8.1 Knowing the Facets of Time

The main lines of the role played by science and technology in the history of civilizations up to the present time have been succinctly presented. The myth that has prevailed over all the changes in myths, religions, and religious practices and over all social and political transformations, and is now flourishing, is technology. Technology is the current magical companion of *Homo sapiens*, able to fulfil all his wildest dreams of well-being, entertainment, and economic prosperity and all the excesses that make life exciting and worth living.

Time is different from all the other constraints that science and technology have helped humankind to overcome. Time remains, to our chagrin, unconquerable. Technology is utterly unable to change or improve its nature for our benefit. Happily, we dominate space and speed, and we dream of colonizing Mars and exploring the Solar System and eventually beyond, as fast as possible. Our angry reaction to the impregnability of time is to use it as much as possible and to extend the life that gives access to it as long as possible. Humankind has learned about how to use time ever more efficiently, and about experiencing the thrill of time acceleration. The practice of the maxim that there is no time to lose, that time is money, and that there is always something more to do than simply being, is widespread and rarely discussed. Nevertheless, we cannot help feeling that time is never enough to appease or satisfy all our expectations. Instead of using time greedily as if it is a rare resource, we would do better to recover peace and learn to enjoy the flow of time at our leisure.

The historical narrative and analysis of the advent of progress, growth, and technology developed in this book is guided and supported by the concepts of operative social time, operative social time structure, the element of operative social time, and historical time, and also by their relationship with the concepts of psychological time, biological time, and physical time. The long and continuing interaction between the two groups of concepts has contributed decisively to influencing and characterizing our long cultural evolution, which can be traced back to the Upper Palaeolithic, when *Homo sapiens* developed a more complex social behaviour that shaped cognitive and
symbolic thought and symbolic representation. The process of adapting to external cycles and a constantly and deeply changing environment has played a decisive role in the biological evolution of hominids that led to the emergence of *Homo sapiens*. The contrast between the uncertainty of everyday human life and the superhuman regularity of the external time cycles of the Sun, Moon, and planets was a very fertile mystery that influenced various civilizations, especially the Egyptians and the Maya. The latter went as far as admitting that time had a cyclical nature that was a reflection of the cycles observed by the Maya in life and in the terrestrial and cosmic environment. More importantly, the cycles of time enabled them to peer into the future and help make the right decisions. The fascinating initial steps in the use and interpretation of the concepts of time have marked the cultural evolution of humans.

We do not know how long our species *Homo sapiens* will live but it will be practically impossible for it to last forever. There is, then, an element of operative social time—*Homo sapiens* time—that includes and surpasses all the other elements of operative social time. One of the main difficulties in the analysis of *Homo* and *Homo sapiens* time is our inability to imagine periods of time that last hundreds of thousands of years and the impossibility of gaining access to and analysing the relevant events and processes that took place within them and had a crucial influence on our evolution. Some of the modes for the termination of *Homo sapiens* time induced by natural environmental transformations or by causes related to human behaviour, including the advent of transhumanism, were addressed.

The concepts of time that have been introduced and analysed also play a crucial role in understanding the impacts of progress, growth, and technology on sustainability. It is argued that the contrast and resulting tension between the cyclical nature of the element of generational social time and the uniqueness of the element of time that is our lifetime is an essential challenge of the human condition. To what extent should we appreciate and enjoy something that is unique, personal, and cannot be repeated—our lifetime as an element of operative time—and, on the other, value our active participation in the social generational cycle by helping it to continue in a sustainable way? What is the compatibility of personal interests, behaviour, and lifestyle with the interests of future generations, including our own descendants? The permanent tension between these two types of driving forces is responsible for shaping the human approach to sustainability and intergenerational justice.

Sustainability also depends crucially on intertemporal choices that involve decisions with consequences having repercussions in the future. This type of decisions, which are very common in everyday life, force us to imagine the future and make comparisons between the costs and benefits that take place at different times. They are personal decisions in which time, the way it is perceived, and our awareness of the finiteness of our own lifetime play an essential role. Intertemporal decisions are also made collectively, for instance by governments, institutions, and organizations at the local, national, and international levels in all fields of action, including social, political, economic, financial, and environmental, in which case they have a much broader influence on sustainability. Choosing to obtain valuable sustainable benefits that are distant in time and having the patience to wait for them, rather than gain
immediate access to unsustainable benefits now, is one of the hardest exercises for human willpower.

Most analyses of intertemporal choice in the context of economics are based on the model of discounted utility, where it is assumed that people assess the gains and losses resulting from intertemporal choices in accordance with an exponential time-discounting law, just as the financial markets assess gains and losses over time. This model implies a rate of time preference or time discounting rate independent of time. Deviations from the discounted utility model are often interpreted in neoclassical economics as anomalous patterns of economic behaviour. However, the rate at which people discount future rewards is not constant but declines with the length of the delay.

The rate of time preference is an important characteristic of operative social time. People who have a high rate of time preference tend to favour their interests and well-being more in the present or very short term, while people who have a low rate of time preference assign relatively greater importance to their interests and well-being in a more distant future. It is argued that the tendency for an increase in the rate of time preference that has been documented in various domains, such as eating habits, personal savings, and consumer habits, is likely to have its origin in the acceleration of operative social time associated with modernity, and more recently with the current economic and financial model centred on fostering consumerism.

Economic intertemporal choices are determined by the time-discounting rate that makes it possible to convert cost and benefit flows with a future economic value into the equivalent value in the present. There are a wide range of economically important projects and plans for which the most suitable time-discounting rate needs to be determined. On the one hand, there are private, corporate projects that are generally short in duration, lasting less than one social generation, and social projects, which are often run by governments or private funding organizations that frequently have time frames spanning several social generations. Thus, there is a need to calculate corporate and social rates of time discounting. In general, corporate rates are higher than social rates because people are most interested in their prosperity, well-being, and quality of life in the short term of their lives and are more averse to risk during their lifetimes, while society as a whole tends to have a time horizon that reaches further into the future over the medium and long term. The value chosen for the social discounting rate is systematically used in public policy and governance to calculate the amount of future investment in health, education, research, and development, as well as investment in protecting the environment, achieving the sustainable use of natural resources, and combating climate change, which implies that it is an instrument for intergenerational equity and justice.

In Ramsey’s theory of optimal long-term economic growth based on a constant social time discount rate, time discounting results from expectations of perpetual economic growth based on scientific and technological progress. In a world where future generations will certainly benefit from growing economic prosperity, current utilities will gradually lose their capacity to attract and satisfy. The search for the compatibility between the principles of intergenerational justice and economic intertemporal choices has led to the development of several utility optimisation criteria and models, such as the discounted utilitarianism model. There are numerous studies that attempt
to adapt the current economic system to deal with long-term issues by way of models for calculating social discount rates in the intergenerational context. A constant social time discount rate overly devalues what will happen in the distant future. The use of social time discount rates that fall over time, or soft discounting, in long-term public policy is better adapted to the present uncertainty about the future.

Climate change intergenerational justice is especially sensitive to the value chosen for the social time discount rate used in investing in climate change mitigation, a choice that has generated long and unresolved controversies. A high discount rate corresponds to a low social cost of carbon and implies that there is not much need to mitigate climate change now because future generations will have better ways to deal with the problem with the help of forthcoming technological progress. A low discount rate is favoured by ethical considerations of intergenerational justice based on the severity of the future impacts of unmitigated climate change.

The importance of time has increased very quickly since the beginning of the 16th century, with the firm resolve to measure physical time and to use clock time to regulate transport and progressively everyday life. Operative social time gained more economic and financial value and the temporal resolution of the operative time structure increased significantly. Modernity is to a large extent the history of time.

With the theory of relativity the concept of physical time evolved away from Newton’s absolute time and became disconnected from psychological time. But technology ensures that relativistic physical time is also relevant in everyday life, although in a much more subtle way. Atomic clocks in GPS satellite run fast by on average roughly 38,000 nanoseconds per day relative to atomic clocks on the ground, and this is incompatible with the precision required by a GPS positioning system. This time dilation is a relativistic effect resulting from the relative speed of satellites to atomic clocks on the ground and from the fact that the atomic clocks on satellites are located at a greater distance from the Earth’s centre, where the Earth’s gravitational field is weaker. If this time difference were not continually corrected, the GPS system would become useless. This is an example of a technological application that depends on scientific knowledge in ways that are disregarded by the end users. There are many other examples in our operative social time where science slips into the background and is devalued. This devaluation may convince people that it is possible to preselect whatever in science is useful for their own interests and negate or omit whatever is unfavourable for them. That is dangerous because science is a coherent structure built by the scientific method, whose conclusions and predictions are universal and potentially falsifiable. If one accepts the narrative of science, one has to accept all its outcomes with impartiality.

Physical time, like all the other concepts of time, is an inexhaustible source of new ideas and knowledge. It retains the same mystery and elusiveness that it had when the Sumerians, Egyptians, Chinese, and others started to invent devices to measure it. Our knowledge has evolved remarkably and we are now reaching a point in which the incompatibilities between quantum mechanics and the theory of relativity are becoming clearer and require a solution, especially as regards time. The problem of non-locality associated with quantum entanglement is that it apparently clashes with the theory of relativity because the instantaneous connectivity between particles
separated in space is incompatible with the speed of light being the maximum speed at which matter and all forms of information can travel. Up until now, it has been possible to include the theory of relativity in quantum mechanics by making quantum mechanics covariant, but what probably needs to be done is to start with relativistic spacetime and find a way to include quantum mechanics in it. This program will probably involve the discovery of a new structure of spacetime that includes the possibility of retrocausality. There is going to be an end to physical time which entails also an end to all other facets of time.

It is impossible to retrace the steps in the development of human lifetime awareness and how life became an element of operative social time. Nevertheless, we may attempt to glimpse the initial forms of that awareness by observing how chimpanzees, bonobos, and other animals behave when they face the death of a member of their group. In the case of *Homo sapiens*, a possible conjecture is that the awareness of the finiteness of life and all its psychological consequences started to evolve more rapidly with the emergence of symbolic thought and spoken language acquired about 100,000 years before present (BP). Probably the main defence that was developed against death anxiety were some primitive forms of repression and denial. The denial of death became progressively one of the most powerful expressions of the psychological ego’s defence mechanism of denial. Nowadays, denialism is a fairly common form of psychological strategy that is unconsciously used to protect from the feelings of anxiety which arise because we feel threatened by very diverse risks.

Humans have been affected by many catastrophes since prehistoric times. At present we are continually confronted with catastrophic risks, which can be regional or global. The former include natural disaster risks, such as floods, droughts, tropical cyclones, intense extra-tropical storms, earthquakes, tsunamis, volcanic eruptions, and socioeconomic and technological risks such as regional famines, epidemics, terrorism, large migrations, wars, and potential regional effects of ill-judged application of the emerging technologies. Global catastrophic risks seriously threaten the well-being and economic prosperity of humankind on a global scale and are considerably more challenging because their mitigation depends on the cooperative and coordinated response of all the countries affected. Global catastrophic risks can be natural, such as large asteroid collisions, supervolcanoes, and natural pandemic diseases. They can also be anthropogenic, such as a generalized nuclear war followed by a nuclear winter, accidental or engineered misuse of emerging technologies, such as nanotechnology or artificial intelligence, engineered pandemic diseases, extreme anthropogenic climate change, climate geoengineering impacts that result from the failure to countervail anthropogenic climate change, undetermined forms of global ecological collapse, critical transitions in the biosphere, extreme consequences from overexploitation of natural resources coupled with increasing demand, worldwide social and political disruption and tyrannies, and severe global economic crises generated by the inner workings of the current economic and financial system, by an escalating trade war, or by concurrence with the preceding drivers of risk.

Some of these global catastrophic risks, because they can be perceived as having the potential to imperil humankind in a long-lasting or even irreversible way, are called existential risks. It is important to realize that there are unknown catastrophic
risks that do not fit entirely into the preceding list and also that may be perceived as existential risks. An increasingly common way to react to the anxiety generated by global anthropogenic catastrophic risks is to understate or deny them, or to defer actions that would reduce the risks.

