THE PHYSICAL IMPACTS OF TECHNOLOGY
How Technology Influences the Thinking and Living of the Society

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ABSTRACT
This article concerns the societal impacts originated by the physical nature of technology, described as a joint activity of science and technology called technoscience, and concerning also the erroneous vision of technology as an application of science. The article highlights the importance of technology for the survival of the humanity because of the coevolution of technology with biology in the human species, and its neutrality being a physical process with benefits or dangers depending in fact on human purposes of its use. There are three impacts that have a physical origin, the first one concerns the impact of modern science and technology, the second one the impact of technologies increasing human intellectual capacities such as artificial intelligence (AI), and the third one concerning the impact of technologies on the environment. The impact of modern science and technology started with the bombing of Hiroshima, showing the existence of mysterious atomic forces, and how the perception of science and technology by the society changed after this event. Beside the danger of use of atomic bombs in wars destroying the humanity, there was the raising of fears about the use of nuclear fission for the production of energy, and modern superstitions about dangers of microwaves for smartphones and GMO in food, because of a general lack of knowledge of quantum physics explaining the atomic forces and chemical behavior of molecules. The impact of technologies increasing intellectual capacities is explained by the deterministic nature of AI based on physical processes, and the consequence that in fact the real intelligence is in people that have developed the software and designed the machine, and in people that interpret as intelligence the physical effects produced by AI machines. The consequence of AI is a diffused transfer of human rationality to machines, with loss of the human rational capacities. The impact of technology on the environment concerns pollution, depletion of resources and in particular global warming. Environmental policies do not take account of the importance of technology and the necessity of a great number of new technologies for the solutions of environmental problems, limiting their role to regulate the reduction of use of conventional technologies, not considering also technologies able to mitigate the unavoidable global warming. Concluding technological impacts may be faced by a better education explaining quantum physics also in secondary schools, and how to exploit AI without loss of human rational capacities. The environmental impacts may be faced by a new technology innovation system based on knowledge, and not capital strategies, in order to develop the necessary high number of new technologies. Finally, it would be useful for the society to consider both technology and biology essential to the survival, contributing to a real human sustainability from the technical, economic and social point of view.

Keywords: science, technology, technoscience, technology innovation, artificial intelligence, environment, society

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1. INTRODUCTION

It is undeniable that technology has important societal impacts transforming deeply our society. These impacts are not just based on internet or social networks, or jobs replaced by robots or artificial intelligence, but they transform the society, not just altering specific sectors of the economy, but changing the way we think and live not necessarily in a positive way (Schultz 2015). Typically, the impact of technology in the society are studied considering mainly the social and economic aspects of technology that transform the society. However, this view of technology does not consider fundamental aspects of technology linked to its physical nature leading to erroneous interpretations of the position of technology in the society concerning its relation with science, and even unrealistic oppositions to the use of technology considered a dangerous activity. Furthermore, the limited knowledge in the society of modern science and technology has raised fears such as that for nuclear technologies, or of dangers of microwaves and GMO that do not have any real scientific justification, and dangers of technology on the environment, joined with an excessive interest for artificial intelligence (AI) without considering the danger of transfer of human rationality to machines.

In this article we will discuss the fundamental physical aspects of technology and experimental science, forming a joint activity that may be called *technoscience*, producing technology innovations, and determining the evolution of technology. In this way we examine the origin of some impacts concerning the modern science and technology, the use of AI, and the relation between technology and the environment, and how the knowledge of these aspects may suggest solutions to the problems raised by these impacts that are dependent on the physical nature of technology. These arguments are discussed starting with a description of the position of technology in the society, the origin of science and technology, the coevolution and neutrality of technology, the philosophic view on the nature of technology, and explaining what we intend as technoscience. It follows a discussion about the impacts of modern science and technology, the impacts of AI and those of technology on the environment. Most of the physical aspects of science and technology, used for the description of the impacts in the society by technoscience, are the results of studies on the dynamic of technology (Bonomi 2020) and on technology innovation (Bonomi2023).

2. THE POSITION OF TECHNOLOGY IN THE SOCIETY

Looking to the position of technology in the society, we may note in particular the diffused erroneous idea that technology is an application of science. In fact, as explained further about the common physical nature of technology and experimental science, actually technology interacts with science in the activity of scientific developments, by exploiting new phenomena discovered by science (Arthur 2009), and at the same time supplying to science the means to discover new phenomena. Another observable aspect, existing in the communication of science, is that its description is based on its technological applications showing, as observed by the German philosopher Jürgen Habermas, that the informative content of science cannot be directly relevant in the perception by the society, but that on the contrary this perception occurs through its technical valorization, making technology a transfer means of knowledge between science and the society (Habermas 1968). Considering the fundamental aspects of science and technology, the position in the society of technology appears unbalanced from one side with an overestimation of its possibility, for example in the realization of an artificial consciousness in the development of an artificial general intelligence (AGI) or, from the other side, to consider technology as a danger, suggesting the reduction or even the abandon of technologies and a return of humans to the nature. As we will explain further, these ideas about technology are in contrast with the essential role of technology in assuring the survival of human species, and with the neutrality of technology in which its dangers are linked to the human purpose of its use, and not to technology that has a neutral physical nature.

