INTRODUCTION TO ETHICS OF SCIENCE AND TECHNOLOGY

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Summary

Traditionally there have been two opposite conceptions concerning the ethical problems of science and technology. On the one hand, there is a view which argues that science and technology, *per se*, are ethically neutral, and that problems arise only when, and

insofar as, scientific knowledge is applied or technology is in fact used to obtain wrong ends. According to this view, aims that are pursued through the application of knowledge, as well as their non-intended consequences, may be evaluated from an ethical point of view; however, *pure science* and *pure technology*, it is argued, are value free, at least free of non-epistemic values, and they are, therefore, neutral from an ethical point of view. This position is known as the neutrality thesis with respect to science and technology. The opposite point of view argues that neither science -not even with respect to the generation of knowledge- nor technology is free of ethical norms and values, and it is possible to judge them from an ethical standpoint. Some of the main ethical problems raised by science and technology are discussed in this article having as its axis the controversy over the neutrality thesis. The ethical problems raised by science and technology have become more acute since the emergence in the 20th Century of new systems where knowledge is produced and applied, called "technoscientific systems". The Manhattan Project —the construction of the atomic bomb—, was one of the earlier technoscientific systems; biotechnological systems constitute nowadays paradigmatic examples. In this article a characterization of such systems is discussed, having in mind the ethical problems they pose, and their differences with scientific and technological systems are analyzed. Ethical responsibilities of scientists, technologists, institutions, firms, policy-makers, governments, international organizations, as well as citizens are also discussed. Some ethical dilemmas, both in the context of research and concerning applications of science and technology, are also analyzed. Finally, problems of experimentation with human beings and with animals are examined and special emphasis is put on the effects of science, technology and technoscience in society and the environment.

Introduction: value free science and technology?

It would be tempting to open the discussion of the ethical problems facing science and technology by focusing separately, on the one hand, on issues concerning the generation of scientific knowledge and, on the other, on problems of its application and their consequences. However, although this distinction is useful for some analytical purposes, it is biased and misleading, insofar as actual scientific and technological practices involve both the generation and application of knowledge. Furthermore, from that perspective, technology is conceived as applied scientific knowledge; a very controversial way of understanding it, as we shall see.

It is indeed very common to make a distinction between *pure* and *applied* scientific knowledge. Nevertheless, when the problems at issue are ethical, this categorization favors the so called *neutrality* thesis, namely, that science and technology, *per se*, are ethically neutral, and that problems arise only when, and insofar as, scientific knowledge is applied, and technology is, in fact, used to obtain wrong ends. According to this view, aims that are pursued through the application of knowledge, as well as their non-intended consequences, may be evaluated from an ethical point of view. However, *pure science* and *pure technology*, it is argued, are value free, at least free of non-epistemic values, and they are, therefore, neutral from an ethical point of view.

The opposite point of view to the neutrality thesis argues that neither science -not even with respect to the generation of knowledge- nor technology, are free of ethical norms and values.

As we shall see, the controversy and its possible solutions turn around the way in which science and technology are conceived. It must be acknowledged, however, that both points of view accept that scientific and technological systems have an impact on individuals, on society and on the environment. It is, therefore, worth discussing the question of what kind of evaluations those systems may be subjected to, according to each of these positions, and the extent to which value judgments with respect to them - especially ethical evaluations- are seen as the exclusive competence of scientific and technological experts, or whether it is admitted that they can also be evaluated, in a legitimate way, by individuals and groups other than those having undergone scientific and technological training.

We will also examine arguments to the effect that science and technology pose ethical obligations not only to scientists and technologists participating in the generation of knowledge and in its applications, as well as in other technological practices, but that in evaluating scientific and technological systems and their effects, every citizen – particularly those affected by their consequences - not only can and should take part in the mechanisms of ethical evaluation, but also have an ethical duty to do so.

We shall begin by discussing the two opposing theses concerning the ethical neutrality of science and technology. Since the discussion revolves around the ways in which both science and technology are understood, it is necessary to first review the concepts of science and technology, and their relationships.