The oldest known records of the human awareness of the transition from life to an afterlife is the use of graves by *Homo sapiens* from the Middle Palaeolithic period, about 80,000 to 100,000 years BP, already reflecting the emotional importance of the person who died. Evidence for the use of graves by *Homo neanderthalensis* is rare and up to now has appeared only at the end of their existence, about 50,000 years BP, at a time when miscegenation between Neanderthals and humans probably began.

The study of the development of myths, the symbolic narratives about the origins, nature, and future of the world and humans, is a way to decipher the evolution of the concept of time. According to Michael Witzel, world mythology systems can be divided into two main groups: the Laurasian group, which includes mythologies from North Africa, Eurasia, and the Americas, and the Gondwanan group, which includes mythologies from Sub-Saharan Africa, the Andaman Islands, Papua New Guinea, and Australia. While the former group of myths has a structured narrative in which the Universe has a beginning and includes the origins and development of the human presence within it, most Gondwanan mythologies describe a timeless Universe without a well-defined beginning, in which the emergence of humans and their forms of cultural expression happens through a forest of tales unrelated in time. Over the last 3000 years, many of the characteristics that distinguish Laurasian mythologies have been adopted and reformulated by some of the major world religions, especially Zoroastrianism, Judaism, Christianity, and Islam. The Abrahamic religions replaced Laurasian polytheism with a monotheist framework, but retained the linear time narrative of a Universe created by God and a final demise with the promise of a paradise. In all these narratives, the element of operative time of the human life became a metaphor for the element of operative time of the Universe.

The records left by the ancient civilisations enable us to retrace the evolution and increasing complexity of the concepts of life and afterlife. Egyptians were fascinated by the enigma of the end of life from the very beginnings of their civilisation, and they constantly sought to reinterpret and revere it. This essential concern can be seen in all aspects of social, political, and religious life and, above all, in the funeral rituals and in their tombs, which they called “Houses of Eternity”. The latter ranged from the simplest mastaba to the Pyramid of Khufu. According to Hecataeus of Abdera, a Pyrrhonist philosopher who was active in the 4th century B.C., the Egyptians gave the time they spent living very low value and called the houses for the living “dosshouses”. They placed “the most value on the time after death, during which the memory of virtue will preserve them” (Assmann 1984). Especially in the Old Kingdom, the Houses of Eternity and the temples were usually built in stone or were cut in the rock, while the houses and palaces of the Pharaohs were built in air-dried loam bricks.

The Dharmic religions of the Indian subcontinent developed more complex concepts of life and the afterlife by introducing a cyclic and a cosmic dimension, where the identity or soul of each human being, of each animal or plant, of each stone, river,
or mountain is equally valued. The Abrahamic religions are structured in belief systems that encourage humans to follow the right path towards salvation along a linear and unrepeatable time, while in Dharmic religions, humans are invited to accept a much more complex and contradictory world, where life is dominated by continuous cycles of birth, life, death, and rebirth until one reaches some form of deliverance.

Faced with the impossibility of achieving immortality, humans, after the beginning of the triumphal development of modern science and technology that started about 1820, have become increasingly accustomed to rely on both to extend healthy life expectancy as much as possible. Absolute immortality goes beyond the framework of biological life as we know it on Earth. Conditional immortality or ammortality, a situation in which the organism’s lifetime is not limited by ageing or by disease, but can potentially terminate due to an unavoidable external cause, is compatible with biology. Most humans strive to reach ammortality but they reserve the concept of eternity for the realm of religion. Eternity may be the quality of that which is outside time (timelessness) or the property of lasting forever (everlastingness). The latter meaning implies an infinite time and is therefore unrelated to physical time.

Unicellular organisms have a form of conditional immortality because the original organism reproduces through cell division to produce clones that only stop living if they are destroyed by an accidental external factor. The new cells produced in binary fission are not exact copies of the parent cell because the division process generates malformations, which accumulate in the proteins. However, the situation is very different in multicellular organisms that are subject to a programmed aging process at cellular level or apoptosis, which eventually leads to death. The differentiation between germ cells and somatic cells is ultimately responsible for the ageing processes. The fact that the separation of these two types of cells takes place at the start of the embryo’s growth ensures that genetic or regulatory modifications in somatic cells that occur during the development process do not have consequences for the cells involved in the sexual reproduction.

Sexual reproduction provides evolutionary advantages because it leads to a greater genetic diversity and therefore higher adaptive capacity in a continually changing environment. There is a trade-off between the much more advanced capacity for evolution and diversification of species provided by sexual reproduction, leading to an enormous range of increasingly complex organisms including intelligent beings, and ageing followed by death. It is a small price to pay for the remarkable human capacities, but also one that is deeply perturbing and conditions life.

We are still far from fully understanding the cellular, genetic, and molecular processes that lead to ageing, and, in particular, the reasons why multicellular organisms have quite different lifespans. Ageing is mostly the result of an accumulation of somatic damage caused by the organism’s decreasing investment in maintaining and repairing DNA. Longevity is regulated by a range of genes that control maintenance and repair actions. Nature’s strategy has been to allow this damage to accumulate without being duly repaired, which inexorably leads to the decline and death of the organism. On the other hand, it has invested in the renewed vigour and adaptation capacity brought by descendants generated through sexual reproduction.
But nature’s pursuit of survival is unbounded. Some multicellular organisms have devised ways to circumvent apoptosis to keep alive. The jellyfish *Turritopsis dohrnii* and some other cnidarian species reproduce sexually through fertilisation of eggs in the marine aquatic environment to generate larvae that swim freely and then attach themselves to the seabed and produce a colony of polyps that eventually detach themselves to become adult jellyfish. However, if the jellyfish faces adverse environmental factors or senescence, it can invert its development process and return to the juvenile benthic polyp stage. The jellyfish is capable of ontogeny reversal using a process of cellular transdifferentiation to return to its juvenile form, a cycle which, by being repeated indefinitely, delivers conditional immortality.

Humans are unable to use inverted metamorphosis but try to prolong their lives with the help of medicine and the most advanced science and technology. This situation coupled with the weakening belief that human life is an unalienable gift from God has changed the way people deal with death, making euthanasia increasingly popular, especially in countries with advanced economies.

### 8.2 Origins of *Homo Sapiens* Time and the Acceleration of Time

The emergence of the *Homo* genus, 3 to 2 million years BP, and the emergence of *Homo sapiens* much later, 3 to 2 hundred thousand years BP, is a perennial subject of fascination. What circumstances led to it in the context of the Darwinian evolution of primates? What are the essential characteristics of our biological species? Does unravelling our deep past and inquiring about its main drivers tells us something about our future? Is there an essential coherence within *Homo sapiens* time?

A first crucial aspect of our evolution is that primates found their adaptive niche in trees. Statistical methods applied to a model of speciation and molecular-clock studies indicate that primates started to diverge from other mammals around 81.5 million years BP in the Late Cretaceous. The oldest known fossil of a primate lived more recently, about 55 million years BP, and was an early member of the tarsier lineage named *Archicebus achilles* (Ni et al. 2013). It was a very small tree-dwelling animal weighing about 20–30 grams that lived in the tropical forests of China.

The early primates had three major characteristics that resulted from their adaptation to arboreal living: hands and feet adapted to life in the trees, with nails instead of claws; front-facing stereoscopic vision in which the images provided by each eye overlap, resulting in the capacity for depth perception; and a higher level of encephalisation, the relationship between brain mass and the animal’s body mass, compared to other families of animals. These characteristics were the result of adaptation to the increased diversity of forests of angiosperms during the Upper Cretaceous and interestingly the latter would later became critical for the *Homo* genus. Front-facing vision made it easier to locate and consume insects and small plant elements, particularly the fruit which was becoming abundant and diverse at the time.
Angiosperms, plants with flowers and fruit, emerged about 160 million years BP, and dispersed quickly across continents, overtaking forests of conifers, dominating global flora and becoming a great evolutionary conquest. Their flowers have the crucial advantage of allowing animals to participate and facilitate the reproduction process, the success of which is the central aim of Darwinian evolution. Thus the evolution of our primate ancestors is inextricably linked with flowering trees.

The second crucial development in the history of our prehistoric ancestors is the long-term global climate change initiated after the Eocene Climatic Optimum, 54–48 million years BP, when the mean global temperature of the atmosphere peaked at values about 9–14 °C higher than today. There were no polar ice caps and the atmospheric CO₂ concentration was likely higher than 1000 ppmv. After that time, the Earth’s climate started to cool, changing from a greenhouse to an icehouse in about 50 million years. Instead of being continuous, the cooling was quite complex, showing various oscillations on time-scales of a few million years.

The cooling trend had its origin in the lithosphere through a reduction in magmatic activity and in tectonic plate movements that reduced the global heat transport by ocean currents from the equatorial regions to the high latitudes. Large ice sheets started to form in Antarctica at about 34 million years BP but only about 3 million years BP in the Arctic. All living species were forced to adapt to these changes, which implied significant and long-lasting impacts on their evolution strategies. Some evolved through an adaptive radiation where organisms diversify rapidly to take advantage of the new environmental niches created by the changing climate. An interesting example is the radiation of mammals during the Eocene Climatic Optimum into two new orders: Artiodactyla, which includes the pig, oxen, sheep, and goats, and Perissodactyla, which includes the horse and donkey, all animals that were much later on domesticated by humans. Plants adapted to the colder and drier climate by the development of grasslands dominated by Gramineae at the expense of a reduction of forested areas.

The increasing seasonality and loss of forest habitats resulting from the cooling climate implied that, at the end of the Miocene, about 10 million years BP, apes became extinct in Eurasia and restricted to Africa. The first fossils of bipedal hominins that have been found in Africa are from the late Miocene, about 7 million BP, while during the Pliocene, hominins experienced an adaptive radiation. At the end of the Pliocene, about 3 million years BP, the global climate suffered a new transition becoming cooler, drier, and more variable, progressively dominated by the Milankovitch cycles (see Fig. 3.4), as a result of the formation of ice sheets in the northern hemisphere. The emergence of the Homo genus occurs precisely at this time when the hominins had to adapt to a more adverse and challenging climate, which was responsible for replacing large swaths of forest by grasslands and savannahs, with open spaces where it was difficult to compete in the search for food. This adaptation is very likely to have benefited from the intensive encephalisation that is one of the most distinctive morphological features in the evolution of the Homo genus. This implies that global climate change played an important role in the emergence of the Homo genus and consequently of Homo sapiens. Adaptation to the arrival of
a more adverse climate benefited from the enhanced complexity of social intragroup and intergroup relations and strategies.

Fossil records indicate that *Homo sapiens* emerged in Africa and until recently it was thought that they appeared in East Africa around 200,000 years ago. However, fossils of individuals morphologically very close to *Homo sapiens*, dated to 315,000 years BP, were discovered in Morocco, North Africa, in 2017. It is more likely that present-day *Homo sapiens* results from interbreeding between human groups across Africa that emerged in different locations and were linked by migrations. Interestingly, 315,000 years BP was a time close to the third interglacial period before the present one, the Holocene, when the global climate was warmer and wetter and the Sahara had rivers, lakes, and savannah. It is very likely that global climate changes associated with the approximately 100,000 year cycle of glacial and interglacial periods influenced human dispersal and evolution in Africa and elsewhere. Studies based on the analysis of maternal L0 mitochondrial DNA have indicated that the primordial population of *Homo sapiens* had its origin about 200,000 years BP in southern Africa in a region that is now northern Botswana and migrated during the last interglacial period 130,000–110,000 years BP because the increased humidity opened green corridors to the northeast and to the southeast (Chan et al. 2019).

There is much that remains unknown about the origins of *Homo sapiens* and about the influence the climate had on its evolution, migrations, and global dispersal. One of the biggest challenges is to correlate the global climate change data with terrestrial records of climate change at the local and regional level where hominin fossils are found.

In the Holocene, and particularly during the historical period, it is less difficult to reconstruct the effect of climate changes on human activities and development. Africa is a revealing example because of the records left by the Egyptian civilization. It is well known that the intensity of the monsoon in Africa varies with a 26,000 year cycle associated with the precession of the Earth’s axis. Due to this motion, the monsoon was intense in the period 11,000–6000 years BP and most of the Sahara desert was transformed into a savannah. However, 5500–6000 years BP, the wet period ended and the Sahara returned to being a desert in just 1000 years. This climate change was likely to have caused the migration of people that lived in the Sahara to the Nile valley, where they would later develop the Egyptian civilisation. The same climate event affected other regions and contributed to the collapse of the Ubaid culture, the first stage of the Sumer civilisation, which lasted from c. 8500 to 5800 years BP in Mesopotamia and was replaced by the Uruk culture, a more evolved stage of the same civilisation.