3. ORIGIN OF SCIENCE AND TECHNOLOGY

Technology had its origin in ancestral times with homo erectus, about more than one or two million years ago, with the working of stones to make tools. Paleontologists, studying the technology of working of stones, has shown the appearance, about six hundred thousand years ago, of a complexity in the formed tools considered derivable by a cumulative experience, and showing the important difference in respect to tools made by primates, or even by early homo species (Paige, Perreault 2024). This fact shows the existence of an activity of technology innovation in homo species that is absent in the case of animals, and contributing to the evolution of technology. The use of technology by homo species since the ancestral time, in absence of writing and maybe a primitive form of language, has been accompanied by the formation of a direct knowledge in the human brain through the use of technologies called knowhow, a knowledge that is also necessary to operate the present technologies and also in experimental science (Bonomi 2023).

The origin of science is relatively much more recent than technology. A scientific thought may be considered born with ancient Greek philosophers in the 5th-6th century BC, with the elaboration of ideas used after in science such as for example the atomism. The modern science is much more recent. It is considered born in the 16th-17th century, in particular with Galileo and Newton, with the use of measures, experiments and mathematics for the explanation of natural phenomena. It is interesting to note that, in the development of scientific knowledge through experiments, it is necessary to use technologies, and to have the knowhow to use them. In fact, in the development of modern experimental science, it is necessary to use more and more complex technologies and knowhow. This last one cannot be transferred simply by oral explanations or manuals, but it requires imitation and direct experience. Technology and knowhow are essential aspects of scientific activities, and without a knowhow modern science and technology would not exist. Concerning the nature of modern science, the first discussion is present even with Galileo that, with its dispute with the Church, this last required that the scientist considered his description of the solar system simply as an easier mathematical method to calculate the positions of planets without invalidating the geocentric position of the Church. In other words, considering the science of Galileo simply instrumental, a vision not accepted by Galileo considering his mathematical description a demonstration of the validity of the heliocentric system. This instrumental vision of science was after also supported by the English philosopher Georges Berkeley that, examining accurately the science of Newton, concluded that it was simply a mathematical hypothesis, an instrumental vision for calculation and forecasting of phenomena, not corresponding to nothing of real. In opposition to the instrumental vision, there was an essentialist vision that considered theories and calculations an explanation of observable facts. Instrumentalism and essentialism constituted the argument of numerous disputes among philosophers but, beside few exceptions, it was not considered by scientists that continued the research of the verity as intended by Galileo. Much later, with the advent of quantum physics, with the study of atoms and subatomic particles, the instrumentalism was reconsidered because of the difficulty to interpret the observables with the common vision of the reality (Albert 1992). A modern vision of science close to the physical view of technology may be found in Karl Popper discussing the logic of the scientific discovery (Popper 1959), and in Thomas Kuhn discussing the structure of the scientific revolution (Kuhn 1962).

4. COEVOLUTION AND NEUTRALITY OF TECHNOLOGY

The availability of technology and the possibility to make technology innovations has resulted probably in a coevolution in homo species between technology and biology, with technology substituting in part the Darwinian selection in the evolution, with more efficient and rapid solutions for the survival of the species (Bonomi 2023). For example, it might be considered that the homo sapiens, facing the beginning of the glacial era, developed technologies to kill a prey and recover its fur for cold protection, instead of having the biological Darwinian selection of the population through the growth of body hair. This substitution of the Darwinian selection with technologies continues today making a situation for the homo sapiens that, deprived possibly of its technologies, would not be able to survive as in the case of animals. It is interesting to note that the survival character of technology was present in the ancient Greek thought. That is well represented by the Greek Prometheus myth as reported by Plato in his book "Protagora" (Dolza 2008). This myth describes the reason of the steal of technology to Athena, and of fire to Hephaistos, because of the error made by his twin Epimetheus, charged by Gods to give the natural means for survival to all living being, that distributed all the means to animals, leaving the men naked, barefoot and without any means of defense. In fact, the myth of Prometheus represents the Greek thought about the nature of technology as a means of survival making its use indispensable. A further valid view of ancient Greeks was the recognition of the neutral nature of technology, naming *pharmakos* in the Greek language a preparation of a product that may be at the same time a poison killing a person or a medicine saving the life. In fact, in the present times, the neutral nature of technology has been object of various discussions, but it is evident that technology, being a physical process, shall be considered neutral, and that the benefits or dangers for the society being in relation with the human purposes of its use, and not because of its nature. It may be objected that sometimes technologies are specifically developed for a use producing damages. Actually, it may be demonstrated that technologies, as a physical process, may be used possibly for both benefic or dangerous purposes. For example, arc and bows may be used to kill a prey assuring survival or to kill a man in a fight, or the atomic bomb may be used in a war destroying the humanity, or used to vaporize an asteroid precipitating to the earth saving the humanity. Coevolution with biology has made the extremist environmental ideas of a return to the nature with reduction or even abandon of technology unrealistic, and being technology a neutral physical process it is wrong to accuse technology as origin of observed damages, when in fact these are originated by purposes of people to use technology with dangerous effects. Problems such as pollution, depletion of resources or global warming are not ascribable to technology, but to the fact that technologies are not changed in order to avoid these problems.