1. Science, Techniques, Technology and Technoscience

1.1. Science

Scientific knowledge is often understood as *pure knowledge*, unrelated to values other than epistemic values (e.g., coherence, truth, verisimilitude, simplicity, fecundity, explanatory power), and also unaffected by human passions. This is the meaning reflected, for instance, in the second sense given by the *Compact Oxford English Dictionary*, where science is defined as "a systematically organized body of knowledge on any subject".

This is a line of thought followed by many people, including many scientists. One leading Mexican scientist for instance, Ruy Pérez Tamayo in his book of 1989 has characterized science as a creative human activity whose aim is the comprehension of nature, and whose product is knowledge obtained by reliable methods, and which aspires to obtain as much rational consensus as possible

These attempts to characterize science, focusing on its epistemological aspects (knowledge production by reliable methods), are adequate when the interest resides mainly in analyzing the reasons why it is rational to trust scientific knowledge, and to what extent we should do so, that is, in defining the limits of this trust from an

epistemological point of view. However, this approach is biased with respect to the controversy over the ethical neutrality of science, since, in its very definition of science, it overlooks the role of the agents generating knowledge, who are people of flesh and blood, with interests and emotions, who resort to specific means to obtain their desired ends (knowledge), and who undertake actions and make decisions that can be evaluated according to sets of norms and values.

This is acknowledged in the first meaning given by the same *Oxford English Dictionary*: science is the intellectual and practical activity encompassing the systematic study of the structure and behaviour of the physical and natural world through observation and experiment. Although limited to the physical and natural sciences, and emphasizing its character as "study", this definition acknowledges the practical character of scientific activity, an aspect which, indeed, must never be overlooked.

This is a point of view that has been stressed by many philosophers who have considered science as something more complex than merely a body of knowledge. Mario Bunge (1996), for instance, has stressed that science is much more than a body of knowledge or a systematic study. For Bunge, science is rather a dynamic organism composed of practices, actions and institutions, oriented towards the achievement of specific ends, where emotions, desires, interests and values are determinant.

Following this line of thought, and inspired by a characterization of technology proposed by the Spanish philosopher Miguel Angel Quintanilla (2005), science could be characterized as a system of intentional agents who realize complexes of actions, guided by representations of the world –including sets of beliefs, theories, models of different kinds (mathematical, iconic, propositional). Agents within the system usually transform entities (objects, relationships), with the aid of instruments, with the *principal aim* of generating knowledge that has potential applications (technical, social, political, economical, cultural).

1.2. Technology

Something similar happens with respect to technology. Once again, the *Compact Oxford English Dictionary* offers definitions which are commonly accepted and very often used. Technology, according to that dictionary, technology is: 1 the application of scientific knowledge for practical purposes. 2 the branch of knowledge concerned with applied sciences.

These definitions go along well with the idea that that science is a body of pure knowledge. From this perspective, science would be neutral and ethical problems would arise only with respect to its applications.

Another common idea regarding technology is that it is composed mainly of artifacts and techniques. Thus, it is often said that there is a "new technology" available, referring, for instance, to a new kind of airplane, or a new type of motor car (producing less air pollution, for instance), where emphasis is clearly placed on the new kind of artifact.

We can contrast these conceptions of technology, as being just applied scientific knowledge, or just a set of techniques or artifacts, with the idea that what are central to technology are **technical systems**, which are composed of intentional agents, their actions, the aims they want to achieve, beliefs, knowledge, norms and values that operate when agents in the system realize actions, in order to transform objects, in trying to achieve their desired ends. When technical systems operate, they produce results. As Quintanilla says in his book of 2005, some of them may represent the ends the intentional agents were looking for, and others may be unintended consequences .The importance of this conception is that intentions, aims, means used to achieve them, and results can be evaluated from an ethical point of view.