Later, around 4200 years BP, a new climate event, which has little known origins, produced droughts in various regions of the world with impacts that are relatively well documented since various civilizations had already appeared. In Egypt, around the year 2150 BC, and for two or three decades, the Nile floods fell drastically, sands invaded part of the river valley, the Faiyum Oasis dried up, the soils of the delta deteriorated, and famine spread throughout the country, paralysing the political institutions and sowing chaos. After some time, the reaction to the deep social and economic crisis was the emergence of a new political vision characterised by greater sensitivity
to social issues, mercy, and compassion. It was probably one of the first instances in history where a strong government based on a highly centralised hierarchy, adopted, albeit in an embryonic way, social concepts of equality that involved the pharaoh protecting the weakest and poorest in society, especially in times of adversity. The droughts that occurred about 4200 years BP also contributed to the fall of the Akkadian Empire in Mesopotamia, the decline of the Harappan civilisation in the Indus valley, the disappearance of the Liangzhu Culture in China, and the emergence of the Motillas Culture in Central Spain. There are many other examples of climate influencing the rise and fall of civilizations, such as the end of the Classic Maya in Central America between 750 and 900 AD. In all the above cases there were certainly various non-physical factors that contributed to the civilizational upheavals, but climate was surely one of the drivers.

A crucial process in Homo sapiens time was the development of symbolic representation. Symbolic representation in the form of writing, visual arts, and all types of digital visual communication is so much taken for granted nowadays that we tend to forget the time when humans had yet to create it. Symbolic representation is one of the most important building processes of operative social time and especially of multigenerational operative social time because of its capacity to promote intergenerational communication. The oldest consistent records that we have of symbolic representation are engraved ochre stones and an engraved bone dated between 100,000 and 70,000 years BP, found in the Blombos Cave in the southern tip of South Africa, near Cape Agulhas. The collection of human artefacts found in the cave is very rich and includes also beads made from shells, bone instruments, and stone tools that are very advanced for the time. All these items are probably the first visible signs of symbolic thought and a proxy for the emergence of the capacity for spoken language in humans. The next step in symbolic representation is the representation of figures of therianthropes and animals interacting, dating from the Upper Palaeolithic, 43,900 years BP, found in a cave in the island of Sulawesi in Indonesia (Aubert et al. 2019), and the more recent figurative representations found in Eurasian caves dating from about 40,000 years BP onwards. We will never fully understand the symbolic meaning of the parietal art that began to flourish in Europe, from the Urals to the Iberian Peninsula, about 37,000 years BP. Nevertheless, we understand that it had a social purpose and represented a world view that was transmitted to successive social generations over about 22,000 years, shaping a multigenerational operative social time identifiable by that cultural canon. During those 22,000 years, there were evolutions in stone tool technology, hunting and fishing implements, adornments, and probably in many other human activities, but the essential characteristics of rock art remained the same.

Later, time began to accelerate with the Agricultural Revolution which began in five independent centres of domestication in the early Holocene epoch—the Near East, China, southwestern Mexico, northwestern South America, and southwestern Amazonia (Lombardo et al. 2020)—and operative social time changed profoundly. With the development of agriculture based on the domestication and use of some plants and animals, food surpluses were generated, part of the population was freed from strictly agricultural activity, and a social process of division of labour began,
which created an increasing specialisation of human activities, new occupations and professions, and, eventually, new forms of social stratification. Division of labour increased efficiency in the production of goods and services in the agricultural society, and it created more opportunities to develop new technologies. In turn, these technologies helped boost efficiency and diversity in the production of goods and services. Such processes, many of which were amplified by positive feedback, created surpluses of different types—not only food—and therefore greater wealth that was distributed in society according to the relative power of the various social actors and groups, creating further inequalities.

The Agricultural Revolution represents the beginning of a process that led to the main ancient civilisations, in which the most diverse technologies were discovered, where mathematics, philosophy, and primordial forms of the natural and social sciences began to flourish. The abundance created by the Agricultural Revolution enabled the remarkable development of the arts: architecture, visual arts, theatre, dance, music, literature, and poetry. The same abundance eventually led to an increase in human population, to the militarisation of societies, to wars and large scale battles, and later on to widespread degradation of the environment and the overexploitation of natural resources. After the Industrial Revolution, the latter trends became more serious and climate change emerged.

Since the Agricultural Revolution, humanity has become accustomed to surpluses in the production of goods and has been able to use them to increase the power of a few powerful groups in society, but also to increase economic prosperity, well-being, and quality of life for a large part of the human population. All these changes have exacerbated the expression of some essential traits of human nature that have been present since the beginning of *Homo sapiens* time. Social stratification and the resulting social and economic inequalities were strongly present in hunter–gatherer societies, but the surpluses created by increased productivity in the Agricultural Revolution opened new corridors for the intensification and diversification of inequalities.

The Agricultural Revolution created the possibility of experiencing increasingly differentiated and luxurious lifestyles, new opportunities for social mobility, professional diversification, unlimited enrichment, rapid ascent to power and political power over increasingly larger populations, huge military victories, large land conquests, and lucrative pillaging. We may curb the impulses that drive us to indulge in individual or collective behaviours that are damaging to society, but we cannot suppress them. We will have to go on learning to live with them until the end of *Homo sapiens* time.

The Industrial Revolution that emerged in Great Britain in the 18th century immensely increased efficiency in the production of goods and services by mechanisation in the new factory system that gradually replaced the domestic system. This transition to the intensive use of machines was made possible by the ability to convert the chemical energy of coal into mechanical energy, provided by James Watt’s steam engine, but it implied a much bigger energy consumption per capita. Between 1820 and 2017 the diversification and global expansion of this chain of processes meant that the world energy annual consumption per capita rose roughly from 21 to 77 GJ (1 GJ = 10^9 J). The greater supply of goods and services induced population growth
and increased consumption of goods and services, leading to a significant increase in GDP. During the same period 1820–2017, the world population increased by a factor of 7.1, and world GDP at constant prices and per capita increased by a factor of 14.2, although in a highly unequal way between different regions and countries. The success of the new development model depends critically on the availability of increasing supplies of energy and continuous economic growth.

The Industrial Revolution, modern science and technology, and the extraordinary growth of economies all over the world promoted by capitalism has produced a vast range of social, political, ethical, and cultural changes. Family relations, class structure, and society have been reformed, gender equality has become accessible and improved significantly, a large part of the rural population has moved to cities, leading to the global phenomenon of urbanisation, extreme poverty has been progressively eradicated across the globe, and mobility has increased, considerably facilitating contact between people with different cultural, political, and religious backgrounds. Migration, segregation, and integration issues have become increasingly important. A growing number of countries have adopted democratic forms of government, human rights have been proclaimed and applied to a growing part of humankind. Democracy, economics, and demographics are core issues now and especially for the future. Natural resources, environment, climate change, and sustainability have become emerging issues, embarrassing and often controversial.

One of the prices that humankind had to pay to benefit from the successes of the Industrial Revolution was the overwhelming increase in the power of time. The prototypes of current operative social time structures were the assembly lines of the first factories of the Industrial Revolution. Division of labour in production forced the introduction of strict working hours that all workers had to follow. If some did not comply with them, it had a multiplicative effect on the assembly line and reduced production per unit of time, i.e., it reduced labour productivity, leading down the line to reduced profits. First factories and then schools, hospitals, public administration, and trade all adopted working hours that had to be followed rigorously. The town itself began to operate as a metaphor for the public clock installed in the church bell tower or in the clock tower. An ever increasing number of people adopted the belief that one should not “waste time”, but instead make full use of every minute or else some irretrievable opportunity might be lost.

As the Industrial Revolution progressed people were immersed in an increasing density of experiences, perceptions, feelings, actions, activities, commitments, deadlines, events, and all sorts of changes per unit time, which amounts to an acceleration of operative social time. In other words, the tempo of life has been ever increasing since then, except in a few very abnormal periods, such as in the confinement period of the 2020 COVID-19 pandemic. This acceleration is closely linked to increases in speed in the most diverse activities: in human performance, in all lines of business and professional activity, in all three economic sectors—extracting raw materials, processing them into products, and providing goods and services—, in the communication of all kinds of news through news media and social media, in the access to information and knowledge, and in all forms of transportation and travel. On longer temporal and spatial scales, it relates to a faster pace of social, cultural, political,
economic, and technological changes, and finally to the acceleration of historical time. In the past, the time scale for decisive societal changes was generally longer than human lives, so adaptation to change often took place over several generations. Currently, the time scale for change is frequently shorter than a human lifetime, so this requires training for constant adaptation throughout one’s life.

Time plays a crucial role in the way humankind deals with the highly disruptive impacts that the contemporary financial and economic system, based as it is on ever increasing consumerism, has on the environment and on natural resources. The events, activities, experiences, and expectations experienced, shared, and communicated in the social context, which structure one’s operative social time, are mostly located within the element of operative time of one’s own life. The central role played by this element of operative time, our own lifetime, is in fact a form of time discounting and is characterized by the personally adopted rate of time discount. What is thought will happen to human societies and to the environment beyond each of our own lives, whether they are expectations, forecasts, or projections based on scenarios, has a much lower value than what is expected or imagined will happen during our lives. In the latter case, events and situations have a direct personal value, whereas in the former they have only an indirect value based on different forms of family and social solidarity, involving our descendants, other members of the family, friends, and people who are from the same area or nationality, and also on solidarity with humankind considered as a whole, in some infrequent cases. Naturally, all forms of solidarity tend to disappear as we imagine social generations in a progressively more distant future.

The problem is that the biogeophysical subsystems of the Earth system where anthropogenic interference is creating human risks have a response time that is much longer than the human life expectancy. From a human point of view, it is very different if we can foresee that a risk will manifest itself severely in the coming hours, days, and months, or in the next few decades or centuries. In the former case, we are faced with a risk associated to an event that, if it takes place, is very likely to affect us and our family. In this situation, the response to the risk is driven by an instinct for survival and to protect our lives and the lives of those who are close to us and that we especially care for. We share our concern with all those who are subjected to the same risk and we are willing to help them. The situation changes when the risk only becomes severe in the long term, for example, in time horizons of 50, 100, or more years, as is the case for very severe anthropogenic climate change. In this case, the harmful impacts make relatively slow progress, leading people to believe that they are unlikely to significantly affect their own lives, well-being, or economic prosperity. However, future generations, including our descendants, will very probably be more severely affected. The justification for acting in the present to reduce future risk in the long term is no longer our own survival, but solidarity between generations, which is an ethical and moral issue.
8.3 Science, Progress, and Economic Growth

The second half of the 18th century, when the Industrial Revolution was beginning to emerge, was a very productive time from the conceptual point of view. Jacques Turgot and Nicolas de Condorcet, both of whom were Encyclopaedists, were the first to analyse and explicitly advocate the idea of progress. In 1750, in his *Discours sur le progrès successifs de l'esprit humain*, Turgot said: “The total mass of the human race, by alternating between calm and agitation, good and bad, marches always, however slowly, towards greater perfection.” He acknowledged that progress in the sense of human perfectibility is not continuous, or the same for all, but was statistical in nature, as we would say today. Turgot had a linear concept of historical time in which the human race, like an individual, advances from its infancy towards greater perfection, opposed to the cyclical “time of nature”.

Condorcet, a protégé and close friend of Turgot, was the main promoter of the ideology of progress in his famous *L'esquisse d'un tableau historique des progrès de l'esprit humain*, written under dramatic circumstances, precisely when history started to seriously question the hopes of the Encyclopaedists. The book constitutes a formulation of the ideology of progress within the framework of an historical analysis and reveals Condorcet’s unbreakable belief in the perfectibility of man. For Condorcet, human perfectibility could always be surpassed and had only physical limits. In fact, he wrote that “the perfectibility of man is absolutely indefinite; that the progress of this perfectibility, henceforth above the control of every power that would impede it, has no other limit than the duration of the globe upon which nature has placed us”. Condorcet’s belief was that progress could be planned and secured across the whole world by using reason, developing the sciences, perfecting moral ideas, and implementing human rights. In fact, more than 200 years later, a large segment of humankind in various regions of the world still live in a mental framework comparable to those of pre-Enlightenment times. Claude Lévi-Strauss, the French anthropologist, who worked among indigenous groups in Brazil, noted that the word “anthropology” should be changed to “entropology”—the study of the homogenization of human life around the world. In this sense, Condorcet’s plan for progress is the ultimate and definitive step in entropology.

