

TECHNO-SCIENCE AND CONSILIENCE AS AN AGENDA FOR THE PHILOSOPHY OF TECHNOLOGY

Tecnociencia y consiliencia como una agenda para la filosofía de la técnica

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Abstract

The article addresses a novel topic that has recently had very diverse treatments. Some of its objectives could be the following: it aims to point out some of the paths taken in the dialogue between science and technology over the last few decades and briefly describe the milestones that have led from classical (Newtonian) science to current techno-science. In the background, also offer a few brushstrokes on the new philosophy of technology, which is built apart from old humanist prejudices, which has the theoretical development of consilience and does not want to be directed primarily or exclusively towards engineering. In short, a philosophy of technique with a new 'agenda'. The work has large blocks: the first describes the project of techno-science in its historical perspective. In a second moment, the aim is to situate technique in the history of sciences and techniques. The third part deals with the possibility (and also the need) for a new vision of these subjects, which has been called a sapiential and transdisciplinary vision. Finally, in the fourth part, some steps are being taken in the field of technical philosophy under this new perspective, which could be considered as conclusions, the new 'agenda': the emergence of ethical approaches (among others, that of responsibility) and new visions of science-technology-society.

Keywords

Consilience, technoscience, Big Science, philosophy of technology, STS (Science Technology and Society).

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Resumen

El artículo afronta un tema novedoso que ha tenido recientemente tratamientos muy diversos. Algunos de sus objetivos podrían ser los siguientes: pretende señalar algunos caminos realizados en el diálogo entre ciencia y técnica a lo largo de las últimas décadas y describir sucintamente los hitos que han conducido desde la ciencia clásica (newtoniana) a la tecnociencia actual. En el fondo, ofrecer también unas pinceladas sobre la nueva filosofía de la técnica, que se construye apartando viejos prejuicios humanistas, que cuenta con el desarrollo teórico de la consiliencia y que no quiere estar dirigida ni principalmente ni exclusivamente hacia la ingeniería. En definitiva, una filosofía de la técnica con nueva 'agenda'. El trabajo tiene cuatro grandes bloques: en el primero se describe el proyecto de la tecnociencia en su perspectiva histórica. En un segundo momento se pretende situar la técnica en la historia de las ciencias y de las técnicas. La tercera parte aborda la posibilidad (también necesidad) de una nueva visión de estos temas, que se ha dado en llamar visión sapiencial y transdisciplinar. Finalmente, en la cuarta parte, se señalan algunos pasos que se están dando en el campo de la filosofía de la técnica bajo esta nueva mirada, lo que podrían ser consideradas como las conclusiones, la nueva agenda: irrupción de enfoques éticos (entre otros, el de la responsabilidad) y nuevas visiones de ciencia-tecnología-sociedad.

Palabras clave

Consiliencia, tecnociencia, Big Science, filosofía de la técnica, STS (ciencia, tecnología y sociedad).

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Introduction

The history of the relationships between sciences and techniques is very complex and has been the subject of many studies and perspectives (both historical and thematic). Some have described the technique as applied science (Mario Bunge). Others have reduced, at least at some point, science as a mere instrument of technique (perhaps Martin Heidegger, Nicholas Resher, perhaps Javier Echeverría). This reduction has sometimes been able to conclude in a total identity. For some, this would be the complex techno-science itself (S. Lelas, M. Bunge, etc.).

The article aims to show how to see techno-science on a broader horizon that includes autonomy or independence and at the same time mutual interaction.

Some of its objectives could be elucidated as follows: we aim to point out some paths made through the dialogue between science and technology over the last decades and succinctly describe the milestones that have led from classical (Newtonian) science to current techno-science. At the same time, bring within the reach of philosophers and historians of science some brushstrokes on the new philosophy of technique, which has been built on a constant departure from old humanist prejudices, which has always had the theoretical development of consilience and that does not want to be directed, neither principally nor exclusively, towards engineering. In short, a philosophy of technique with a new 'agenda'.

The word “consilience” is quite novel and snobbery—you might say—and does not appear in the scientific literature until very recently. It was coined in the twentieth century and refers to long-standing separate research fields that come together to create new ideas, establish creative synergies, as has happened in some fields of contemporary science, for example, in molecular biology, the result of the convergence of two major disciplines such as chemistry and genetics.

This article has four parts: the first describes the technoscience project in its historical perspective. In a second moment, we intend to place the technique in the history of science and technology. The third part addresses the possibility (also need, to a large extent) of a new vision of these issues, which has been called the transdisciplinary knowledge and/or perspective. Finally, in the fourth part, some steps are being taken in the field of technical philosophy under this new look, which could be considered as the conclusions, the new ‘agenda’: irruption of ethical approaches (between others, that of responsibility) and new visions of science-technology-society.