5. A PHILOSOPHIC VIEW ON THE NATURE OF TECHNOLOGY

The philosophic view on science and technology is of interest being in relation with the technological impact on the society, discussing in particular the philosophic views about the nature of technology. Actually, technology has never had a great importance in philosophical thought, and an interesting source on the relations of technology with philosophy may be found in the proceedings of a meeting, organized by the International Federation of Philosophical Societies, hold in Brussel on June 2002, and published with the title "The Philosophers and the Technology" (Chabot, Hottois 2003). It is well known that the first philosopher to consider technology giving to it the name, *techne* in the Greek language, was Aristotle. Actually, he gave a meaning to technology as a practical skill, distinguishing this skill of making from the skill of doing (Evans 2003). The establishment of such difference might be considered reductive nowadays after the development of modern technologies involving machines with AI. The philosopher Plato is often considered far from the scientific and technical thought, but it may be shown that his theory of ideas has given a fundamental indirect basic contribution to science and technology. This theory considers that ideas exist independently of material things and humans, being in fact the true universal reality. Plato expressed this idea with the famous myth of the cavern in which humans may observe, through their experience, only the shadows of the universal reality projected by the world of ideas existing at their shoulders at the extern of the cavern (Preti 1957). That leads to consider two possible views, one as ideal view and the other one as a human experienced view of the reality. Actually, in science and technology the Plato view is in a certain way overturned, and the real world is described through ideal representations and modelling of scientific or technological processes. However, the separation of ideal from real representation has been of great importance in the Western culture, for example with the development of the Euclidean geometry, using ideal figures for practical applications, not existing in the Eastern cultures. An idea about the nature of technology, similar to that considered in technology dynamics (Bonomi 2020), may be found in Ernst Kapp, a minor German philosopher that considered technology as a way with which humans increases the capacities of their arms, legs and senses developing machines, means of transport, microscopes, telescopes, etc. (Timmermans 2003). Another philosopher with ideas similar to those seen in technoscience is Gilbert Simondon with its view of technology as a process and formed by combination of preexisting technologies (Simondon 1959). The most important philosophical thought contributing to the understanding of fundamentals of technology has been given by the German philosopher Martin Heidegger, reported in his famous essay "The Question concerning Technology". As noted by Lovitt the translator in English of this essay (Heidegger 2013), the text is difficult to understand especially by the use of words with meanings that are not employed commonly, and that must be redefined. In fact, Heidegger, like in technoscience, considers technology an activity with a purpose, then as a means, and concluding that the current conception of technology, according to which it is a means and a human activity, can therefore be called the instrumental and anthropological definition of technology. Furthermore, differently of a common thought, and in agreement with technoscience, modern technology is not considered by Heidegger an application of natural science. Technology makes use of scientific knowledge, but this knowledge depends also on technical instruments and their construction, i.e. science would not exist without the existence of technologies that precedes scientific discoveries. Heidegger considers then technology, and not science, as a fundamental in the relation of humans with the nature, independently of its good or bad developments (Kemp 2003). Two scholars of Heidegger, Hans Jonas and Hans Georg Gadamer, were also important about discussions on technology. Hans Jonas elaborated the precautional principle (Jonas 1979), and his thought will be discussed in the section about the relation of technology on the environment. Hans Georg Gadamer discussed the dangers of the modern means of communication (Gadamer 1976), and his thought will be presented in the section about technologies with intellectual capacities. Concluding, some important philosophers had in fact erroneous ideas about the nature of science and technology, considering science a simple system of measurement and, for example, a well-known philosopher such as Hanna Arendt (Roviello 2003) considered modern research, for example in physics, as simple source of data revealed to us as from our instruments of measurement. She gave the example of Eddington's measurements, demonstrating the Einstein's general theory of relativity, and considered these data having the same resemblance in their reality as a phone number linked to its subscriber in a phone list. Arendt was not aware that few decades later the theory of general relativity, confirmed by Eddington's data, was useful to determine a geographical accurate position on earth through geostationary satellites,