Louis de Bonald, a contemporaneous critic of Condorcet, continued to defend the apocalyptic salvation announced by Catholicism and believed that science was usurping it, forgetting the brutal, everlasting realities of passion, conflict, and human violence. Thomas Malthus preferred to stress the idea that no matter what, misery was an integral and unstoppable part of societies, stating that “no possible form of society could prevent the almost constant action of misery upon a great part of humankind, if in a state of inequality, and upon all, if all were equal”. David Hume was less categorical about progress, pointing out that the mutual dependence of political and intellectual development implied that progress would require political stability.

In spite of the criticisms and different points of view of many thinkers such as Kant, Schopenhauer, Marx, Engels, and Nietzsche, the ideology of progress based on the principles of the Enlightenment and liberated from religious constraints has
been increasingly adopted and the belief that modern times are clearly superior to previous ones has been encouraged and widely accepted. People began to be convinced that historical time is changeable and that an evolution towards a better future driven by progress can be achieved. Before, historical time was relatively slow because horizons of expectation were very limited. The main expectation about the future was eschatological and it consisted of an apocalyptic prediction of the Last Judgement. The better future promised by progress came associated with an acceleration of time. Since the beginning of the 19th century, the acceleration of time has intensified, pushed forward by economic growth based on the growing supply of accessible energy and expanding commodity markets, greater scientific knowledge, and growing technological innovation.

In Judeo-Christian religious doctrines, historical time is linear, irreversible, and finite because there will be a final day after which the chosen will receive the eternal joy for which man was created. With the modern faith in progress, historical time has remained linear and is supposed to lead progressively to ever better times, but now with the condition that its irreversibility must be guaranteed by human actions. In other words, humans must actively and continuously engage in the generation of progress.

How do these two perspectives of historical time blend with the narrative of science? The first one is outside the narrative of science because it relies on a salvation action at the end of time by supernatural powers whose existence the scientific method has been unable to prove. However, those that believe in or practise the scientific method in their professions and accept the narrative of science may also believe in the historical time perspective offered by the Judeo-Christian doctrines or in historical time perspectives offered by other religions. The belief in God and in other supernatural beings continues to be strongly rooted either as faith or in a subconscious way, and plays a vital role in the minds of people from the contemporaneous social generation. Some consider that this belief is in contradiction with the methodology of science but contradictions are one of the most essential and powerful drivers of *Homo sapiens* time, although we don’t like to acknowledge that we entertain them. Contradictions inhabit the human mind and may be a source of creativity. In classical logic, they must be eradicated, but in everyday life they constitute a vehicle to interpret the absurdity and nonsense that one often finds in the world and in one’s personal experiences. Although permanent consistency is not part of our nature, contradictions are potentially dangerous.

Blending the second perspective of historical time with the science narrative should be straightforward because it originated in the recognition that science and technology coupled with the power of capitalism have the capacity to promote progress indefinitely by improving human health and well-being and raising economic prosperity. However, one finds contradictions once again. Before addressing them, one has to further analyse the concept of progress.

Progress manifests itself in different areas of human activity and takes different forms, including human, social, economic, political, ethical, and moral progress, as well as the progress of science and the progress of technology. These forms are always changing with historical time, but the arrow of operative social time
has become firmly supported by the arrow of progress. Currently, the dominant standpoint is that among all the above forms of progress there is an essential and overarching one that conditions all the others, which is economic growth, usually measured by GDP growth, at national or global level. One of the most distinctive features of contemporary operative social time is the exclusive focus on economic growth as a measure of progress. Human, ethical, and moral progress is occasionally an interesting subject for debate, but of limited practical consequence.

It has frequently been pointed out that GDP is an economic indicator that does not reflect levels of poverty and social exclusion, wealth distribution, education, and other aspects of human and social development, environmental conservation, and questions regarding sustainability, but attempts to agree and start using alternative indicators have so far failed to be put into practice. In the present economic and financial system, income distribution inequalities have been aggravated for decades by the deterioration of worker’s bargaining power and by a rise in profits as a share of total income, with the rate of return on capital being higher than the rate of economic growth. Furthermore, with the emergence of the new technologies of the Fourth Industrial Revolution, inequality is worsening because capital is becoming a frequent substitute for all but very highly skilled labour. The last four decades have witnessed a decoupling between productivity growth and employment growth in countries with advanced economies, which implies that salaries have less capacity to redistribute wealth. These new developments have led to the expansion of the gig economy, to a larger precariat, and to a distribution of wealth that may become incompatible with social inclusion and democracy, meaning that they are contrary to human, social, and political progress.

A further perturbing aspect is that the model used to secure economic progress is perpetual economic growth, which science says will eventually become incompatible with maintaining the health of the Earth’s environment, the sustainability of natural resources, and the capacity to recycle rejected material flows. The way out has been to formulate analytical models that ensure sustainable economic growth for the “intermediate run”, meaning the next 50–60 years. The reason for this preference is very simply that the operative social time of the contemporary generation is focused on its own element of operative time. What happens after should gradually become the concern of the following social generations as has happened in the past. In fact, in spite of various warnings, in particular those of the Club of Rome that started in 1972, continuous economic growth has been achieved since the 18th century, with the exception of periods of crisis.

Science, nevertheless, has been very explicit in saying that we are now rapidly approaching quantitative planetary boundaries, which when crossed, increase the risk of generating large-scale abrupt or irreversible environmental changes that will be harmful for humankind as a whole, although in differentiated ways. In fact, some of these planetary boundaries have already been crossed, such as the increasing atmospheric concentration of greenhouse gases that controls climate change, the lost integrity of the biosphere and the uncontrolled perturbation of some biogeochemical flows. The hazardous and destructive effects of this global interference are already affecting communities around the world, especially in developing countries. Science
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is saying explicitly that the present situation is not a recurrent one that *Homo sapiens* has previously encountered in his time but a truly new and exceptional one. The Earth system is now operating in a no-analogue state as regards its dynamics and functioning, which means that some environmental indicators that characterize its state have moved outside the natural ranges of variation of at least the last half a million years.

In spite of the damaging effects on human life of environmental pollution and degradation, natural resource overexploitation, the incapacity to manage and recycle the flow of waste, climate change, and scientific warnings about the future dangers of our interference with the Earth system, there is no visible political will around the world to effectively adapt the current economic and financial system at the national and global levels to the need of achieving sustainability. Furthermore, in some countries, particularly in the USA’s, conservative and libertarian circles, often associated with certain religious movements, there is an attempt to distinguish between “solid science” and “politicized science”, the latter being the one that warns about the dangers of environmental degradation and especially about climate change. Politicized science should be rejected because it hinders economic growth. Science is no longer viewed as a provider of truthful and useful evidence to inform policy but as one of the many inputs into production which can in some cases hinder profitability. Profitability is the overriding objective of the multinational corporations that free-ride the market place, supported by their respective government institutions.

The modern perspective of historical time that owes so much to science and technology has become so powerful and presumptuous that it now tends to selectively reject the advice of science. This rejection, besides being a conceptual contradiction, is a dangerous reaction of negation. It is an ominous sign that to guarantee the progress that is supposed to secure the irreversibility of modern historical time, science must be selectively rejected, especially when it addresses the present and future consequences for humankind of the anthropogenic interference on the Earth system. The tendency to refuse selectively certain scientific results and advice also manifests itself in the rejection of evidence-based policies and in spurning experts, especially when their advice is not aligned with the professed world view. Very often such world views are constructed in a process of negation or systematic misunderstanding of contemporaneous problems, a process that can be fuelled by a cultural reaction of disenchantment and anger, by economic dislocation, and by a nostalgia for the past. The systematic discrediting of experts that form the elites creates an inexhaustible supply of charlatans and is leading to the decline of democracy.

The narrative of science says that humankind is already suffering the destructive effects of the perpetual economic growth model and advises that it is highly recommendable to adapt the model to the new challenges of sustainability if humankind wants historical time to remain linear and lead to better times. By refusing to accept the narrative of science, but at the same time being forced to acknowledge external changes that are impossible to fully understand without the help of science, leads to a dangerous flourishing of conspiracy theories and to political polarization.

Climate change provides a clear example of the risks of unsustainability. It has been estimated, using a data set of 174 countries over the period 1960–2014, that
unmitigated climate change, represented by the RCP 8.5 scenario corresponding to a mean increase in average global temperature of 0.04 °C per year, will lead to reductions in global real GDP per capita of 0.8, 2.51, and 7.22% in 2030, 2050, and 2100, respectively (Kahn et al. 2019). Abiding by the Paris Agreement, represented by the RCP 2.6 scenario corresponding to a mean increase in average global temperature of 0.01 °C per year, will reduce the loss of GDP to 1.07% in 2100. Unmitigated climate change will have long-lasting adverse effects on most economic sectors, employment, and labour productivity, affecting all countries, although in differentiated ways.

A unilateral transition to a more sustainable model is unlikely, due to the extreme economic competition between countries, especially between the major economies. There is a lock-in situation regarding the present economic and financial system that is supported by the majority of the human population. The system has been very successful in convincing people that there is no other credible alternative model and that the present model is the only one that can provide well-being and economic prosperity. Economic growth will not necessarily provide further well-being and economic prosperity to a significant part of the global population, but humankind as a whole is stuck on a “treadmill” of production and consumption (Gould et al. 2004) that generates excessive environmental risks. Incremental changes to the business-as-usual models are being implemented in the framework of various national and international initiatives, in particular the UN SDGs, but the trends regarding the goals that involve natural systems continue to be negative. This failure is leading the UN SDG community and other international organizations to consider promoting transformational changes that would tackle the root causes of the present situation (Díaz et al. 2019). Another approach is to develop transition movements where communities seek to establish sustainable ecovillages and transition towns and territories. These communities have been successful in reaching their objectives at local level and constitute a good example, but the main challenge that remains is their scalability to large urban areas at national and global level.

The present status quo is likely to change slowly but progressively as successive social generations begin to feel the economic insecurity. Generation Z will mostly enter the work force at the beginning of the serious economic recession caused by the COVID-19 pandemic which began in 2020, after having already witnessed the negative impacts of the financial and economic crisis of 2008–2009. An analogous situation looks likely to be repeated for generation Alpha, the demographic cohort succeeding generation Z, with birth years in the period between the early 2010s to the mid-2020s. Generation Alpha will begin life with a greater uncertainty about the future than did generation Z or generation Y at their age. Generation Y found themselves in a worse situation than generation X as regards improving their economic prosperity relative to their parents, although they had on average a better education and better health.
8.4 Technology and Democracy

There is another crucial player in the debate about progress, which is technology. Technology is much older than science and precedes Homo sapiens time. As already mentioned, there is significant consensus that the emergence of the Homo genus was very likely a form of adaptation to a drier and colder climate that spread more savannah grasslands in some regions of Africa. This event happened at the time when the production of sharp-edged stone tools of the Oldowan culture started around 2.6 million BP. These earliest tools, which were discovered in 1964 in association with fossils looking more likely Homo than Australopithecus, reveal that those who produced them, had a good knowledge of stone-fracture mechanics and that they knew how to extract flakes from the cores of particular stones. They had learned a specific lithic technology that was going to evolve extraordinarily through the Palaeolithic, Mesolithic, and Neolithic periods, the latter beginning just 12,000 years BP. More recently, in 2015, a discovery was made near Lake Turkana in Kenya of simpler 3.3 million-year-old stone artefacts in spatiotemporal association with hominin fossils (Harmand et al. 2015). Surely, many more discoveries will be made in the future that will provide further light on the interconnectedness between the origin of the Homo genus time, the first usages of technology, and the repercussions on the African climate of a global climate change. However, it is fair to say that primitive forms of technology have been closely linked with the Homo genus from its first existence. The only remaining species of the Homo genus now firmly believes that technology will always lighten up his future and rescue him from his adventures and excesses.