The techno-science project

Techno-science is a recent discipline, but with deep roots in the history of ideas, which collects and attempts to respond to the debate about the separation between science (theoretical) and technology (practice), especially maintained by philosophers. The emphasis that the term techno-science puts on technology, as well as the intensity of the connection between science and technology, varies. In addition, most scientists and philosophers of science continue to externalizing technology as applications and consequences of scientific progress. However, they recognize that the success and efficiency of technology promote the realism, objectivity, and universality of science.

The prehistory of the technoscience concept dates back, at least, to the beginning of modern science. Francis Bacon (1561-1626) in *Novum Organum Scientiarum* explicitly associated knowledge and power; science provided knowledge of the effective causes of the phenomena and, therefore, the capacity for efficient intervention within them. Bacon was the first great thinker to describe how science should be done and explain why. Scientific knowledge should not be gathered by itself, but for the practical benefit of humanity. Finally, Bacon promoted experimentation,

getting to outline and define the rigorous procedures of the ‘scientific method’ that today, with small variations, remain in force.

The concept became clearer during the first half of the twentieth century. Gaston Bachelard (1884-1962), in *Le nouvel esprit scientifique* (1934), places the new scientific spirit under the preponderant influence of mathematical and technical operations and uses the technique of scientific expression to designate contemporary science. However, the term techno-science itself was not coined until the 1970s.

We intend to point out some paths made in the dialogue between science and technology throughout recent times and succinctly describe the great milestones that have led from classical (Newtonian) science to current techno-science, including some of its latest developments. In the end, also offering some brushstrokes on the new philosophy of technique, which is built away from old humanistic prejudices, which has the theoretical development of consilience and does not want to be directed, either principally or exclusively, towards engineering. In summary, a philosophy of technique with a new agenda.

The history of techno-science

The first important appearance of the term takes place in the title of the article “*Ethique et technoscience*” by Gilbert Hottois, first published in 1978 (Hottois, 1996, 1999; cf. Agora, 2005, pp. 149-175). This first use expresses a critical reaction against the theoretical and discursive conception of contemporary science, and against blind philosophy towards the importance of technology. Associate technoscience with the ethical question: What are we going to do with human beings? Raised from an evolutionary perspective open to technical intervention.

Throughout the 1980s, two French philosophers, Jean François Lyotard and Bruno Latour, contributed to the dissemination of the term in France and North America. For Lyotard, technoscience carries out the modern project of the human being, as argued from the work of René Descartes (1596-1650), as master and possessor of nature. This project has become very technocratic and must be denounced because sometimes it is politically associated with radical capitalism.

In *Science in Action* (1987), Latour uses the plural ‘technosciences’ to underline his empirical and sociological approach. Technosciences refer to those sciences created by human beings in real-world socio-economic and political contexts, by conflicts and alliances between humans and also between human and non-human (institutions, machines and ani-



mals among others). Latour insists on networks and hybrid mixtures. He denounces the myth of a pure science, rejecting any philosophical idea of a science that is supra or extra social and apolitical. Latour has contributed to the success of the term technoscience in the socio-constructivist discussion since the 1990s.

Donna Haraway's work¹ illustrates well the diffusion of technoscience mixed with the postmodern and socio-constructivist discussions of North America. Technoscience becomes a word-symbol of the contemporary tangle of processes and interactions (science, technology, societies, etc.), including all kinds of elements, from purely symbolic practices to the physical processes of nature in global networks, productions and exchanges.

In continental Europe and in Latin American countries, the use of the term technoscience has often remained closer to its original meaning, which implies the ontological (such as the German philosopher Martin Heidegger, 1889-1976), the epistemological and the ethical questioning. In fact, in a perspective that complements what I have provided here, in *The Technoscientific Revolution* (2003), Javier Echeverría offers an extensive analysis of technoscience as a concept and phenomenon. However, political use is not uncommon, especially in France, where there is a tendency to attribute to technoscience a series of contemporary evils such as technicality and technocracy, multinational capitalism, economic neoliberalism, pollution, the depletion of natural resources, climate change, globalization, planetary injustice, disappearance of human values, and more, all related to US imperialism.

The common archetype of technoscience is Big Science,² originally exemplified by the Manhattan Project (Guerrero and Vega, s/f), which closely associated science, technology and politics. In this interpretation, technoscience is presented from the point of view of domination and control, and not from exploration, research and creativity. It is technocratic and totalitarian, not technopoietic and emancipatory.

Questions

What distinguishes contemporary science as technoscience is that, unlike the philosophical enterprise of science identified as a fundamentally theoretical activity, it is physically manipulative, interventionist and creative. The determination of the function of a gene, either to create a drug or to participate in the sequencing of the human genome, leads to the realization of technoscientific knowledge, power, and capacity. In a



technoscientific civilization, the distinction between theory and practice becomes blurred. Philosophers are invited to define human death or birth taking into account the consequences of these definitions in ethical-practical plans, that is, with respect to what will be allowed or not allowed (for example, the removal of organs or embryos) in experimentation.