A technical system may be very elementary, it may consist of one person, the intentional agent, having a definite purpose, say, to open a coconut, in order to drink its juice and eat its flesh. In order to achieve his end, the agent transforms a given object (say, using a stone to polish another one and manufacture a knife). Thus, there is at least one object which is transformed (a stone that becomes a knife by means of the agent's intervention). The product of this technical system is the result of intentional actions, where an object was transformed; in this case, the knife, which is an artifact.
Technical systems produce artifacts, and agents within those systems apply techniques. However, the unit of analysis, from this point of view, is the whole technical system, not the set of artifacts alone, nor the sets of techniques in isolation. Nonetheless, these two concepts are important for the concept of technical system and, therefore, that of technological system. Let us, therefore, further elucidate these three concepts (techniques, artifacts and technological system).

Techniques are systems of abilities and rules that are useful in solving problems. Techniques are invented, communicated, taught, learned and applied. For instance, we can speak of the "burin" technique for engraving, or techniques for the resolution of a system of equations. There are also publicity techniques for selling commodities, cloning techniques, etc.

Artifacts are objects that result from the transformation of other objects through the application of techniques. Artifacts are produced, manufactured, used and exchanged. We live surrounded by artifacts: TV sets, telephones, computers, cars, planes, trains, and genetically modified organisms. Additionally, a cloned organism, such as Dolly the sheep, is an artifact, since it is the result of a system of intentional human actions, where techniques have been applied on the basis of a complex of scientific and technological knowledge, and where some objects have been modified and transformed to generate a new object: the artifact (the creature Dolly).

Contemporary technical systems can be very complex. Let us consider, for instance, a nuclear plant, or a health system where vaccines are used. These are systems that include complexes of actions, together with scientific knowledge (from atomic physics in one case, and from biology in the other). Some authors restrict the use of the term "technological" to systems of this kind, that is, to systems that necessarily include scientific knowledge, and cannot operate without that kind of knowledge. It is thus possible to put forward the following characterization of a technological system.

A **technological system** is a kind of technical system. It is composed of intentional agents who pursue at least one end. Technological systems include those objects that are transformed by agents, in order to obtain specific ends, through the use of some instruments. A characteristic of *technological* systems, as opposed to mere *technical* systems, is that, in the former, scientific knowledge is used within the production process of the artifact that is the outcome of the system's operation.

Thus, for instance, a technological system may consist of an engineer who is trying to produce a new kind of air conditioning machine that will consume less electric energy and generate less pollution. The engineer may use some instruments to produce metal alloys that will be used in constructing the machine. In designing and constructing the prototype, the engineer may resort to chemical knowledge (scientific knowledge), in order to obtain the appropriate alloys for the body, and to manipulate gas reactions for cleaning the air in the pumps.

Within technical systems, intentional agents pursue their goals against a background of beliefs and values. This is the case in simple technical systems as well as in complex technological ones. Someone may want to polish a stone because he believes that it will serve well to cut fruit with. The polished stone is thus *valued* by the intentional agent. A group of people may want to produce a medicament, believing that it will help restore the normal functioning of human organisms with specific problems; we can thus assume that health is something of value to them. Thus, technical and technological systems also involve beliefs and values.

Regarding science as systems of intentional agents and actions, and technology as sets of technical and technological systems, has profound consequences with respect to the neutrality thesis. This, due to the fact that technical systems can be ethically evaluated (approved or condemned), according to the intentions of the agents, the ends those agents seek to achieve, the means they use to attain those ends, the results that are actually produced (some of them intentionally and some unintentionally) and, finally, both according to the way they treat human beings as moral agents and —as we shall see— according to the way they treat animals and relate to the environment.