Technology progressed steadily but relatively slowly from the beginning of the Neolithic up to the 16th century, with major inventions such as irrigation in Mesopotamia about 6000 BC, metallurgy, sailing, paper production, gunpowder, windmills, the mechanical clock, the oceanic carrack, and printing in 1455. Then came the Renaissance, which created the conditions at the end of the 16th century for the emergence of what we now call science, although at the time it was called natural philosophy. Scientia originally meant just knowledge and until the eighteenth century included also theology. Some of the most important contributors to the process that led to the establishment of the methodology of science up to the end of the 17th century were Leonardo da Vinci, Nicolaus Copernicus, Andreas Vesalius, Tycho Brahe, Francis Bacon, Galileo Galilei, Johannes Kepler, René Descartes, and Isaac Newton. Science, however, was practised away from society in the seclusion of observatories, laboratories, libraries, and academies, and therefore remained rather mysterious to society as a whole. The public spectacle of science began in the 18th century, in the Age of Enlightenment in the streets of several European cities, especially London and Paris. Inventors, science communicators, and enthusiasts offered demonstrations and experiments in the streets, squares, markets, and cafés that amazed an audience eager to experience new sensations, enjoy themselves, and be surprised and dazzled. There were long queues of people waiting to take part in Abbé Jean-Antoine Nollet’s
experiment, where they could experience an electric discharge, which was called a sensation scientifique.

The invention of the steam engine, which played a crucial role in the development of the Industrial Revolution, was made by Thomas Newcomen, an inventor, and perfected in the period 1763–1775 by James Watt, an inventor and instrument maker who worked as a technician in the laboratories of the University of Glasgow. So the invention did not arise from an application of what we now call scientific knowledge and information but by the successful exercise of practical mechanical skills. Only later, in 1824, did the French mechanical engineer Sidi Carnot’s (1796–1832) theoretical discussion on the efficiency of an idealized steam engine initiate the development of the science of classical thermodynamics. The invention of the steam engine was what we would call today an outstanding technological innovation, but when it occurred the word “technology” was very uncommon in Great Britain. Instead, people referred to “technics” for the useful arts as an antonym to the performing and fine arts. Only after 1820 did the word “technology” come into more frequent use, acquiring its present meaning in the second half of the 20th century, especially with the fast development of information and communications technologies (ICT).

The First Industrial Revolution was mainly characterized by the beginning of the intensive use of coal, the invention of the steam engine and other powerful new machines, such as the spinning jenny used in textile mills and the cotton engine, and the development of new technologies such as a way to make puddled iron with better properties than pig iron and the new road-building technology developed by John McAdam. The Second Industrial Revolution, which started in the latter half of the 19th century and lasted up to the beginning of the Digital Revolution, was mostly based on the use of electricity and made it possible to develop production lines in factories. It led to successive outbursts of remarkable inventions, such as the telegraph, photography, telephones, water turbines, phonographs, electric light bulbs, cinema, electric motors, dishwashers, aircraft, photoelectric cells, plastics, washing machines, television, refrigerators, antibiotics, radar, photocopiers, satellites, lasers, microwave ovens, nuclear power plants, and many others. Many of these inventions were based on modern science. It became increasingly clear that the synergy between science and technology was very creative and could be used to improve human well-being and economic prosperity.

It can also be used or developed specifically for the exercise of the darker impulses of human nature, such as violent aggression, war, human oppression and persecution, and the promotion of vice. In the military domain, the main goal of applying science and technology is simply to produce new weapons more deadly and destructive than those that one’s adversaries are able to build. In the civil domain the success of a technology depends on its capacity to render people addicted to the products it helps to produce. The range of products is unlimited, from smartphones, tablets, and SUVs to semisynthetic opioids, which have been responsible for tens of thousands of fatal overdoses annually in the USA in recent years. The addictive power of technologies is enhanced by using the most advanced techniques and the most advanced science in various domains, for instance frontier knowledge in human psychology. The countries that first benefited from the Second Industrial Revolution witnessed a
profound change in their way of life and a general improvement in the well-being of their citizens. Then the new economy and the wave of new lifestyles propagated progressively around the world. Intellectuals, writers, and philosophers tried to imagine how the world would be once it had been utterly transformed by the overwhelming power of scientific and technological progress. One of the more interesting insights is from Herbert George Wells’ non-fiction bestseller *Anticipations of the Reaction of Mechanical and Scientific Progress upon Human Life and Thought*, published in 1901. According to Wells, nation-states would disappear and be substituted by a great federation of English-speaking peoples using English as a universal language and guided by the New Republic, an educated class of unprecedented people who would influence and control the apparatus of their ostensible governments. The New Republic is reminiscent of the contemporary economic and financial elites who run the large multinational corporations and share a disproportionate part of the world’s economic, financial, and political power. Wells was also a visionary when he wrote that “the peasant of today will be represented tomorrow by the people of no account whatever, the classes of extinction, the People of the Abyss”, whom we now recognize in the precariat and the working poor, left behind by the inexorable Fourth Industrial Revolution.

Nation-states have not disappeared as Wells forecasted about 120 years ago, but the English-speaking world, comprising Great Britain, together with its former colonies and the imperial possessions of the Victorian era British Empire, and the USA, a former colony from the pre-Victorian era, is now the dominating economic and military power structure in the world. These countries do not constitute a unified nation or a federation, but they are a rather loose family that know well how to take advantage of their common language and pragmatically unite when the circumstances so require. The English-speaking peoples have been guided by the ideas of Adam Smith and uncountable followers, by the success of the First Industrial Revolution, by the early firm belief in science and technology, by utilitarianism, by the systematic adherence to parliamentary democracy, by a pragmatic rule of the Empire summarized in the motto under which the British army went to war in 1914—For God, King, and Country—, and by US exceptionalism and the inevitability of its superpower status. Their contribution to contemporary civilization is undeniable and in certain specific ways they represented the civilizational values of the West and have often assumed its leadership.

However, the world is fast transforming and there are many pressing old and new challenges that should be urgently addressed and require new solutions. The question that one may ask is whether the English-speaking world will be able and willing to lead to a safer and more sustainable world future or whether it will just be part of the problem. Various indicators point to a decline of US influence in the world. The same applies to Great Britain, which is currently dominated by an ideological impulse to move away from Europe and build a stronger English-speaking world with the USA, Australia, Canada, New Zealand, India, Malaysia, Singapore, and various countries in Africa. A further crucial issue is to identify the possible alternatives. Surely, there will be no power vacuum. There is fierce competition from China and other emergent economies to gain increasing prominence and economic
power. The European Union spends most of its energy consolidating itself, and although it constitutes a remarkable achievement, especially as regards peace, human rights, freedom of movement and residence for its citizens, scientific and cultural development, environmental protection, and an ambitious pioneering world level program of science-based sustainability, it has no superpower ambitions.

China is an old civilisation that started with the Shang dynasty in the 16th century BC, and is very proud of its identity and achievements. The country went through a painful period of decline during the Qing dynasty caused in part by the colonialism and imperialism of the Western powers and later by the intervention of Russia and Japan. That period ended with what the Chinese call the century of humiliation from 1839 to 1949. On 1 October 2019, on a high balcony overlooking Tiananmen Square, President Xi Jinping said: “On this spot, seventy years ago, Comrade Mao Zedong solemnly declared to the world the establishment of the People’s Republic of China. That great event thoroughly transformed China’s tragic fate, ending more than a century of poverty, weakness, and bullying.” There is no doubt that China wants to be the world’s strongest economic power and to surpass the West precisely in the domains that created its unsurpassable power—science and technology, the ideology of progress, and the current economic and financial system. Its primary goal is to copy and adopt the West’s flawed paradigm of perpetual economic growth. In this process it will go its own way, since China has a different culture and different values from the West, which will endure for a long time yet.

China adopted an authoritarian political system based on the communist party and wants to prove that its system is superior to Western democracies, especially as regards achieving robust economic growth and increasing the economic prosperity of its citizens. Thus China pursues the objective of patiently extending its model all over the world, just as the West used to do so vigorously in the past. Democratic values, in particular political freedom of expression and dissent, protection of minorities, diversity, and popular sovereignty are ruthlessly supressed in China. As long as the vast majority of its citizens are satisfied, finding that their expectations of well-being, increasing economic prosperity, and growing consumerism are being fulfilled, they may consider political freedoms to be a secondary issue that may be forgotten. The open-ended question is which of the two political regimes, democracy or the Chinese authoritarian regime, will be the most resilient to the recurrent crises that are occurring as a result of an unsustainable global economic and financial system. A more fundamental question is whether democracy will be able to adapt to the powerful forces that are trying to perpetuate the present system or whether it is bound to decline under such pressures. Science plays a crucial role in the elucidation of these questions and on the outcome of these ongoing processes. All political regimes that selectively negate science are likely to be less resilient to crisis. Moreover, democracies that selectively negate science tend to decline and eventually adopt authoritarian forms of government. Those political regimes that strive to maintain a thriving democracy are more likely to accept the advice of science, adopt evidence-based policies, and make a future transition to a sustainable economic and financial system. Science should be sufficient to convince humankind that it needs to reverse its course of action. If it turns out that it isn’t, humankind will learn the hard way how to reach
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sustainability. Western values will decline and authoritarian and dehumanised values will take their place, while dystopian societies will proliferate.

Various writers in the first half of the 20th century, particularly the Russian writer Yevgeny Zamyatin and the English writers Herbert Wells, Aldous Huxley and George Orwell, used dystopian novels to explore the consequences of totally ordered and controlled utopian societies, coupled to or more often created by the power of technology, which became increasingly autonomous and ruled the course of history. They were probably motivated by the hope of a change in direction and just tried to convey their concerns in an attractive way to a wide audience. Later in 1959, Martin Heidegger recognized the inevitability of the technological dominance of historical time when he wrote (Heidegger 1959):

In all areas of his existence, man will be encircled ever more tightly by the forces of technology. These forces, which everywhere and every minute claim, enchain, drag along, press and impose upon man under the form of some technological contrivance or other – these forces […] have moved long since beyond his will and have outgrown his capacity for decision.

Sixty years later Heidegger’s forecast has been entirely vindicated, but societies, especially in the advanced economies, are still not entirely convinced about the supreme admirableness of the contemporaneous model. Dystopian literature has become increasingly popular in the past few decades, particularly since the financial and economic crisis of 2008–2009, and mostly among young people, creating a whole new business for movies and merchandise. It is difficult to fully understand this tendency, but it likely reveals the need to find analogies of today’s operative social time in fictional narratives of various coherent forms of dystopia. The renewed success of such novels implies that they offer a model and possibly a foretaste for some of today’s programmatic worldviews.

The Third Industrial Revolution began in the 1960s and was mostly based on the Digital Revolution and the rapid development of ICT. The extraordinary success of digitised information communication resulted from the development by Claude Shannon of a Boolean algebra of electronic circuits that could be used to transmit any type of information electronically—documents, books, images, or music. Information theory unified the issue of communication and storage of digitised information in an increasingly diverse range of devices and technological media. Today, one can access the news, social media, online lectures, courses and meetings, music, games, videos, and films in personal computers and mobile phones. All this bounty is instantaneously and constantly accessible and has become inseparable from billions of people’s everyday lives. The internet platforms are now the map and the clock, the printing press and the typewriter, the filming and photographic camera, the calculator, telephone, sound recorder, music player, radio, and TV for billions of people. Since the 1980s, we have been witnessing a transition from the role of being a citizen to the role of being a digital citizen.

Humanity is now navigating in two parallel worlds, the physical world of the Earth system, where we live as a biological organism, and the virtual digital world of ICT, where the mind spends an increasing amount of time. The way towards the future is to integrate these parallel realms as far as possible with a wide variety of devices and
structures located at different points in physical space and virtually mapped in digital space so that we can extend our presence and power over the physical world. The relationship between physical space and time in the real-time virtual digital world is regulated by the speed of light, making it almost time-coincident with the physical world in the Earth system and in the surrounding outer space where satellites operate.