With great clarity in the *Techno-scientific revolution* (2005), Javier Echeverría states:

Where there has been a radical change is in the scientific activity, in the very structure of what scientists and engineers do and it is manifested in research, development, and innovation. That is to say, it is not only about research, but technological developments that result in innovations that are put into practice in the market, in the business, in society (p. 19).

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Another very familiar example, especially for bioethics specialists, is that of experimental mice. Since the 1980s there has been a line of transgenic mice (*oncomouse*)³ used as a model for research on certain cancers. Here is an object both natural and artificial, theoretical and practical, abstract and concrete, alive and patented as an invention. Its existence and use in research also implied many different scientific and cognitive issues and interests: therapeutic, economic, ethical and legal. It is even a political problem because transgenic mice are at the center of a conflict between the European Union and the United States over the patentability of living organisms.

The most radical questions posed by techno-sciences have to do with their application to the natural (as a living organism formed by the evolutionary process) and to the manipulated (as a contingent creation of human culture). These questions become more rigorous when considering the immensity of biological, geological and cosmological temporality, as when asking: What will become of the human being in a million years? From this perspective, the investigation of human beings seems open not only to the symbolic invention (definitions, images, interpretations, values) but also to the techno-physical invention (experimentation, mutations, prostheses, cyborgs). Both approaches raise questions and responsibilities that are not alien to ethics and politics and ie should look at them critically.

Therefore, the word technoscience designates a complex network of contemporary science and technology, which has a special conceptual burden. Medina clarifies this aspect in his article “Technoscience, challenges, models” (2003):

In the field of science and technology, systems, subcultures and traditions correspond to specific cultural practices and legacies, embodied in the capabilities of the agents and in the material, symbolic and organizational environments of each scientific and technological field. These practices and environments, as well as the characteristic modes of innovation and stabilization of modern sciences and technologies, are fundamentally distinguished by their techno-scientific character, that is to say, by practices and environments in which the elaboration of precise conceptual and technical devices and the production and use of sophisticated artifacts and technological procedures intervene and interact. The same technologies constitute complex systems of artifacts and techniques that have been generated and stabilized in the context of theoretical and material practices and environments of a scientific nature. The framework between scientific systems and modern technological systems is so inseparable in practice that the use of the term technoscience to characterize current scientific systems and, in general, scientific traditions has been widespread since at least the end of the 19th century. (p. 25).



The complex interactions between science, technology, society and nature form an inseparable unit of fact and a network that can only be addressed in global and transdisciplinary studies. In a succinct way, with the help of Luis Silva Arriaga (2012), the characteristics of technoscience could be synthesized as follows:

- Descriptive, explanatory and predictive. Because it tries to describe the phenomena it studies explaining how they work and anticipating how these phenomena will behave in the future.
- Methodical and systematic. Because it follows certain guidelines or methods to account for its research and is articulated within a system of theories that support it.
- Verifiable. Since its theories and methods are public.
- Clear and precise. Because the explanations must be exempt from all ambiguity.
- Objective. To avoid by all means the subjective vision of the researcher.
- Provisional. Because the knowledge tested today can be refuted tomorrow by superior knowledge.
- Critical. To permanently question the provisional knowledge that has not yet been refuted (p. 2).

Technique on the horizon of the history of science and techniques

Since Antiquity (it would be necessary to go back to Greek thought), but more noticeably since the scientific revolution of the 16th and 17th centuries (Modernity), humanity has been strongly influenced by science. The prestige achieved by science has given it the role of the most important rationality and catalyst of social change.

Above all, modern science is constituted as a clear and precise project, especially since Newton. It is not that it wasn't definitively configured from the beginning, but it is a century later, with the powerful influence of the Laplace school, when Newton, the new Moses, becomes the symbol of the European scientific revolution. It will definitely be the 19th century that gives Newton's name a magical and exemplary power in which all science tends to converge. Some see in his method an idea of a mathematical experience protocol. For others, the central idea is to isolate a specific fact from which everything can be deduced. Each one makes his own hypothesis of the value of the Newtonian doctrine, although all recognize that some of the dynamic concepts that Newton has introduced constitute a definitive acquisition, and, even for some, as for his disciple Pierre Simon de Laplace (1749-1827), an unbeatable roof.

The strength of Newtonian synthesis is/was incredible. The common aspirations to the science of all time, the desires of unified science, are collected and grouped, although its final resolution is never reached, since the questions that are at the base never lose their generating force.