1.3. Technoscience

Scientific and technological development in the 20th Century, particularly in its latter half, was marked by the emergence and growth of the kind of systems that many authors call "techno-scientific", not only where science and technology are indissolubly imbricated, but where the collaboration of different groups is required: scientists, technologists, managers and investors. As Javier Echeverría has clearly stated in his 2003 book *The Technoscientific Revolution*, these systems also require enormous amounts of money for their financing, so they are normally related to economically powerful groups and institutions, such as federal states or large companies. They are also often linked to military interests

Some paradigmatic examples of those techno-scientific systems are found in the area of nuclear research, in space exploration and computing sciences, as well as in the development of telematic networks. Without doubt, among the examples of techno-

science that today most readily capture the public's attention, as well as attract the largest economic and military interests, are biotechnology in general, and genomic research and genetic engineering specifically.

We may, then, propose the following characterization:

Techno-scientific systems are systems of intentional actions that are guided by beliefs, norms, values and rules, and that have scientific and technological foundations. They are related to research systems and institutions, but also to political, economic, business and, many times, military systems. As Echeverría clarifies, such actions are performed by agents, with the assistance of instruments, and are intentionally oriented toward the transformation of other systems, with the aim of achieving results that the agents consider valuable, and which, upon being applied, produce results that positively or negatively affect society and the environment

Technoscientific systems, like scientific ones, seek to describe, explain or predict facts. However, not limited to that, they also have, like technology, the central purpose of intervening in and transforming parts of the natural and social world. Although technosciences have enjoyed spectacular growth over the last three decades, and have displaced the traditional sciences and technologies in economic and social importance, these latter disciplines are far from having been eliminated. More properly put, today we are witnessing a coexistence of scientific systems, technical systems, technological systems and technoscientific systems.

Like their technical and technological counterparts, technoscientific systems are oriented toward the achievement of certain aims. A group of scientists and businessmen, for example, may try to produce a new vaccine for the market, or may seek to produce organs by means of cloning techniques. The systems include, then, agents having beliefs and values. The systems also include the objects that agents use for particular purposes (for example, instruments used to modify genes in order to produce organisms with particular phenotypic characteristics). Additionally, the systems contain at least one material object that is transformed (the genes that are modified). The result of the operation of the technoscientific system, the object that has been intentionally transformed by someone, is an artifact (e.g., a genetically modified organism, or cloned animal, such as Dolly).

2. Ethics and Morality

Prior to analyzing some aspects of the ethical dimension of science and technology, it is worth commenting here on some of the senses in which ethics has been understood, and opt for one that may prove fructiferous for the aims of this study.

The first thing that must be underlined is that there exists more than one correct answer to the question: What is ethics? There are, in fact, several ways to comprehend it. One of the most common considers it as a branch of philosophy that makes analyses and produces theories about the nature, function and value of moral judgments. Moreover, considering that one of the principal tasks of philosophy in the Socratic tradition is the exercise of the reflexive and critical faculty of human beings, this position would

consider that the fundamental objective of ethics is to rationally justify moral judgments, for instance:

human cloning for reproductive ends is ethically reprehensible

hen particular judgments on practical situations are analyzed, such as in the case of the foregoing example, some authors speak of *applied ethics*. Those who conceive of applied ethics in this way, consider, for example, that the analysis of the fundaments of moral judgments in relation to the phenomena of life is a type of applied ethics, which in recent years has been dubbed *bioethics*.

Another important meaning of the concept of ethics, related to the aforementioned, is that of ethics as a theory that, in addition to attempting to underpin moral judgments, tries to account for norms and moral values, for example, relating them to the ends that should follow human actions, when they are actions that we should – according to those theories – approve of from a moral standpoint.

Among the classic theories taking this direction, the so-called **teleological ethics** and **deontological ethics** are notable. The former derive their name from the Greek term ""telos", which signifies end or aim. The ethical task then is conceived as the elucidation of forms, by means of which one may achieve the end to which human actions should be directed. Among the most well-known is Aristotle's conception exposed in his book *Nicomachean Ethics*, which considered that the aim of human action should be happiness also, understood as the achievement of maximum pleasure, was the aim to which human action should be oriented, according to the so-called utilitarian theorists, such as Jeremy Bentham and John Stuart Mill.