ICT digital communication and media devices are changing social interactions and the processes and structure of mental activities. Face-to-face encounters are now frequently considered to be time consuming and inefficient for many objectives. Generation Z teenagers have been using video call applications, in particular Zoom, for years and call themselves “Zoomers”. With the COVID-19 pandemic, hundreds of millions have become Zoomers by using various video platforms socially in high schools and universities and in all sorts of professional activities. Air travel will be reduced in the future, specifically for face-to-face meetings. One of the main outcomes of the COVID-19 pandemic is an increasing use of modern digitally based strategies in most fields of activity, especially in medicine.

The compulsive and irresistible use of digital devices and platforms is essentially driven by a desire for instant gratification as often and intensely as possible. One of the cognitive processes that is most affected is attentional control because the internet and social media platforms are specialized in providing information and many forms of entertainment in an unceasing atomized flow, leaving little or no time for concentration. The relatively long periods of attention fragmentation and scattering are transforming operative time structures around the world. Idleness, tedium, and solitude continue to exist but we may now have the feeling that they can be chased away by overloading time. Much more diverse experiences have been created. All were potentially possible and just needed technology’s remarkable capacity for innovation to appear, flourish, and culturally transform us. Digital information devices have broadened human private and social abilities and experiences, in particular the capacity to communicate, stay informed, be entertained, be alienated, and be exploited. Each person’s digital world has become a refuge in which virtual time and space are firmly under their control.

The Information Age and its ICT devices have produced a deep transformation in societies and in the political, economic, and financial systems of all countries, significantly contributing to the globalization process. The new global digital world, and the connectivity that provides access to it, have made it possible to improve health conditions in many regions of the globe, prevent and better manage natural disasters, boost social inclusion and cohesion, improve access to education and professional training, promote access to information, knowledge, and active citizenship, and enable civil society movements and organisations in social, political, economic, and environmental fields.

At the same time, the intensive use of digital devices is likely to change our memory and thinking habits and maybe also the way we think. There are various research studies on the subject, emphasizing either positive or negative impacts, but there is a notorious lack of scientific consensus, and positions tend to become rather polarized and emotional. The most frequent conclusion is that the effort to understand what is happening to humans is futile because there’s no going back
from the progressive atomization of our operative social time by a constant flood of
information. Probably, due to brain neuroplasticity, humans will become much better
at the modes of thinking involving surfing, skimming, scanning, and multitasking,
while some of the other modes will tend to be atrophied.

Digitalization opens up new opportunities to reach the UN’s Sustainable Devel-
opment Goals, but it can also generate risks for humankind. ICT, in cooperation with
emergent technologies and various social sciences, such as big data, data science
and artificial intelligence, psychology, political science, and marketing, have been
improving methodologies and procedures to successfully use the internet and social
media for abusive personal data collection and to disinform, misinform, manipu-
late, and deceive citizens. Authoritarian states excel in using such methods to recruit
new supporters, undermine the democratic debate, and attack and black out their
opponents. The same techniques, usually in a more sophisticated form, are also used
in democratic countries, particularly by foreign players and interests, to influence
people’s political opinions, actions, and voting intentions, using Facebook, Twitter,
and other digital platforms. An example of these emerging techniques was provided
by unacknowledged Russian government interference in the 2016 US presidential
election through the Internet Research Agency, based in Saint Petersburg, and other
institutions. The same digital means of communication are also used by corporate
interests, especially in the USA, to make an assault on specific areas of science con-
sidered by some lobbies, corporations, news media, politicians, and opinion makers
to be “politicism” science.

The internet is used today in almost all countries, democratic or non-democratic.
China has the largest online community in the world and the percentage of people
using the internet is around 60%. At the global scale, the political use of the internet
is low compared with other uses, such as online music, films, games, and sports.
In countries where there is no internet censorship, citizens are free to criticize their
country’s political institutions and leaders, exerting an increasing pressure for the
adoption of reforms. On the other hand, in non-democratic countries, citizens that
spend a large amount of time in the internet enjoying its social and entertainment
content tend to be less concerned with living under authoritarian political conditions
as long as the regime offers some measure of well-being and economic prosperity
(Stoycheff et al. 2016). The internet’s democratic potential can be boosted by build-
ing demand for internet freedom, but unregulated internet freedom is also used to
attack democracy. The access that digital platforms have to hundreds of millions of
people’s personal data, travelling movements, and political, ideological, and eco-

demic preferences, as well as other information, is a potential threat to the future of
democracy.

Digital platforms could be an instrument for actively promoting democracy, but
instead they are mostly used for optimising both individual self-interests, in the form
of online consumption of goods and services, and the profits and economic power of
the digital technological corporations, start-ups, and entrepreneurs that support them.
They are not prepared to promote human and social development and innovation.
Initiatives focused on these objectives may appear in the digital platforms, but they
remain outside their main consumer culture. Solidarity-based economic experiments
that present themselves as alternatives to the current economic and financial system have great difficulty in penetrating the digital platforms and are not considered to be sufficiently attractive or are outright rejected.

Finally, the Fourth Industrial Revolution is an extension of the third but differs from it in terms of the new opportunities and plans for automation, interoperability, the use of intelligent technical support systems, decentralised decision-making, and information exchange in production technologies for goods and services. It is marked by the development of emerging technologies and the production of new products and services. In the Fourth Revolution, information technology, which automates business and office processes, will be coupled with operational technology in the internet of things so that industrial and operating processes in factories, infrastructures, and homes can be fully automated.

The main areas of activity and emerging technologies that will support the Fourth Revolution are ICT, artificial intelligence, robotics, the internet of things, big data, additive manufacturing, including 3D printing, rapid prototyping and direct digital manufacturing, blockchain, digital cryptocurrencies, autonomous vehicles, drone technologies, precision agriculture, nanotechnology, genetic engineering, synthetic biology, and geoengineering. The new 5G technology, the fifth generation in mobile network technology, is essential for the success of the Fourth Industrial Revolution since it is designed to connect virtually everyone and everything, including people, objects, devices, offices, businesses, markets, infrastructures, and factories. By operating at a much higher frequency than the four preceding generations, 5G has faster download speeds, reduced congestion, and lower latency. The main driver behind this accelerated program is the military, economic, and technological competition between the major world powers, especially between the USA and China.

Artificial intelligence (AI) will likely come in four waves, named by the American computer scientist Kai-Fu Lee as Internet AI, Business AI, Perception AI, and Autonomous AI. With the fourth wave, machines will finally become entirely autonomous. Some hope that these machines will eventually be transformed into human-like entities with selected powers superior to those of humans, an exploit that will give their creators the unique feeling of superiority that results from overshadowing humans. Others are fully convinced that science and the emergent technologies of the Fourth Industrial Revolution will eventually deliver the unlimited extension of healthy human life, or ammortality, which fulfils a dream that is central to the human condition. Finally, other researchers are using the same tools to achieve human enhancement, superintelligence, and transhumanism. The achievement of these plans is probably far away in time, but they are moved by powerful and unquenchable dreams.

Three hundred years after the beginning of the Enlightenment, humankind continues to be fascinated by the wonders of science and technology, just as thousands of Parisians watched in amazement a balloon with flammable air floating up into the air with Jacques Charles and Nicolas-Louis Robert aboard at the Jardin des Tuileries on 1 December 1783. Now we have the International Space Station, the promise of establishing a one million strong colony on Mars, the unbelievable progress promised by AI, the hope that synthetic biology will enhance humans and make them almost
disease-free. Furthermore, they could be designed to reproduce the most popular and desirable stereotypes. This perpetual wonderment with technology has been a distinguishing characteristic of human time since the First Industrial Revolution. But besides producing feelings of awe, technology also is also useful and can solve pressing human problems such as ensuring the increase in agricultural productivity that would satisfy the food demands of more than ten billion people that are likely to inhabit the Earth by the end of the century.

AI surveillance technology is being deployed around the world to monitor and track citizens for security, economic, and political objectives, some of which are lawful while others violate human rights. Smart city and safe city platforms, smart policing, and facial recognition systems, are being fast developed in many countries, especially in China. It is estimated that in 2019 more than 75 countries out of 176 worldwide were actively using AI surveillance technologies. The social credit system that was initially promoted by private corporations in 2014 is now being used by the Chinese government to register all aspects of life to judge citizen’s behaviour and political trustworthiness. If, for instance, someone writes about censorship and government corruption, they are likely to be blacklisted and lose some rights, such as the right to buy property, make a loan, or undertake certain kinds of travel, without any previous warning or official notification. The extension of this system so that the government can control the whole population represents a frightening dystopian future.

The COVID-19 pandemic has given the opportunity for the largest extension of state power over its citizens since the Second World War, through the application of the most advanced surveillance techniques to contain the disease. The success of China, South Korea, and Taiwan in controlling the spread of the virus faster than Western countries is largely due to the digital surveillance measures adopted, in particular the technologies of contact tracing. It is well-known that states increase their power in crises. The question is: will they give it up when the crisis ends? States’ routine access to citizen’s medical and electronic records may be a consequence of the 2020 pandemic. A potentially more dangerous result of the COVID-19 pandemic and similar crises is the risk of abuse of power by political leaders, which can seriously endanger democracy, as has happened in Hungary.

States also increase their economic power in violent crises. In the USA, Congress passed an initial $2 trillion stimulus package, representing 10% of GDP, to soften the economic blow of the COVID-19 pandemic for workers and businesses. The European Central Bank created a quantitative easing (QE) program worth 750 billion euros until the end of 2020 to buy government and corporate debt from countries across the Eurozone, representing 6% of its GDP. A large number of central banks at global level announced analogous measures to protect their economies. This generalized response underscores an underlying tendency for a transition from the capitalist market economy to an economy managed by the central banks, which has been apparent since the 2008–2009 financial and economic crisis. Between the two crises there was hope for normalization of global monetary policies but it is now likely that it will take some years to abandon very low interest rates and large scale QE. “QE infinity” is now a likely outcome. The danger is that, as happened in 2008,
the liquidity is used to generate money through financial capitalism, in particular rewarding shareholders through stock-buyback schemes, instead of being directed toward good investment opportunities in the productive economy. The other danger is that while central banks must extend loans to businesses, this emergency happens at a time when the global private debt, which is the driving force behind the global debt, reached historical heights. According to a 2019 IMF report, global private debt has tripled since 1950 and the debt of the emerging economies has exceeded that of the advanced economies (IMF, 2019). Global debt has reached $184 trillion, which is equivalent to a global debt of $86,000 per capita, more than 2.5 times the mean income per capita. Global debt levels are now well above those at the time of the 2008 financial crash, which according to the IMF increases the risk of another crash.

The massive fiscal and monetary stimulus that governments and central banks have released to support their economies also shows that, in a time of crisis, the economic and financial system adopts Keynesian economics and temporarily puts aside the neoliberal roadmap. Countries that follow neoliberal economic policies, such as the USA, social democracies, particularly in Europe, and the single-party communist state in China, have all adopted the same type of large scale government spending policies. However, the prevailing system believes that robust economic growth must be rapidly reinstalled, and that can only be achieved by returning to strong neoliberal policies.

The COVID-19 pandemic confronts the emerging and developing economies with much more difficult and dramatic problems than the advanced economies. The former countries cannot replicate the solution of the latter by creating stimulus packages through massive QE. Furthermore, for hundreds of millions of people living in export-led emerging and developing economies, the loss of income due to the global economic crisis may mean severe poverty, famine, and forced migration. Advanced economies should show the utmost solidarity by announcing a stay on developing and emerging economies’ debt service. In many of these countries, if their government chooses to continue paying their foreign creditors, that will likely mean starvation for many of their citizens.

The characteristics and inner-workings of the current economic and financial system make the situation of the emerging and developing economies particularly dramatic in a deep global crisis such as the one created by the COVID-19 pandemic. The G20 nations are already committed to a moratorium on $20 billion of the private and bilateral debt of some of those countries. Furthermore, the IMF and the World Bank, supported by the G20, have pledged grants to cover debt payments and plan to issue “pandemic bonds”.

The problem is, however, that since the Bretton Woods agreements the dollar has become the world’s reserve currency, which implies that the world’s financial system is largely under the control of the Federal Reserve of the USA and functions as an instrument to secure the geopolitical supremacy of the USA. In the Bretton Woods Conference, John Maynard Keynes forcefully proposed the creation of an International Currency Union based on a new currency called bancor, but that was not accepted by the USA because it wanted to give disproportionate power to the Federal Reserve at the time of the Cold War. Times have changed and there are many
proposals to end the centrality of the dollar in the global financial system, but they have all been unsuccessful.