He shares with the mythical stories the attempt to explain and interpret the organization of the world and the situation of human society in the midst of nature, but it departs from the mythological question when it comes to verification procedures and critical discussion. However, philosophy and science often carry parallel or even convergent discourses, even though they are both discourses of a critical nature.

For some, the uniqueness of modern science is characterized by an experimental dialogue, by the encounter between technique and theory, the systematic 'alliance' —again the keyword (Prigogine and Stengers, 1990a, pp. 29-48; cf. 1990b)— between the ambition to model the world and to understand it. It is true that this relationship did not bring only advantages. The experimental dialogue founded the originality, the specificity and the limits of science, but at the same time, it was put before a simplified nature, prepared, sometimes mutilated according to the previous hypothesis, the one which experimentation interrogates.



This science, due to its intrinsic dynamics and the sociocultural circumstances that surrounded it at the time of its birth, becomes a myth and thusly has remained until the second half of the twentieth century. The theoretical content of classical science has contributed, without any doubt, to stabilize the myth of omniscient knowledge.

The Newtonian laws of the movement make a synthesis that had been projected for some time between two convergent developments. As Prigogine and Stengers (1990a) point out: “The one of physics —the description of the movement, with the laws of Kepler and those of the fall of the bodies formulated by Galileo— and that of the mathematics that culminates in the ‘infinitesimal’ calculation” (p. 228). With the concept of the infinitesimal quantity, they have a powerful instrument in their hands. The infinitesimal quantity, which results from a step to the limit and is defined as the variation of magnitude between two successive instants when the interval between the instants tends to zero, allows to describe, decompose the change, into an infinite series of small fields.

From now on, whatever the dynamic system, the shape of the laws of motion, $F = m \cdot a$, remains valid. This formula has three characteristics: legality, determinism, and reversibility. This reversibility is linked to the principle of sufficient reason, according to Prigogine and Stengers (1990b):

The impossibility of defining an intrinsic difference between before and after, to which dynamics is condemned, is evident to us today, but, already in its origin, it was both affirmed and concealed by a principle that, with the works of Galileo, Huyghens, Leibniz, Euler, and Lagrange, became the very principle of conceptualization of dynamics. Leibniz baptized it as “principle of sufficient reason.” In Leibnizian terms, this principle states the equivalence between the “full” cause and the “total” effect (p. 281).

But today it can be affirmed that the Golden Age of Newtonian science is over and that its rationality is not enough to unify knowledge. The imp of Laplace lacks two dimensions that currently seem indispensable for the understanding of the world: complexity and history.

The second half of the twentieth century offered, among others, a special, different image of science. It is what is called technoscience. This is characterized by the fact that there is no scientific progress without technological advancement and vice versa. The interdependence between science and technology is very narrow in the case of Big Science, and that is why it is convenient to distinguish between science, technique, technology, and technoscience.



Although science became hegemonic and sometimes despotic — as a consequence of the force it reached— the second half of the 20th century and the beginning of the 21st have meant a radical change for the consideration of almost all things, especially science. It could not be considered as an autonomous discipline, but rather, a mixture of various value systems that are deeply interwoven with each other and that can be described with these two statements:

- The philosophy of science cannot be limited to being a theory of scientific knowledge.
- The emergence of technoscience has changed the praxis of scientists and engineers.

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But what is this discipline that is the object of study? The title of the work of Alan Francis Chalmers (1988) *What is that thing called science?* which also had such importance in our culture, now serves as an epigraph to deal with a definition of science.

It is not easy to define science —Agustín Udías says (2010, p. 20)— . The American Physics Society set out to arrive at a definition, but after the attempt, it gave up on its purpose. The definition closest to the ideal they pursued is the following, according to Udías (2010): “A disciplined search to understand nature in all its aspects [...] demanding an open and complete exchange of ideas and data [...] and an attitude of skepticism about its own results” (pp. 20-21).

A new sapiential and transdisciplinary view

What is understood by the sapiential view? The qualifying sapiential almost always refers to an integrating and overcoming vision with respect to those at the base. In this context, talking about a sapiential view of science means that it must be accompanied by a well-founded philosophical worldview. Now it is understood that technoscience, that is, the new scientific conception that combines technology and science, implies a reference to a philosophical system from which it is allowed to talk about values and other elements that emerge from a philosophical conception.

In the encyclical *Fides et Ratio* (1998), John Paul II also spoke of a “sapiential dimension”, in this case of philosophy and theology. There it is stated that:

To be consonant with the word of God, philosophy needs first of all to recover its *sapiential dimension* as a search for the ultimate and ove-

rarching meaning of life. This first requirement is in fact most helpful in stimulating philosophy to conform to its proper nature. In doing so, it will be not only the decisive critical factor which determines the foundations and limits of the different fields of scientific learning, but will also take its place as the ultimate framework of the unity of human knowledge and action, leading them to converge towards a final goal and meaning. This sapiential dimension is all the more necessary today, because the immense expansion of humanity's technical capability demands a renewed and sharpened sense of ultimate values. If this technology is not ordered to something greater than a merely utilitarian end, then it could soon prove inhuman and even become potential destroyer of the human race.