6. TECHNOSCIENCE

As we have already noted in the introduction, we consider science and technology joint in a common activity for the generation of new technologies, a common activity that may be called *technoscience*. This term is not a neologism, and it has been introduced by the sociologist Bruno Latour to describe the close social relations existing between scientist and engineers (Latour 1987), a term that we consider also valid to describe the relations between science and technology. A physical definition of technoscience may be found considering the physical definitions of experimental science and technology. In fact, experimental science may be defined as the study of single physical phenomena or processes, defining a phenomenon as an observable event, and a process an event depending on variables. Technology may be defined physically as the study of the organization of physical processes in a time-oriented structure, producing a physical effect exploitable for human purposes (Bonomi 2023). Technoscience activity has as objective the development of new technologies made, as cited in the introduction, in a loop of activities in which science makes available new phenomena and processes for new technologies, and technology makes available the means to science for discovering new phenomena and to study new processes exploitable by technology. An important link existing between science and technology, because of their common physical nature, is knowledge, intended as knowledge of researchers and operators of a technology, different from knowledge characteristic of socioeconomic activities concerning entrepreneurship and marketing.

The structure of the technology based on physical processes may be object of a model considering, in a simplified view. as a structure of technological operations (Auerswald, Kauffman, Lobo, Shell 2000). In fact, a technological operation may be considered a set of physical processes, and the set of technological operations of a technology may include all the physical processes of the technology. This model may have a mathematical description in terms of technological space and landscape concerning technology efficiency (Auerswald, Kauffman, Lobo, Shell 2000), but also the representation of technologies in a space of technologies (Bonomi 2020) and as a technology ecosystem composed by a universal set of technological operations in which a technology is represented as a subset (Bonomi 2023). Technology innovation may be considered a change of the structure of the physical processes or operations of a technology. Such change occurs in system organizing fluxes of knowledge and capitals (Bonomi 2020). There are three types of systems for technology innovation: the industrial R&D projects system, the startup-venture capital system and the industrial platform system (Bonomi 2020). These systems are not alternative but inclusive. In fact, the R&D projects activity, in which is made the change of the structure of the physical processes to form a new technology, is present also in the other organizational structures. These models may be used to simulate the functioning of a technology, to study the relation between number of R&D projects and number of formed new technologies (Bonomi 2020), and also suggesting a new technology innovation system able to generate the numerous needed new technologies by the society, especially to face environmental problems.

7. THE IMPACTS OF MODERN SCIENCE AND TECHNOLOGY

We may consider that the impacts of modern science and technology started with the bombing of Hiroshima, showing how technologies may generate enormous amount of energy of atomic origin, that leading to potential dangers of destruction of the humanity in the case of an atomic war. This impact has made aware the society of the existence of mysterious atomic forces, studied by a novel discipline called quantum physics, unknown to most of people. That showing, as already noted, that the informative content of science cannot be directly relevant in the perception by the society, but that on the contrary this perception occurs through its technical application, making technology a transfer means of knowledge between science and the society (Habermas 1968).

The question of impact of the modern physics and technology on the society was discussed at first by Werner Heisenberg, a scientist founder of quantum physics and Nobel Prize, in an essay written just few years after the bombing of Hiroshima (Heisenberg 1954). He considered in particular that this bombing event changed the scientific ideas about the nature and then the way of thinking of the society. He considered that technology appears nearly no more as a conscious human involvement into an effort to extend the material force, but as a great biological fact in which the structures of the human organism are transferred in a growing way to the environment as biological process subtracted to the human control, i.e. humans can make what they want but not will what they want. Heisenberg considered that the first radical transformation of technology not occurred with technology of steam machines, clearly visible in their functioning, but with the development of electrical technologies exploiting physical forces unknown by humans in their immediate experience. In the same way, outside of an immediate experience, atomic forces made possible liberation of enormous amount of energy, and chemistry able to transform technology through an indirect knowledge of a not perceptible world of atoms and molecules. Following Heisenberg, the strength of the Western culture comes from the close link between theoretical formulations and practical actions. He notes that the relation of atomic physics and the Greek philosophy of the nature is a unique case in the field of science, and that is reflected in other disciplines linked fundamentally to atomic physics such as chemistry built on the base of existence of invisible atoms. This important evolution of physics has transformed the human way of thinking, not only raising fears about possible enormous atomic destructions, but also resulting in the absence of knowledge of the origin of this energy, based on phenomena of quantum physics in fact contrasting the common human experience (Albert 1992). The consequence is a general underestimation of the importance of quantum physics in the society, confirmed also by philosophers (Dalla Chiara, Toraldo di Francia 1999), despite of the fact that this new physics is involved in many important technologies, such as electronics used for computers and AI, modern communication, medical instruments, etc. (Bonomi 2023). Its knowledge, differently from classic physics, is poorly diffused being secondary education limited to the teaching of the atomic structures, without giving a more fundamental although simplified view of the postulates of quantum physics, explaining differences from Newtonian laws of classic physics, and their implications on the nature of the reality. The general lack of knowledge of this discipline is at the origin of fears, and opposition to use the nuclear fission for the production of energy, despite of the fact that the main accidents occurred with this technology, the case of Chernobyl and Fukushima, the first was due to a human error combined with an obsolete nuclear technology, the second because of an exceptional tsunami. The type of Chernobyl accident cannot occur with modern nuclear technologies, and Fukuyama case is avoided simply not building nuclear plants on coasts exposed to tsunami. Concluding, modern technologies of nuclear fission are not more dangerous of other used technologies, and are presently indispensable to produce energy avoiding greenhouse gas emissions (Bonomi 2022).