Currently about 60% of all world’s central bank reserves are held in US dollars and the Federal Reserve can discretionarily increase or decrease the flow of dollars. Furthermore, the superabundance of dollar-dominated debt in the world gives the Federal Reserve an inordinate power to control the world economy. Its first priority in the COVID-19 crisis is to keep the current economic and financial system in good health, which involves providing direct lending to overleveraged corporations that have benefitted from loans with low interest rates and quantitative easing since the last crisis in 2008–2009.

Meanwhile, indebted countries from emerging and developing economies receive only temporary loans that often come attached with conditions regarding their development model. The Federal Reserve chooses in accordance with its own criteria the countries for which it creates swap lines with their central banks, to make dollars less scarce. For instance, the economic and financial system favours those countries willing to sell off their drilling rights to the large multinational fossil fuel companies. Some of these countries, such as Mozambique, are perfectly aware that they will suffer the adverse climate change impacts resulting from their contribution to the continuing use of fossil fuels, but they desperately need to increase their debt-servicing revenue. The present crisis reveals the huge fragility and risk affecting most of the human population, particularly those living in the emerging and developing economies, and the need to implement a reform of the current economic and financial system based on the principles of human rights, justice, solidarity, and ethics. Without that kind of reform it will be increasingly difficult to avoid dramatic social and economic situations across the world that are likely to run out of control. David Beasley, the executive director of the United Nations World Food Program warned the Security Council on 21 April 2020 that: “We are not only facing a global health pandemic but also a global humanitarian catastrophe.”

The COVID-19 crisis serves as a rehearsal of what is likely to happen as the environmental and climate change crises continue to unfold. The difference is that in these two crises there is no hope of finding a fix like a vaccine for the coronavirus that acts relatively rapidly. Effective responses are long overdue and whenever humankind decides to use them they will only be able to act slowly over many decades. The longer we wait to respond resolutely, the longer it will take to recover some sort of equilibrium with the environment.

8.5 Adapting to or Building the Future

Humankind is now following an unsustainable path encircled by five main types of strongly interrelated and dangerous crises: the COVID-19 pandemic, the debt crisis, the crisis that results from increasing socioeconomic inequalities at the global level, the environmental crisis, and the climate change crisis. The first is a sudden crisis that is progressing very rapidly and, at the time of writing, is still developing and not
yet fully understood by science, while the other four are progressing in slow motion and are quite well understood by science. Time forces an immediate response to the first and has delayed effective solutions to the others, apparently indefinitely.

Many authors have warned that humankind’s interference with the biosphere is forcing it into a global critical transition that would put ecosystem services at risk with dramatic consequences for human well-being and prosperity. The current species extinction rate is higher than those that caused the previous five mass extinctions and if it continues uncontrolled it may produce a comparable mass extinction. The percentage of threatened species for various groups are: amphibians 41%, selected reptiles 34%, reef-forming corals 33%, mammals 25%, sharks, rays, and chimaeras 30%, birds 13%, conifers 34%, and selected dicots 36%. Tropical forests are likely to be the biome where the anthropogenic mass extinction caused by systematic deforestation over many decades will first be identified. To prevent a planetary-scale critical transition, the most important actions are (Barnosky et al. 2012):

[…global cooperation to stem current global-scale anthropogenic forcings. This will require reducing world population growth and per-capita resource use; rapidly increasing the proportion of the world’s energy budget that is supplied by sources other than fossil fuels while also becoming more efficient in using fossil fuels when they provide the only option; increasing the efficiency of existing means of food production and distribution instead of converting new areas or relying on wild species to feed people; and enhancing efforts to manage as reservoirs of biodiversity and ecosystem services, both in the terrestrial and marine realms, the parts of Earth’s surface that are not already dominated by humans.

There are many reasons why it is dangerous for humankind and also disgraceful that unlimited human greed, egoism, and hubris is destroying tropical forests, the biome that supported the emergence of our primate ancestors.

Climate change has been extensively addressed in the main text of this book, so it will be referred to here in a very succinct way. The climate change crisis results to a large extent from humankind’s strong dependence on fossil fuels. Fossil fuel global energy consumption as a percentage of the total has oscillated between 78.72 and 94.63% in the period 1960–2018 and stayed systematically close to 80% in the period 1990–2018 (see Fig. 4.2) (WB, 2020a). The persistence of this high-level dependence over more than half a century in spite of the high visibility of the climate change issue, of the risk it represents for humankind, at present and especially in the future, and of the persistent call for action from countless scientists, engineers, economists, politicians, and activists the world over, clearly shows that the current economic and financial system is not interested in solving this problem. We know much more now about the science of climate change and about its present, middle, and long term impacts on the various socioeconomic sectors and biogeophysical subsystems than in the 1980s when climate change was first unequivocally observed across the globe and the IPCC was founded in 1988. Furthermore, the way to mitigate climate change so that it has a minimum impact on economic growth at national and global level is well known. On the other hand, it is well established that there will be a slowing down of the global economy if the business-as-usual emissions scenario continues to be followed. None of these arguments has had any noticeable influence on the attitude of the majority of the fossil fuel corporations and industry and on the governments
that support them. On the contrary, they insist in prospecting more coal, oil, and natural gas deposits, often with the support of government subsidies, and to explore and sell as much fossil fuels as possible. The warning that by continuing prospecting for fossil fuel deposits, especially oil and natural gas, corporations risk creating a large amount of stranded assets and eventually a carbon bubble, is disregarded.

At the same time, the fossil fuel lobby has excelled in the art of creating doubts or fully denying that climate change is to a large extent caused by anthropogenic CO$_2$ emissions. Another frequent endeavour is to convince governments, politicians, and citizens that the continuous use of fossil fuels is the only way available to increase economic growth and economic prosperity and to reduce poverty, especially in the developing countries. This program of misinformation, disinformation, and manipulation made through publications and reports and on the social platforms, with the support of generous funding from the fossil fuel industry, has been very successful and has managed to confuse a significant fraction of the world’s citizens, especially in the USA, which derives much of its economic and military power from oil and natural gas. Meanwhile some renewable energies have become cheaper and economically competitive with fossil fuels. A slow global energy transition from fossil fuels towards renewable energies has started and is progressing.

This transition does not mean that the extremely important contribution that fossil fuels gave to the Industrial Revolution and to its success in creating the contemporary civilization is not fully acknowledged. The point is that a harmful side-effect of burning fossil fuels has been identified, namely the emission of CO$_2$ in large quantities, which increases the atmospheric greenhouse effect and produces climate change. There are of course other anthropogenic emissions of greenhouse gases, but CO$_2$ contributes about 65% of the anthropogenic radiative forcing. So, in conclusion, it is time to modernise the global energy paradigm and start effectively decarbonising the world economy. Most of the large fossil fuel corporations, especially those that produce oil and natural gas, in cooperation with the governments, banks, and financial institutions that support them, do not accept this argument and they will make every possible effort to continue prospecting, exploring, and selling fossil fuels. The behaviour of the fossil fuel industry and of the associated governments is currently one of the best examples of rational egoism applied to world affairs.

In spite of all the negotiating effort that has been patiently made over more than three decades by many hundreds of negotiators, scientists, and engineers to reach a world consensus on climate change mitigation, the UNFCCC Paris Agreement will not be fulfilled. However, UNFCCC negotiations will proceed in the hope that climate change mitigation measures will keep increasing and that they will continue to become more effective. There is a great hope that there will be no symmetry between the beginning and end of the Homo genus time as regards global climate change. The symmetry will only prevail if humankind lets anthropogenic climate change develop out of control, allowing it to evolve into an existential threat. It is more likely that humans are entering a period of many hundreds of year of anthropogenic climate change, in which crises will be more frequent and the well-being of a large part of humankind will be seriously degraded.
As happens with all crises, the present five may bring the opportunity to start rebuilding a more inclusive and sustainable world, causing them to recede into oblivion. Essentially everything that should be learned about how to find and follow a new globally sustainable pathway is already known. New research and development on that subject is always desirable, necessary, and important, but that is not the main obstacle.

The main problem is the lack of collective global willingness to change direction because of long-standing opposing worldviews. The COVID-19 crisis, instead of opening new avenues for the convergence of those worldviews, is more likely to entrench them. The currently stronger worldview, or the worldview of the status quo, is founded on the belief that the present economic and financial system is the best one to improve well-being and economic prosperity around the world. Its defenders may concede that small incremental changes could be made to improve the system without putting it at risk, but deeper transformational changes are considered to be very risky and fully rejected. This is essentially the worldview of the global financial and economic corporate elites that control an inordinate part of the world economy and are the ones that most benefit from the system. The same worldview is also shared by many politicians, but unlike the corporate elites, instead of active players they just support and benefit from the system. The world view of the status quo is defended by most politicians in the emerging economies, where the outstanding priority is to improve the well-being and economic prosperity of its citizens in order to reach the standards of the advanced economies. In the advanced economies that worldview is shared with nuances by a political spectrum that goes from neoliberals, conservatives, and libertarians in the USA to most political parties that have governmental responsibilities in Europe and elsewhere. In fact, the strongest driver of the status quo is the large differences in economic prosperity between the advanced economies and the emergent and developing economies that urges them to bridge the gap as fast as possible, before it is too late. The solution to this problem would be proactive economic convergence of the advanced economies towards the emergent and developing economies. This programme, however, is contrary to the principle of rational egoism and individual self-interest.

The fact is that a majority of people around the world have identified consciously or subconsciously with the principle of the inevitability of progress based on perpetual economic growth. This conviction is supported by an unaltering belief that technology will always provide further economic prosperity and free humankind from the adverse impacts of all five present crises and all future crises. Furthermore, one of the defining features of operative social time since the beginning of the Great Acceleration is that the extraordinary development of science and technology coupled with the application of emergent social sciences has succeeded in captivating and attracting humans to indulge in boundless consumerism, often with borrowed money, or in other words to embrace a lifestyle of opulence that helped them climb the social status ladder. The vast majority of people do not enjoy opulence, but that is the dream they entertain. All these beliefs in the irreplaceable power of economic growth are strongly related to or rooted in personal and collective behaviour that is very common in countries with advanced economies, increasingly common in
emerging economies, and fast penetrating less developed countries. The notion of prosperity that is closest to this behaviour is naturally economic prosperity, which opens the doors directly to the delights of consumerism.

Economic prosperity is a modern construction that tends to rank people on a one-dimensional scale that is socially damaging because it is based on comparing what a few have and others don’t. The one-dimensionality of the scale promotes the stairway effect and functions as a social trap where there are no limits to poverty and wealth. It encourages consumerism and a society dominated by greed and egoism. That is not surprising because neoclassical economics is based on individualism and more specifically on the assumption that the economy must be guided by the optimization of individual self-interest, which follows directly from the practice of rational egoism. However, the 20th century went much further and elevated egoism to the rank of the most important and productive of human qualities. One of the most visible champions of the new trend was the Russian émigré Ayn Rand, who fiercely and successfully defended the practice of a form of normative ethical–rational egoism in the USA under the pretence that it was a philosophical theory called Objectivism. Her efforts had an enduring influence on the ideological and moral grounding of the new neoliberal policies and made it possible to erroneously present them as an ethical system in which successful business people ensure an amazing economic progress for society as a whole and should therefore be venerated. Attempting to deny our imminently social nature by ignoring or rejecting actions that do not bring individual self-interest, such as cooperation, mutual help, solidarity, and active compassion, is a form of perversity that leads to social exclusion and dystopia. It means ethical and moral retrogression instead of progress. Is that the type of world that we want for us and for humankind? If citizens were to be confronted with this question, the answer would probably be “No”, but that answer is inconsistent with the observation that rational egoism is increasingly accepted and diffused around the world as an inevitable behavioural style.