In a similar way, one can extrapolate and say that ethics (philosophy) and sciences are called for greater integration and ethics can become that guiding discipline that drives sciences and techniques (technosciences) towards a definitive objective and meaning. This is what our "sapiential view" could, in the first instance, consist of.

The heading refers to another qualifier: transdisciplinary. What is a transdisciplinary relationship? In history, there have been many models of the relationship between disciplines. There are two broad categories in the models of relationship between the human sciences and theology: of a conflictive type (tension, exclusion, separation, closure or mutual ignorance) or of peaceful coexistence, characterized by a more or less stable balance between the partners (cohabitation, commitment, concord, reciprocal openness, and dialogue).

There are two types of dialogue: multidisciplinary and interdisciplinary (transdisciplinary). The multidisciplinary is that type of dialogue through which the representatives of both sciences become both listeners, receivers, and informants, based on a more complete knowledge of a common field of research. What does it require? Five characteristics necessary for a dialogue relationship can be identified:

- It requires that the two disciplines want to dialogue, and are interested in exchanging information (to which each discipline comes with its method).
- It is also necessary for both to give up the claim —almost always existent, although sometimes unconscious— to consider their discipline as the only valid scientific approach to reality. They must be open to what the other party can contribute.



- The dialogue must take place under the sign of provisionality. Both disciplines are contested; therefore, we must realize the provisional reality.
- Dialogue and confrontation should not occur on the abstract level, but in their concrete historical realizations.
- The other partner is also required to be able to understand the scientific procedures and the specific language of the other science.

The interdisciplinary dialogue adds only one novel fact to the previous one and is that of a greater relationship and overlapping of the various sciences. When the relationship allows for deeper exchanges, such as the use of common concepts, we are in the transdisciplinary field. For a dialogic relationship of these characteristics between sciences to be possible, the production of trans-specific concepts must occur (cf. Piaget, 1989; Groppo, 1991).

It could be concluded by trying to clarify if any philosophy serves to grant that sapiential view to science. The answer is flatly negative. Not all philosophies serve to offer a sapiential view, because many philosophies do not start from assumptions like those explained above, well defined and with the will to converge on common goals and objectives.

Consilience

Edward Osborne Wilson, distinguished professor emeritus of biology at Harvard University and recognized as, perhaps, the world's leading ant authority, opened a new field of science in the 1970s with his book *Sociobiology: The New Synthesis* (1975). He argued that social animals, including humans, behave largely according to the rules written in their own genes. The theory caused controversy because not only did it seem to contradict the precious beliefs about free will, but, according to critics, it evoked those racist ideologies of some human groups being biologically superior to others. The reactions were controversial. However, Wilson and some followers have defended and refined sociobiology over the years to such an extent that it is now a concept that is widely accepted in the scientific community, especially by a new generation of evolutionary psychologists. After many years, Wilson has offered us a new, potentially innovative book, *Consilience: The Unity of Knowledge* (1998), which has placed him at the center of debate and controversy once again. Some scholars have praised him as bold and provocative, while others have criticized him as intellectually unstable and poor.



The word “consilience” is strange and does not appear in *Webster’s New World Dictionary* or in other famous dictionaries. As already said, it was coined in the last century and refers to long-standing separate research fields that come together and create new ideas (chemistry + genetics = molecular biology). The controversy surrounds Wilson’s belief that every human effort, from religious sentiments to financial markets and fine arts, is likely to be explained by hard science. Philosophers and artists get angry at what Wilson calls his “unification agenda,” his attempt to show—as he said—that the greatest enterprise of the human mind has always been and will be the attempt to link science with the humanities.

The essence of Wilson’s argument in his book *Consilience* is that the scientific method can be successfully applied to the humanities and social sciences. In fact, the seemingly divergent disciplines of natural sciences and social sciences study the same world and, therefore, there should be a way to reconcile differences in progress in the two areas of study.

Some ideas of Wilson (1998) are rooted in the Enlightenment. He specifically quotes Marie-Jean-Antoine-Nicolas Caritat, Marquis de Condorcet (1743-1794), to whom he also attributes the incorporation of the spirit of the times: “The universe, known or unknown, is necessary and constant. Why should this principle be less true for the development of the intellectual and moral faculties of man than for other operations of nature?” (P. 21).

It should be remembered that this concept had previous circulation. The word consilience was originally coined in terms of “consilience of inductions” by William Whewell (1794-1866) (consilience refers to a “jumping together” of knowledge). The word comes from the Latin *com* (together) and *siliens* (jumping)—as in resilience—.