Deontological ethics, on the other hand, emphasize duty. Their name comes precisely from the term *deon*, which means duty. These theories propose ethical norms, not from a standpoint of an aim that would be desirable to reach, but on the basis of certain conditions that —according to them— make human existence possible. In the history of philosophy, Kant's proposal stands out, with his famous categorical imperative, which has various formulations. One of them, written by Kant in the mid 1780's, is the following: "act only according to that maxim whereby you can at the same time will that it should become a universal law". A later formulation of 1788 states that we should never act in such a way that we treat Humanity, whether in ourselves or in others, as a means only, but always as an end in itself.

This Kantian thesis may be illustrated in the case of a terminally ill patient who suffers extraordinary pain, who has no hope of recovery and whose living conditions are increasingly more loathsome. If a person in that condition asks for help in quickly bringing to an end his distress, with the least possible suffering, we should ask ourselves if we would like to see the norm that states "it is right to help a terminally ill patient in that condition to die well", converted into universal law.

Kant's categorical imperative is the philosophical formulation of a rule that is frequently applied in everyday life: "Do not do unto others that which you would not have them do unto you".

These conceptions include the idea that ethics is the philosophical discipline the purpose of which is to lay the foundation for moral norms, which, at the same time, are interpreted as precepts that regulate interactions between individuals, in the sense that they establish the type of actions and interactions that are correct and those that are incorrect.

However, it should be clarified that the idea of laying a foundation has been principally understood with two different meanings, one, in the literal sense of "foundations", as in the cement foundations of a building. In that sense, to lay a foundation for the norms of coexistence would be to find the firm and immovable foundations that oblige us to accept those norms, at least if we behave rationally. In the other, weaker, sense, by laying the foundations for our ethical norms it is understood that we offer a reasonable basis for accepting them.

The approaches we have mentioned until now are committed to the first sense of foundation-laying, and, for that reason, they are usually linked to a particular conception of rationality. From this perspective, the difference between an authentic moral norm and a maxim that describes solely a custom of accepted fact in a social group, or in a particular society, consists in the fact that the authentic moral norm would be acceptable for any rational being who critically examined the norm in conditions that guaranteed the exercise of his rationality without constraints. The conception of rationality presupposed by this position may be called *convergentist*, because it affirms that, in the case of authentic moral norms, all rational beings who critically examine them will converge toward acceptance of the reasons that support the norm in question. It is understood that the foundation of the norm consists precisely in the elucidation of those reasons. Since it deals with reasons that any rational being would accept in conditions of exercising his unconstrained rationality, the foundation is considered absolute. This is an idea that can be attributed to Kant (1788) and other modern thinkers, as well as to contemporary philosophers like Habermas (1996; Habermas 1984, 1987) and Rawls (1971).

This conception of ethics has been criticized precisely for its commitment to a convergentist idea of rationality and with the belief in the possibility of an absolute foundation of moral norms. As a counterpoint to this view, another conception has been developed, which does not comprehend the work of ethics as that of laying a foundation for moral norms in the aforementioned sense, but rather in that of proposing norms and values that permit the respectful coexistence of groups that adhere to different sets of moral norms and values, which should be found acceptable from the different points of view, even when each group's reasons for accepting those norms differ from the other groups' reasons for finding them acceptable.

From this alternative viewpoint, the following distinction is made between morality and ethics. **Morality** is understood as the "positive morality" of a social group, that is, the set of moral norms and values actually accepted by a community in order to regulate the relationships between its members.

In this sense, one may speak of "Catholic" morality, "Protestant" morality, or, more generally, of "Christian" morality, and also of "Jewish" or "Muslim" morality. Many times moral norms and values are tied to religious conceptions. Nevertheless, morality does not necessarily depend on religious conceptions, and, thus, one may speak of the morality of a specific traditional people, such as one of the indigenous peoples living in many parts of the world, especially in Latin America, Africa, Asia or Australia. However, one may also describe the set of norms and values that regulate the actions and interactions between the members of certain human groups, such as the youth gangs in the big cities, and thus speak of "the morality of the gang".