7.1. The modern superstitions

The lack of knowledge in quantum physics is also at the origin of modern superstitions such as the supposed dangerous effects of microwaves and the use of GMO in foods. Following quantum physics, electromagnetic waves, and then microwaves, are composed by packets of energy called photons with an energy that increases with the increase of the frequency of the wave. In this way high frequency electromagnetic waves, such as gamma radiations, X rays and UV, the photons have enough energy to broke chemical bonds producing damages in living organisms. Infrared waves do not have enough energy for that, and their effect is only in increased vibration and rotation of molecules generating a heating. Microwaves have a lower frequency than infrared, and their effect is a weak heating that disappears with the decrease of the frequency, then these waves go through the matter without effects. Although are cited negative effects of microwaves emitted by antennas and smartphones, they appear in fact as statistical correlations, without any explanations how their very weak energy may interact with the matter. The case GMO is similar considering that an artificial modification of DNA may be dangerous in respect to a natural structure. Actually, a basic principle of chemistry affirms that the behavior of a molecule depends only on its atomic structure, and not by the artificial or natural process of its synthesis. That means that there not reasons to be opposed to a GMO having benefic effects, after it is ascertained the absence of dangerous effects in its use. Concluding, this lack of knowledge about quantum physics is at the origin of fears limiting in certain cases the positive uses of technologies based on this discipline that may be avoided for example by introduction of teaching quantum physics in secondary schools.

8. THE IMPACTS OF TECHNOLOGY INCREASING THE INTELLCTUAL CAPACITIES

After a first radical evolution of technology concerning electrical and after atomic forces, a second radical evolution has concerned technologies, not increasing energetic or sensorial capacities, but intellectual capacities. The availability of technologies increasing the intellectual capacity has generated a great impact in the society for their use also by common people and not only by professional experts. We discuss here in particular AI as a technology and its physical nature. AI has enormous potential applications but also limits and dangers in its use. In this way it is then discussed also the problems raised by the transfer of human rationality to machines, and the dangers of diffusion of the modern means of communication associated to this type of technologies.

8.1. Artificial intelligence as a technology and its physical nature

AI is essentially a technology and, as any technology, it operates with instructions, in form of physical inputs, that make possible the functioning of a series of physical processes in the machine producing an output composed by physical effects interpretable by humans as a result of AI. The main physical process of an AI machine is based on the difference of electric potential controlled by very numerous miniaturized electronic switches, localized in the structure of the machine. The existence or not of this difference, corresponds physically to the logic values of 1 or 0 used for the informatic development of the algorithms necessary to operate the machine. For this reasons AI shall be considered a virtual intelligence, as in fact the real intelligence is that of people that have developed the algorithms and designed the machine (Faggin 2024), and of people that have introduced the right instructions and interpreted as AI the physical effects produced by the machine. AI has an enormous potential of applications increasing the efficiency of technologies, but also limits of use in the solutions of problems or managing of activities. That because, differently from humans, it does not have any critical view of its results in the frame of the complexity of the reality in which its results are used, that because, being a deterministic machine, it takes account only of available data, and it does not have access to knowledge cumulated by humans during their living experience. For these reasons AI results may have hallucination effects concerning elaborated but anomalous answer of AI appearing unrealistic, and also autophagy concerning erroneous answers because of bias of use of statistically more diffused available AI data instead of rare but more realistic data. In fact, AI choices of data, based on their statistical diffusion, may neglect the complexity of the reality. Consequently, the use of results of AI may be a failure for example in the solutions of problems never appeared before, or in management of situations influenced by the complexity of the reality. For these reasons the results of AI should be always submitted to a human supervision for their use. On the other side, AI cannot be considered responsible of damages of its use, being that attributable to the developers the algorithms or designers of the machine, and also to people that have introduced the instructions and interpreted as AI the physical effects produced by the machine. In the same manner AI cannot be considered inventor of a patent.