Wilson (1998) argues that nothing in the world makes sense unless there is a theory to explain it (p. 56). This theory is provided by science, which is the “organized and systematic enterprise that gathers knowledge about the world and condenses knowledge into verifiable laws and principles” (p. 58). For Wilson, the fact that science produces useful laws about the world, in general, is the main attraction of disciplines.

From this desire to generalize both the sciences and the humanities in a unitary formula to find objective truth, the doctrine of logical positivism emerged. The objective of this tension of thought was to unify the scientific method with that of the humanities and, according to Wilson (1998), its failure was caused only by the lack of knowledge of neuroscience (p. 67).



This attempt at unification has been at the base of other claims such as that of Ilya Prigogine and Isabelle Stengers (linking humanities and sciences through a new concept of time, *The Nouvelle Alliance*, 1978), Charles Percy Snow (The Two Cultures, 1959) and Edward Osborne Wilson himself (*Consilience: The Unity of Knowledge*, 1998). Each attempt brings new tools, but even in the midst of progress, the ultimate goal of the unification of knowledge is perceived far away.

In part, the difficulty arises when describing complex systems, since dissection is easier than building something new; It is easier to separate a group of ideas to see why they should work together instead of visualizing all the ideas in the sequence that leads to our current knowledge base. In fact, many of the problems of the social sciences arise from the simplification of the problems beyond the point at which the theory that arises, as a result, is useful. Human interactions are immensely complicated and are not adequately explained by the hypotheses of social scientists.

This does not mean that the natural world is not complex. The interaction and evolution of species are complex and iterated games that are difficult to analyze. There are too many variables that influence, for example, genetic evolution. However, according to Wilson (1998), genes and culture are inseparably linked, there is no way to have one without the other (p. 138).

The crux of his argument is that everything can be reduced to simple physical reactions at the molecular level (p. 291). In essence, both natural sciences and social sciences study situations that arise from the same interactions. The goal of consciousness is environmental conservatism since the unification of the two disparate worlds of study will lead to a greater understanding of man's place in the world and its effect on it. Science has the ability to understand and remedy environmental problems, but only the humanities and social sciences have the ability to reach a group large enough for these advances to take place.

Wilson's goal is noble, but his examination of the current state, both of the social sciences and the arts is insufficient. Specifically, his examination of economic thought leaves much to be desired. However, he acknowledges that, although there are very simple parts of economic theory, there are others, such as the theory of social choice, that are dense and complex and that, in any case, the failure of social sciences to predict human behavior will not be due to any lack of competence on the part of scientists, but because of the unpredictability of the human condition.



Beyond epistemological and humanistic prejudices

The technique, the techniques, have been marginalized throughout the history of ideas until not long ago. The origin of this marginalization should be sought in the philosophical tradition that from the beginning separated *techné* and *episteme*, *poiesis* and *praxis*. Plato and Aristotle would be at the base of this dichotomous separation that brought strong consequences for the understanding of a science and a technique and technology in good relations. Thus, according to Manuel Medina (1995):

The theoretical separation of the technique with respect to science and the humanities configures the philosophical prejudices that have accompanied the long history of philosophy and its relations with the technique, even marking the modern philosophy of technology and facing different currents within it. Overcoming these prejudices, both in the philosophy of technology and in the philosophy of science, involves the integration of both into a philosophy of technoscience, within the current interdisciplinary studies of science and technology (p. 180).

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Aristotle himself in the fourth chapter of Book VI of the *Nicomachean Ethics* (1987) offers us both epistemological and philosophical prejudice. For him “all *techné* is the ability to produce material objects in accordance with a true *logos*” (p. 272). For many authors, here we would find the ‘epistemological prejudice’ (*meta logou alethous*), that is, the *techné* is subordinated to the *episteme*, but also the foundations are laid, after the separation between technique and knowledge or theory, of the primacy of theory on praxis (‘philosophical prejudice’).

The later history is well known. Until the late nineteenth and early twentieth centuries, there has been no notable development of the philosophy of technique capable of reorganizing these contents in another way. Some significant figures in this intellectual process were Karl Marx, Ernst Kapp (*Grunlinieneiner Philosophie der Technik*, 1877), Friedrich Dessauer (*Philosophie der Technik*, 1927), José Ortega y Gasset (*Meditation of the technique*, 1939) and Martin Heidegger (*Die Frage nach der Technik*, 1954).

The philosophy of technology as such arises in the 60s and 70s of the 20th century: Joseph Agassi, Mario Bunge, Lewis Mumford, Henryk Skolimowski, Paul Durbin, Friedrich Rapp... from that time to the present it would be very difficult to recount the history of everything that has happened, given the plurality and heterogeneity of approaches, but it is possible, following Manuel Medina (1995), to affirm that there are two great blocks: a humanistic approach and another of more analytical and

epistemological character. The truth is that even in these new approaches the old prejudices that have been talked about remain.