There is abundant anthropological and historical evidence that, throughout the course of human history, the relationships between members of different societies have been subject to different norms and values. Simply consider the societies that have practiced human sacrifice, or the difference between the monogamous societies and those who accept polygamy; or consider the changes that contemporary western societies have experienced, in the moral sphere, with respect to homosexual relationships, to the extent that today, in several countries, homosexual couples are acknowledged certain rights, including the right to marry, while in some European countries, just 40 years ago being involved in a homosexual relationship was considered a crime.

Based on the foregoing conception of morality, the position here defended understands ethics as the critical analysis and establishment of the values and norms rationally accepted by communities with different positive moralities, which permit them a harmonious and pacific coexistence, which may even be cooperative.

An example of an ethical value in this sense would be *horizontal tolerance*. An example of an ethical norm would be: *we should respect those who are different from us*, for instance, as regards religious beliefs, moral values, sexual preferences, forms of esthetic expression, skin color, etc.

For this approach, the *central problem of ethics* is understood as the critical analysis, the proposal and the laying of a foundation of *legitimate* norms of coexistence for human action and interaction between human beings.

The sense of laying a foundation involved here is the latter of those mentioned earlier, that is, laying the foundation for ethical norms is understood as the elucidation of a reasonable basis for accepting those norms. In contrast to the convergentist positions, from this point of view it is not expected that the reasons that make a given norm acceptable for one group will be the same as the reasons that make the same norm acceptable to other group, even though it is expected that they reach agreement regarding the norms for interaction between them, that is, that they accept the norm even though they do so for different reasons. This is particularly important in modern societies, which are plural, both culturally and with respect to the moralities that exist among them.

In effect, practically in any modern society, as well as in the so-called global society, human groups having different positive moralities coexist; human groups that adhere to different sets of norms and moral values which, many times, are incompatible with each

other. It is sufficient to remember the different moral positions encountered with respect to themes like abortion or euthanasia, in order for us to realize this.

It is a well-known historical fact that different groups of human beings may reach distinct bodies of belief regarding the world, which –in spite of their differences– on many occasions permit different groups to adequately function within their surroundings. During the final decades of the 20th Century, the conviction gained ground that this did not mean that only one of the different viewpoints is the correct one, while the others are mistaken, but that the complexity of the systems of relationship between groups of human beings and their surroundings makes possible very different ways of interpreting the world, including reasoning and, above all, that complexity makes possible different ways of interaction between human beings and the environment. Thus, in spite of the differences concerning their representations, actions of the members of different groups will be successful. This, is in spite of the fact that those actions are guided by different beliefs and interpretations of the world. In other words, it has come to be understood and accepted that there does not exist just one correct form of interpreting the world, nor even of reasoning.

With respect to the coexistence of groups having different moralities, this implies that the very identification of the moral problems may vary widely, that is, what is considered a moral problem and what is not a moral problem may be very different from one group to the other, depending on the historical epoch and in accordance with the social and cultural context. There may be even further differences concerning proposals for dealing with those problems.

The foregoing has resulted in the wide acceptance of the thesis that although human beings have the same rational capacities in common –such as inferential and deliberative capacities– and the same cognitive faculties –e. g. to form representations of the world–, when these capacities are exercised in different circumstances and environments, then it is very likely that the beliefs to which they lead will be different, and that they will equally lead to different sets of norms and moral values.

From this perspective, the existence of a set of absolute criteria or principles that would permit the resolution of the question of which of those different beliefs are the correct ones, the only correct ones, is rejected. The same occurs with respect to the diversity of norms and moral values: the idea that there exist absolute criteria for establishing their correction and acceptability is similarly rejected, and, rather, it is considered that within the diversity of norms and moral values, it is possible that many of those systems may reasonably claim legitimacy.

