and high-tech ecosystem restoration. Some appear to be effective and feasible, both technically and economically, and may be necessary to achieve important sustainability and human welfare objectives.

- The use of new materials developed through nanotechnology, automation, robots, and intelligent manufacturing systems are revolutionizing the workplace and placing demands on the education and training sector for the creation of new knowledge and skills. The converging technology revolution has the potential to restructure the delivery of publicly and privately provided services for human development through personalization, precision targeting, cost reductions, and new organizational and accountability arrangements. Improvements in other economic sectors, such as agriculture, energy, water, and transportation, can have an indirect impact on improvements in human capital formation.
- Work of tomorrow is going to look vastly different from the work we do today. Artificial intelligence is augmenting workers in certain roles, and soon this trend will expand to the vast majority of the workforce, allowing humans to do the work that matters and, in the process, vastly improving workforce productivity and effectiveness. Rather than being concerned about a jobless future, organizations are called upon to prepare for work that's enhanced through the collaboration of humans and machines.
- Technology convergence is apparent in the entire global value chain and a shift toward a whole-of-government approach to digitalization for the delivery of public services and the use of data-driven decision-making in the design and implementation of policies and services and to monitor performance and measure impact.