From the new studies of the philosophy of technology, the result of a 'technological turn'⁴, appreciable in our culture and that reverses the old assumptions and prejudices about the relations between technology, science, and society (Achterhuis, 2001, p. 190), the first fruits have been produced. In prehistory, John Dewey can be placed (cf. Hickman, 1990). According to Larry Hickman (1990), Dewey had a clear interest in technology. He went unnoticed in many later authors because he did not dedicate a monographic book to this issue, but he is certainly at the foundation on some of the arguments that ended the primacy of the theory of praxis in the philosophy of science and technology (Esteban, 1999, p. 138).

Other significant authors are Paul Lorenzen (1974), promoter of the systematic constructive theory of science. From philosophy, Ian Hacking (1999), who has been unchecked from analytical prejudices to approach a more technology-focused vision. From the field of sociology of science, Andrew Pickering (1995) proposes a post-humanist analysis of scientific practice.

I conclude with Medina (1995), who has served as a guide on this tour, stating that:

In any case, if the philosophy of science and the philosophy of technology are to have a future that is to become part of the already well-stocked philosophical museum, they will have to overcome the old prejudices both humanist and epistemological, to integrate interdisciplinarily into current science and technology studies. Meanwhile, we should start by integrating both into a post-epistemological and post-humanist philosophy of technoscience, in accordance with the principle that what comes together in practice and culture should not be academically separated (p. 194; cf. Ihde, 1991).

Beyond an engineering-oriented technology

Contemporary technological philosophy oriented towards society evaluates technology in a broader way than the ethics of technology. However, it also lacks a developed theory of value, whereby the different aspects that are at stake in relation to technology can identify and balance each other. Therefore, it should be noted that current approaches also have their limitations to address the first question, regarding the nature of technology and engineering. However, it mainly concerns technological ethics and the philosophy of society-oriented technology.



It should also be borne in mind that the field would benefit greatly from the development of value theories specifically oriented towards technology, distinguish different types of value, relevant to assess the consequences of technology and analyze how such values are promoted or hindered through the design and use of technologies, artifacts, and processes.

A second way in which the philosophy of technology has not advanced much is that various philosophical studies that focus on the implications of technology are not based on developed theories of society and its interaction with technology.

In general, what is needed in this field is a greater number of theories developed to study how technological artifacts interact with aspects of society, as well as better reports of these social phenomena themselves. These theories can be taken from STS (Science, Technology & Society) or other social sciences (in line with the 'empirical turn'), or imported from a general philosophy, but we must keep them more present in our work (cf. Stirling, 2007).

Third, it is possible to consider some limitations that are specific to current technological ethics. Most importantly, there is a great lack of reflection in the general ethics of technology, as opposed to the applied ethics of specific technologies. Properly, very little work is being done to advance in the field of the ethics of theoretical or methodological technology. The 'empirical turn' has not yielded a single paper on technological ethics that presents theories and methods to address the field.

Another related criticism is that very little work is being done to address the question of how new technology can be developed in a morally responsible manner. On the one hand, technology ethics focuses mainly on ethical and social issues related to existing technologies and, on the other, on the overall responsibilities of engineers.

What is missing are effective models that allow us to evaluate how the accepted norms and values can be taken into account when developing new technologies and how to anticipate moral and regulatory problems with respect to future applications. That is, what is missing are effective models for the ethical evaluation of technology and for the ethical development of new technology.

Finally, it is worth expressing some concern about the possibility that the philosophy of society-oriented and engineering-oriented technology can be separated. The two approaches obviously have a theme that is very different, but both approaches can benefit from each other.

The philosophy of engineering-oriented technology develops theories of artifacts and technological practices, design processes and the



relationship between design and the use that can be made of the philosophy of technology-oriented society. The latter develops theories of society-technology relations that can be used by the former to include better descriptions of the social context of engineering. The hope is that these two approaches do not diverge, but rather interact and mix in those areas where there are common concerns (cf. Jaramillo, 2015, pp. 315-317).

Possible new agendas of the philosophy of technology or techno-science

What has been discussed in the previous section is that, despite the impressive achievements in the field over the past 25 years, there is still much room for progress. In what remains this article, some suggestions are made as to how the challenges posed can be accepted.

There are encyclopedias, such as that of *Ethical Science and Technology* of Mitcham (1985/2005). There are monographs with the classical approach, such as Hans Jonas (1995) *The Imperative of Responsibility*. But there seem to be no studies on general technology ethics after the 'empirical turn' and very few even with a focus on the applied forms of technology ethics.