Life satisfaction does not depend exclusively on economic prosperity, interpreted as opulence or utility, but also involves social capital, which describes the quality of the social environment and the community, especially access to education and health, social, cultural, and psychological factors related to a shared identity, inclusion, trust, solidarity, compassion, integration, and participation in the community. There are other forms of prosperity besides economic prosperity. Sustainable prosperity emerges from developing the capabilities to flourish in a multi-dimensional social, economic, and environmental space guided by the objective of achieving sustainability at the local, national, and global levels. Sustainable prosperity does not exclude economic values, but it replaces opulence by utility and conditions utility to the main goal of sustainability. This option guarantees the social, economic and environmental sustainability of a civilisation that respects freedom, human rights, tolerance, solidarity, justice, peace, and social inclusion in the medium and long term.

Besides the status quo there are many alternative world views, but they all have the disadvantage that they are almost entirely rejected by the global financial and economic corporate elites that benefit from and control an undue part of the world economy. Furthermore, because of their great diversity, they have difficulty in con-
verging to a common position that would present a strong, unified, and clear alternative capable of attracting a majority of citizens. Politically, most of the alternative world views are supported by a wide spectrum of political parties on the left, including the green parties. In non-democratic regimes, the alternative world views are not represented politically and are very often forced to be clandestine. The world views that oppose the status quo have done remarkable work to promote sustainability in many countries, especially at the local, regional, and national levels, but at the global level there is no significant progress because the opposing forces are dominant at that level. This situation aggravates the problem since a significant part of the unsustainability of human civilization has a global nature. This results from the relatively long human cultural evolution in the Holocene, especially in the period following the Great Acceleration.

The way the economic and financial system counteracts the alternative world views is through a “post-ideological” program based on the deployment of digital technologies. In the case of physical problems, such as climate change, instead of addressing and solving the cause of the problem, countervailing actions are deployed, supported by digital technologies, which are supposed to offset or cancel part of the negative impacts. In the case of dangerous contemporaneous behavioural, socioeconomic, and political tendencies, the post-ideological program, instead of addressing the core issues behind such tendencies, uses the digital technologies to build a virtual framework that provides individuals with the erroneous feeling that the harmful effects of such tendencies have been eliminated or are in the process of being eliminated. The origin of this trend that believes in “solving” complex social, economic, and environmental problems by circumventing, reformulating, and reinterpreting them with ICT has been attributed to Silicon Valley and represents an extension of solutionism.

Solutionism is an ideology devoid of ethical and moral dimensions, in which it is believed that all human everyday problems can somehow be solved by the right algorithms, codes, AI applications, automation processes, and robots (see Fig. 5.7) (Morozov 2013). Some of these technologies are very popular, such as the self-tracking gadgets that can be used to stimulate people to have healthier living habits, such as exercise more, eat diversified foods, monitor the blood pressure and other health indicators, practise safer driving habits, and have more stable financial situations. This digitalisation of human life opens a very profitable market for ICT start-ups and corporations. The next step for solutionism is to address and “solve” the global crises of income inequalities, environmental pollution, degradation and destruction, and climate change, which in fact have no solution compatible with the current economic and financial system. A possible way to give people the feeling that inequalities can be reduced by technological means is to expand the use of the blockchain technology that makes it possible to securely inventory, track, subdivide, and transfer wealth over the Internet, underpins the cryptocurrencies, in particular bitcoin and ethereum among many others, and serves as a vehicle for a sharing economy. The application of solutionism to the environmental crisis is essentially based on the ecomodernist view that the Earth system is now essentially a human artefact so that there are no grounds for any concern about further human interference. Finally,
the climate change crisis can be solved by using blockchain and AI to optimise CDR and SRM geoengineering (Lockley et al. 2019).

What then is the solution that addresses the problems themselves? Here, we are once again confronted with one of the essential characteristics of our phylogenetic evolution up to and after the emergence of the *Homo* genus, namely, group-structured sociality. The origin of our direct ancestor’s sociality began a long time ago when primates began banding together as loose groups of both sexes about 52 million BP at the anthropoid root (Shultz et al. 2011). Violent forms of adaptive aggressive strategies in intergroup relations can still be observed today in chimpanzees and bonobos, which belong to the hominin tribe just like *Homo sapiens* (Wilson et al. 2014). Killing members of another social group is an adaptive strategy by which killers increase their fitness by gaining access to territory, food, and mates. The natural selection pressures that led to the emergence of *Homo sapiens* created a complex social behaviour, structured in relatively small groups that simultaneously developed highly protective and cooperative intragroup strategies and highly competitive and aggressive intergroup strategies.

This essential form of behaviour is reflected and can be identified in all human social groups although it acquires different expressions that depend on kinship structures, the degree of social and economic development of the group’s population, and the origin, nature, and function of the group. In a broad sense social groups include the tribes, clans, and chiefdoms of anthropology, the many types of social groups that emerge in contemporaneous societies with different natures, sizes, identities, goals, and functions, and also the sovereign states, federations, and political and economic unions of states, in which a large majority consciously share and protect the same cultural and historical identity. Loyalty to the social group, in particular as regards behaviour and way of thinking, and discrimination or animosity towards the members of other social groups is frequently called tribalism. Tribalism and tribal bias is deeply rooted in our cognitive system and is common to us all (Clark et al. 2019). Recently, the word “tribalism” has acquired a slighting and depreciative meaning by being used as synonymous with strong and destructive political polarization, especially in the USA, where there are symptoms of a faltering democracy. The extraordinary richness of the world’s history, cultures, and artistic forms of expression, and of the world’s national heritage sites, is a cherished and unique legacy of our very fruitful and creative group-based structured sociality, or tribalism in *sensu lato*, to use a simpler expression. However, our tribalism has great difficulty in dealing with global problems, particularly with global environmental changes, which require the ascendancy of the one-tribe-on-the-planet frame of mind, or in other words, the prevalence of humankind’s interest over the diverse interests of each of humankind’s “tribes”. It is an analogous situation to that described by the tragedy of the commons, but applied to the whole of humanity.

In the contemporaneous operative social time most people in the world define their identity in terms of nationality. The utmost priority of a nationality is to protect the country itself, to maximise its autonomy and security, to develop its wealth and the well-being and economic prosperity of its citizens, to secure access or have control over crucial natural resources, and to develop its regional or global influence,
Adapting to or Building the Future

8.5

As has always happened in history, there are plenty of conflicts between countries and groups of countries. The most common in our operative social time are over monetary policy, trade, economic and political influences over other countries, natural resources, environmental issues, and over religious issues, especially when coupled with territorial and geopolitical conflicts. In many cases countries have been unable to resolve such conflicts at the negotiating table, but did not choose to resort to warfare given its immense costs. Nevertheless, the “War on Terror” conducted by the USA in the Middle East and in other regions of the world since 2001, stands out as a notable exception.

The relatively recent and rampant development and popularity of rational egoism has acted as an insurance against large scale warfare between major world powers and against world wars, since they would impair any hope of increasing well-being and economic prosperity across all economic brackets, including the upper 1%. Pyrrhic wars have become incompatible with the decline of all values that do not have an economical connotation. Nevertheless, some level of violent conflict is beneficial for the more powerful countries to assess the efficiency and sophistication of their weapons and to maintain a lucrative military–industrial complex. Recurring crises may progressively destroy economic values and replace them by other, more ideological values, which would tend to increase the probability of large scale warfare.

Meanwhile, conflicts have evolved in the direction of disabling all forms of cooperation between conflicting countries, in particular by denouncing military agreements, such as nuclear arms treaties, socioeconomical and cultural agreements, and the use of various forms of sanction. The preferred way of inflicting harm on the adversary is by imposing embargoes and economic sanctions, restrictions on economic assistance, financial restrictions, financial and travel restrictions on people individually, but also increasing tariffs on imported goods, which starts trade wars, as recently happened between the USA and China. These sanctions and restrictions are additional to those related to countering terrorism and international criminal organizations. At present the US Treasury Department, Commerce Department, and State Department lists embargoes against 30 countries or territories. Instead of resolving conflicts through negotiations or war, the current tendency is to use a panoply of economic and financial instruments aimed at disrupting, disabling, and eventually destroying the economies of adversaries in the hope that they will be forced to change their behaviour.

Solving the environmental and climate change crises is extremely difficult because sovereign states do not abdicate from giving priority to their national interests over humankind’s interest, especially if the level of global geopolitical tension or confrontation is high, as is presently the case between the USA and China. The surge of globalisation in the late 20th century was mainly driven by the ruling elites of the economic and financial system with the objective of increasing profits by promoting the expansion of world markets and lowering labour costs. Protectionist measures in the form of a trade war imposed by the USA on China and on other countries started in 2018, less than two years before the COVID-19 crisis. The geopolitical outcomes of the new crisis are likely to be growing discord between the major powers, acceleration of the decline of the USA, an increasing nativism and protectionism, and a resurgence of the effort to promote greater self-sufficiency against the trend of
recurring crises. However, it must be remembered that the “every country for itself” policies led in the past to a global economic crisis and that the reversal of globalisation would create a more fragmented, unstable, violent, and dangerous world. Citizens, non-governmental organizations, businessmen, and governments must develop all possible initiatives to increase international cooperation between people and states globally and in all aspects of human life and activities, especially at the cultural, scientific, and environmental levels.

So the question is: how can we achieve global sustainability and solve the environmental and climate change crises? Hope should remain intact and strong after we acknowledge the fundamental human shortcomings in dealing with global problems. The logic of our previous successes, based on the belief in progress, science, and technology, requires us to rise to the challenge and progress further. The challenge is to know whether progress is only possible within the framework of the multi-tribal viewpoint or whether it can be extended to the framework of the one-tribe-on-the-planet viewpoint. In the former case, humankind will be forced to adapt to a future shaped by an outdated framework. In the latter case, humankind will be constructing its future with new patterns of behaviour based on a new framework.

To reach the sustainability goal there are three crucial measures that must be undertaken. The first is to recognize that global problems are very difficult to solve, but the wisdom gained by knowing ourselves better is essential if we are to find workable solutions. The second is to progressively adopt the one-tribe-on-the-planet viewpoint framework so that globalisation, instead of being reversed, is developed as a privileged driver to reach sustainability through transformational changes guided by the UN Sustainable Development Goals for 2030. The third regards governance in democratic countries. The discourse of democracy’s political leaders must undergo a change and start frankly addressing two crucial issues.

The first is the incompatibility between our civilization model and perpetual economic growth that implies uncontrolled natural resource depletion and dangerous environmental changes. The second is the urgent need to reverse the process of increasing inequalities worldwide. These issues are not of paramount importance to the electorates of almost the whole spectrum of political parties, because they are not directly related to the self-interests of most citizens, or indeed to their nationalistic preoccupations. However, since they are essential for peace and sustainability, party leaders should base their political discourse more on science and ethics and on the scientific understanding of the global changes that are affecting all world citizens, and refrain from paraphrasing what the majority of their specific electorate wants them to say. Some of the politicians who address these challenges will not be elected, but eventually they will be respected and supported. Without this courageous ethical attitude and vision, democracies will not be part of the solution to the current problems of inequality or the environmental and climate change crises that are threatening humankind, leaving ample space for the proliferation of authoritarian regimes. Without a renewal and adaptation of democracies to the new world challenges, authoritarian regimes are likely to become dominant. Humankind is confronted with the choice of adapting to the adverse future that it has created or to rebuild a new, more propitious future by a process of self-regeneration. Technologi-
cal success has erroneously convinced us that we can disdain our essential forms of sociality. The self-interest cult leads to dystopia. Self-interest should be replaced by social self-regeneration.

The crucial condition for the success of this plan is to decelerate operative social time and to be as much as possible at peace with time. Deceleration does not impair progress but it changes the emphasis on its various forms, giving prominence to human and social progress. It also favours the development of other forms of prosperity besides economic prosperity. Deceleration is compatible with the human essential characteristics and there are many examples of contemporaneous decelerated operative social time at the individual and collective levels scattered throughout the world. If deceleration at the global level turns out to be impossible then there will be no way to reach any form of sustainable development. In this scenario humankind will be assailed by continuing crises that will result from persisting with impracticable perpetual economic growth models coupled with the continuing overexploitation of natural resources, environmental degradation and pollution, biodiversity loss, and climate change. Those crises would inevitably increase poverty and inequalities, decrease social inclusiveness, well-being, and economic prosperity around the world, and that would become too high a price to pay for not having been able to find a sustainable pathway into the future. The notion of progress in its various forms would be impaired and eventually outmoded. Human wisdom and foresight may prevent that outcome. Time resolves all human issues and uncertainties.