Presently, there are also attempts to develop an artificial general intelligence (AGI), with the same capacities of the human intelligence. However, that probably would not be possible because it would need to understand and reproduce the nature of human consciousness that still remains a mystery (Russel, Norvig 2020). Another limitation of AI may be found in the process of creativity in technology innovation or scientific research. In fact, examining the creativity process of important radical innovations or scientific theories, it is found that the innovative idea is not just a combination of scientific and technical elements of knowledge, but possibly also of other types of casual and differentiated elements, normally not accessible to an AI machine elaborating a creative idea just based on scientific and technological information. We may just give two important examples among the numerous cases. The first one is the invention of PC by Steve Wozniak combining the knowledge of microprocessor and the fact he was working at HP on the connection of monitors with a central minicomputer, giving the idea of connecting a keyboard with a domestic TV through the microprocessor realizing the first PC (Isaacson 2010). The second one is the idea of Albert Einstein to develop the theory of relativity, occurred during a trip on a tram in Bern thinking to what happens to the light coming from a watch tower if the tram would go away at a velocity higher than that of light (RSI 2026). Another aspect is the case of the human inventive process, in contrast with the scientific knowledge that is normally used by an AI machine has been reported by George Basalla in his book about the evolution of technology (Basalla 1988). He cited the successful transmission of electromagnetic waves beyond the horizon by Guglielmo Marconi. That was considered impossible by scientists at that time, but in fact possible because scientific knowledge is never definitive, and the idea that in the outer space there is a layer reflecting electromagnetic waves was too far from scientific considerations at that time. Concluding, such type of creativity would not be possible by a hypothetical AI machine based on the scientific knowledge available at that time.

Concluding we may show the limits and major differences between a human intelligence and AI, considering these questions posed to AI, represented by a ChatGPT system (Quarteroni 2025), with answers that may be resumed as follows: AI cannot feel the lack of limits as it does not have a subjective perception of its existence. The great difference is the lack of direct experience as humans have with the real world. It elaborates information creating connections among concepts without considering any real living experience. AI learning is different from that of humans that learn through experience, intuitions and relations. AI may describe courage in all its nuances, but not being courageous.

8.2. The transfer of human rationality and impact of modern communication technologies

After the previous discussion about the physical nature of AI, and its limits in understanding the complexity of the reality, we discuss dangers linked to the transfer of human rationality to machines and of the modern means of communication. Technologies increasing the intellectual capacities have important effects in the society, in particular the tendency of humans to transfer their rationality to machines, that reducing knowledge to how to use touches of a keyboard or points of a tactile screen to obtain the answer to a question, practically acquiring a knowledge but not understanding anything about how this knowledge has been obtained. This transfer may be particularly dangerous in using AI machines for the management of activities. In fact, in the case of a sudden unavailability of the AI machines, that would raise problems because of the loss by humans of the capacity to operate without the AI machines. Furthermore, the combined use of social networks and AI experience in pleasant virtual worlds may have as consequence the human loss of the sense of the reality essential for living. Concerning the modern technologies of communication, they have an impact in the society that have been anticipated by the German philosopher Hans-Georg Gadamer, showing how they are dangerous for social organizations (Gadamer 1976). In fact, the modern technology of communication makes information an unavoidable need compelling the making of choices, and also influencing the formation of opinions with a loss of freedom of action. It is then unavoidable that a society based on technological means of communication leads to a possible manipulation of the public opinion influencing certain decisions, and the possession of technological means of communication is decisive for this purpose. The result is that the increase of availability of information does not correspond to an increase a social reinforcement, and that accompanied by fake news made now credible by AI. Individuals become then dependent on a form of life mediated by the technology, but feeling at the same time to be powerless and leading to a reinforcement of their adaptability and apathy toward public affairs.

9. THE IMPACTS OF TECHNOLOGY ON THE ENVIRONMENT

The relation between technology and the environment is particularly important in the societal impact of technology, and it has raised the necessity of adoption of policies to solve the various environmental problems (Bonomi 2022). In our discussion we take account of the physical nature of technologies and of physical laws, compared with the adopted environmental policies. Then we describe at first critics to the precautional principle, presenting after the main environmental problems concerning pollution, depletion of resources and global warming, and which are the possible technological solutions.