Many of the new approaches that are on the horizon try to develop theories that allow for extensive evaluations of different technologies and technological practices based on ethical and unethical values. But for basing a serious philosophy of technology, a theory of value is needed that considers the relationship between technology and the realization of value. This theory would distinguish different types of values, such as ethical, aesthetic, cultural, social, economic, etc., but also the intrinsic and instrumental value adhered to technological artifacts and processes in society (cf. Echeverría, 2002).

Second, we must develop a view of how such values can be compared with each other. How to compare the value of security with that of privacy and determine which one is more important? How to compare the value of a strong economy with that of a clean environment?

Thirdly, consideration should be given to how values are materialized and promoted with technology. Can technological artifacts incorporate values and what other factors besides technology determine whether values are promoted or hindered when technologies are used? The third of these topics was addressed in theories of values in design as Helen Nissenbaum (1998) and value-sensitive design by Friedman and



Kahn (2003), and by Thomas Misa, Philip Brey and Andrew Feenberg in *Modernity and Technology* (2003), among others.

A second necessary improvement in the field that I identify is the development of more and better theories of the relationship between technology and society. An approximate distinction of two types of theories can be made. Theories of human-technology relations are theories at the micro-level that describe how human beings relate to and interact with technological artifacts or engage in technological practices (first). Theories of technology-society relations are theories that describe how products and technological practices relate to and interact with aspects of society (second). These are *macro* and *meso* level theories that describe, for example, how technological artifacts can influence political processes or how technological design processes interact with economic processes. Currently, there are few such theories in the field that have gained wide acceptance. There are some that are influential, such as the phenomenological theory of human-technology relations of Don Ihde (2004), the theory of the network of actors of Bruno Latour (2005), the theory of the politics of artifacts by Langdon Winner (1983) and the theory of technological rationalization by Andrew Feenberg (2009, 2013). However, these are theories that are oriented to specific issues and questions, and we need additional theories to cover new problems that arise.

To better understand human-technological relationships, theories of the interaction between artifacts and technological practices would be needed, on the one hand, human perception, cognition, action, experience, identity, body image, moral development, moral deliberation, human nature, and basic beliefs and values, etc. on the other. There are currently few such theories in the field and practically none that have widespread support.

To advance in this field, it is possible to prioritize the development of two types of theories of the relationship between technology and society. The first is the development of theories of technology agency: how do artifacts and technological practices affect the environment in which they are presented and used? How do they work to generate consequences? The second is the development of the theories of technology and Modernity: macro-level theories that relate the dynamics of technology with the basic structures and institutions of modern society (Feenberg, 2003).

The third and final challenge refers to technological ethics. In this field, there is a need for the development of theories and methods in various areas. It is necessary to understand how the use or presence of technology influence the moral dimensions of human action and individual responsibility. The pioneering work of Hans Jonas (1995), *The Imperative*



of Responsibility, is valuable for this purpose, but theories are needed that after the ‘empirical turn’ also address this issue.

These are exciting times to develop the philosophy of technology from the perspective of techno-science. Much progress has been made in recent decades and the field is maturing well. However, now is the time to take the field to the next level and strengthen theory and application. To grow more as a field of study, it should be demonstrated that there is more to offer than a series of interesting theories and points of view. It would be necessary to show or demonstrate that in this field there are many people who work together on joint problems, in which there is a constant dialogue about the best way to address them and in which people are aware and rely on the work of others.

These could be some of the brushstrokes of the philosophy of technology and its future agenda.

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Notes

- 1 Technoscience studies from a feminist perspective are “a field under construction” (Åsberg & Lykke, 2010, p. 301).
- 2 Big Science was a major change in scientific practice: concentration of human and material resources in a few research centers; specialization of work in laboratories; development of scientific projects with political and social relevance, which contribute to increasing military power, industrial potential, health or national prestige; interaction between scientists, engineers, industrialists and military; bureaucratization and politicization of science and technology; loss of autonomy of science; high risk of its possible impacts; among others.
- 3 The *oncomouse* is one of the first transgenic animals that have been produced. Researchers at Harvard Medical School in the early 1980s produced a genetically modified mouse that was prone to cancer because an oncogene was introduced that can cause tumor growth. The *oncomouse* (from the Greek word meaning tumor) was conceived as a valid means of advancing cancer research. Harvard University tried to obtain patent protection in the US and other countries, however, as is logical, a wave of reflection on the ethical problems that arose soon developed (Rodríguez, 2007, pp. 25-40).
- 4 Technological turn or empirical turn, which will appear more times, is a term coined by Achterhuis and which refers to the change of epistemological approach to science and technology that has taken place in the last third of the twentieth century (cf. Achterhuis, 2001; Franssen et al., 2016; Verbeek, 2005).

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