9.1. The precautional principle

The precautional principle was proposed by the German philosopher Hans Jonas. He contested the utopic believing, typical of the modern Western civilization, in a technology able to solve all the problems it creates. Consequently, the technology, undissociated from science, with the uncertainness to know the far future of its action on the nature and the mankind, makes necessary to face this unknown by another form of anticipation such as a precautional principle, limiting the development of technologies for which are not known the possible consequences in a far future (Jonas 1979). Although being a reasonable principle, it does not contain any real indication about the conditions it could be applied in practice becoming consequently the source of various different interpretations. From the technological point of view this principle could be overturned affirming that the not development and not use of a technology might leave consequence in the far future outside the possibility of reparation, that because of the aleatory behavior of the nature generating not frequent but extremely dangerous events for which a technology instead would been able to supply a solution. That is a consequence of the fact that technologies are an ecosystem, and new technologies result from the combination of preexistent technologies (Arthur 2009), combination not possible if the preexistent necessary technology to face the dangerous event has not been developed and then not available. Actually, the use of the precautional principle has been criticized for its rigidity and tends to be substituted with a more reasonable evaluation of risk based on a probability approach

9.2. The problem of pollution

The problem of pollution becomes to the public attention with the publication of a book of Rachel Carson in 1962 entitled “Silent Spring” (Carson 1962) documenting the adverse environmental effects caused by the indiscriminate use of pesticides. A valid solution to the problems of pollution from the technological point of view has been proposed in a book describing technologies that may defend and valorize the environment with an increase of natural resources and not with their destruction (Hawken, Lovins A. Lovins H. 1999). That means an important transformation of conventional technologies into environmental technologies with lower consumption of raw materials and energy, lower generation of waste and inexistent or very low emission of pollutants, that requiring consequently the development of a great number of new technologies.

9.3. The problem of depletion of resources

This problem has been put to an international attention by publication in 1972 of a report of the Club of Rome entitled “The Limits of Growth” (Meadows D. H. Meadows D.L. Randers, Behrens 1972). In this book it was presented a scenario, derived from a global model of development, about the consequences of depletion of resources on growth. An answer to the problem of depletion of resources has been given by the development of the concept of circular economy in which the products after use are recycled and transformed into virgin materials in such a way to reduce the consumption of raw materials (Stahel W. 2019). In an evolution of recycling in a circular economy it has been described also the reaching of conditions of a mature circular economy in which consumption of raw materials is practically eliminated by recycling all the wastes. However, a mature circular economy is not practically realizable for thermodynamics reasons, requiring for that new technologies and enormous amounts of energy for the necessary full recycling (Korhonen, Honkasalo, Seppälä 2017).

9.4. The problem of global warming

The present problem of global warming is considered the result of a fast increase of the global temperature, in a natural heating phase of the earth, because of the anthropic emission of greenhouse gas. That results in a rapid change of the climate making difficult the adaptation of the environment and of the society to this change. The complex question of global warming had found a general attention since the Earth Summit, organized by UNO at Rio de Janeiro in 1992, with the creation of an international environmental treaty called United Nations Framework Convention on Climate Change (UNFCCC), followed by an agreement in 1997, called the Kyoto Protocol, establishing policies for limiting emission of greenhouse gas in the atmosphere. The anthropic greenhouse gas emissions are linked mainly to the production of energy, industrial productions, transport and home consumptions. Actually, the only available technologies for production of free-carbon energy, able to substitute practically the whole carbon-based production of energy, are the nuclear fission and the photovoltaic technologies. The combination of these two technologies is indispensable as photovoltaic production is intermittent, and it would require enormous amount of storage capacities if used alone for a global production of energy, and making unstable the necessary continuous production of energy. That also to face not frequent but possible events of solar shielding because for example of exceptional volcanic activity (Bonomi 2022). New technologies under development are far to be ready for a substitution. For example, nuclear fusion technology shall still demonstrate the ability to produce enough energy, not only to maintain the nuclear fusion, but also for a production. That means that the time at which new technologies may be developed and diffused stopping the anthropic emission of greenhouse gas would be very long, with consequent important dangerous effects of global warming. Elaborated policies for global warming may be criticized as they are based mainly on political solutions of the problem on the base of agreements on the rate of substitution of conventional technologies with carbon free technologies, without entering in matter on the development of efficient radical environmental technologies that may result only by an important effort of cooperative developments, existing in fact only for nuclear fusion technology, and not simply based on spontaneous industrial efforts and public aids (Bonomi 2022). Furthermore, it exists the problem of the increased needs of energy of developing countries that, in absence of a valid substitution of conventional processes of energy production, would surpass the emissions of industrialized countries (Grubb M. Koehler J. 2002), that confirmed by recent data showing that the world major emitters of greenhouse gas are China, United States and India. In fact, considering the complete uncertainty existing on the time needed for the global arrest of greenhouse gas emissions, it is now important also to develop technologies able to mitigate the dangerous effects of global warming resulting by climate change scientific research (Bonomi 2022).

10. THE SOCIETAL NEEDS OF NEW TECHNOLOGIES

After the previous discussion on the various impacts of the physical aspects of technoscience on the society, it appears the need for the society of a great number of new technologies in order to face the discussed impacts. Actually, there are two impacts that present the need of a great number of new technologies, the first one is the use of AI with its great potentiality to increase the efficiency of technologies needing new applications and scientific research, the second one concerns technologies for the solution of the environmental problems of pollution, depletion of resources and global warming. In order to increase the generation of new technologies we may consider that, although technologies concerning AI may have a great development in the present technology innovation system based on capital strategies, that is not the the case of environmental technologies with the objective to improve the conditions of life of the society instead of just to have an economic growth. That leads to think to a new technology innovation system based more on knowledge, able to increase the formation of new technologies, than the present system based on capitals strategies. Considering the organizational systems for technology innovation cited previously, and consisting in industrial R&D, startups and venture capital and industrial platform, it is this last one to be based on the increase of the availability of knowledge instead of capital strategies as the other two (Bonomi 2020). The industrial platform coordinates the activity of subsidiaries supplying various services, of peer suppliers such as firms, research laboratories and startups that supply new technologies or their development, and of peer consumers that buy technologies from the platform, returning information about the use of technologies, realizing in this way a great exchange of knowledge among the actors of the platform. This system may evolve into a network of industrial platforms (Bonomi 2020) in which peer consumers focus their activity on the concept of the products using technologies supplied by the various platforms, while peer producers supply new technologies or their development to the various platforms of the network. This new technology innovation system would need an evolution of the present distributed innovation system (Haour 2004), based on firms realizing innovations, not only with their R&D facilities, but also by contract research, collaborations, funding or buying startups. In the formation of a platform network, firms producing technologies are transformed into platforms, firms making products focus their activity on their concepts using technologies supplied by the platforms network, and peer producers supply technologies or their development to the various platforms. In this system there is a great exchange and generation of knowledge among its actors boosting in this way the formation of new technologies satisfying the cited needs of the society.

11. Conclusions about the impacts of technology

We may summarize the impacts of modern science and technology as follows. The first impact appeared after the bombing of Hiroshima, resulting in fears and opposition to nuclear technologies for the production of energy, despite these technologies are indispensable to substitute completely the conventional technologies of production of energy and to limit global warming (Bonomi 2022). Furthermore, the diffused lack of knowledge about modern physics, represented by quantum physics, have been at the origin of modern superstitions considering dangerous the microwaves and the use of GMO in foods. That would suggest the necessity of a more diffused knowledge of quantum physics through secondary education giving a more equilibrated view of the technologies derived from this discipline. Concerning the impact of technologies increasing the human intellectual capacities, although AI has great potential in applications, it presents physical limits being in fact a deterministic process producing a virtual intelligence. That has as consequence a limit for AI to consider its results in the frame of the complexity of the reality in which they are used, necessitating for this reason always a human supervision. Furthermore, we have cited the dangers of transfer of human rationality to machines, and the consequent loss of capacities of humans to operate without these machines. Concerning the environmental problems of technologies, there is an erroneous policy in their approach, based essentially on political agreements on reduction of emissions, neglecting the fundamental technological nature of these problems, needing technological solutions. In the case of global warming, the erroneous policies make highly uncertain the moment in which the greenhouse gas emissions will be stopped, raising the problem also to develop technologies to mitigate the effects of the global increase of temperatures (Bonomi 2022).

Finally, it would be of interest to look also to a possible future impact of technology concerning the evolution of a sector involved in the development of artificial insemination and manipulation of DNA in order to favorize the birth of healthy infants. In the future these technologies might allow the realization also of an artificial uterus, that making available by technology the complete transfer of biological human reproduction to a technological human reproduction. In addition, there are also the development of technologies for euthanasia, completing in this way the cession to machines, not only the human birth, but also the human death. That might be accompanied by a storage of various DNA controlled gametes, available for artificial insemination and uterus, making possible the birth of an infant à la carte, separating completely with technology the reproduction from sexuality. It is hard to think which would be the consequence in the society of the future availability of these technologies but, as in the case of transfer of rationality to AI machines, it is necessary to think which will be the possible negative consequence, and to consider the necessity of a suitable education and possibly even the use of a precautions in ruling the development and use of these technologies.

Concluding, taking account of a physical view of the nature of technology with its impacts, it is necessary a more equilibrated vision of the relation of technology with the society, avoiding consequences of a dangerous attraction of its potentialities, or of the refusal of its benefic uses, contrasting the illusion of a possible human return to the nature without technologies. All that may contribute to a real human sustainability from the technical, economic and social point of view.

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