In contrast to the ethical positions that consider that it is possible to find absolute principles and criteria that permit the discovery of a foundation, in the strongest sense of the word, of ultimate and immovable foundations for ethical norms, the perspective that is now outlined, which is a *pluralist* position, claims that no system of criteria of privileged moral evaluation exists that is above the others and that, as a consequence, there is no single correct way of identifying moral problems, there is no single proposal for tackling them that is the only correct one, and there does not exist, with respect to these problems, a single valuation that is the only just one.

Faced with this situation, what role remains for ethics? The proposal is that in today's plural world, the central problem for ethics is that of giving an account of the possibility of the existence of *legitimate* norms of coexistence, permitting harmonious and pacific interaction between human beings having different moral values and norms, even though there is no ultimate and absolute foundation for those norms. Furthermore, ethics should help to formulate those norms.

Legitimate norms of coexistence are understood as acceptable prescriptions for the diverse social groups that have to interact in specific situations, based on reasons that are *good reasons* from the point of view of each of them –including moral reasons- , even though those reasons are not the same as for other groups, or even if they do not appear as legitimate reasons to other groups. This circumstance may occur because their conceptions of life, their interests and their values are different.

From this viewpoint, a norm is ethically justified when it is acceptable to the diverse social groups that have to interact in a given situation or context, based on the reasons that each of them considers adequate.

To illustrate these ideas, let us consider the situation that occurs in lay states with respect to legislation on abortion. Given that a lay state should not commit itself to any particular moral point of view as far as the admissibility or moral condemnation of abortion is concerned, the state and the citizens should reach an agreement regarding the norms that will regulate the decisions and actions of the state in that respect. Such norms should permit the citizens to act in accordance with their particular moral principles, but should not, for example, oblige the state to impose a punishment on women, or couples, who decide to abort, nor on the doctors or auxiliary personnel, nor on the health facilities, public or private, that assist the woman to abort, as the condemnation of abortion depends on specific moral values and principles that vary from one social group to another. Lay state legislation then, should be based on a norm that establishes that it is ethically correct to respect the moral convictions of each person and each group and, as a consequence, it is not correct to punish, or oblige anyone else to punish, those who practice an abortion because they do not believe it to be morally reprehensible. Such a norm should be acceptable to all citizens –including those who morally condemn abortion- for the sake of a tolerant attitude regarding other moral points of view, in order to achieve a harmonious coexistence between diverse social, religious and ethnic groups.

The same may be said with respect to many other significant problems of the present day –which constitute the central focus of bioethical worries– such as euthanasia or stem cells research: the values that should prevail are those of tolerance towards the different moral points of view, and respect for the right of all individuals to live in accordance with their moral convictions, with the sole condition that they respect others, as well as their freedom to act, as long as they do not interfere with the possibility for action of others.

An important consequence of the preceding is, for example, that the ethically correct manner of constituting bioethical committees in clinics and hospitals in modern societies, is that such committees should have a plural composition, in order that the different moral viewpoints of the society in question are represented.

In sum, for our aims -namely, the analysis of the ethical problems of science and technology- we will adopt the idea that ethics has to do with principles, norms, values, and judgments that regulate human relationships, that is, relationships between human beings themselves, and also between them and the environment, including the beings that live in it. From this perspective, the distinction between ethics and applied ethics is meaningless.

3. Ethical Questions Regarding Science and Technology

For the analysis of ethical problems of science and technology, it should be stressed that the intentional agents that form part of the technological and technoscientific systems have the capacity to construct representations of reality in which they desire to intervene. They also have the capacity of abstracting from reality certain aspects that *interest* them, and of constructing *models and theories* to explain those aspects of reality in order to intervene by modifying or manipulating them based upon certain *interests*.

Human beings too, assign values to states of things in the world. For example, they may consider them to be desirable or undesirable. The evaluation of an object, of a situation, or of the consequences of a process, are necessarily made from a certain point of view, based on values, norms and specific interests.

However, human groups do not share every value and norm, thus it is frequent that they make contradictory judgments. For instance, construction materials that are obtained by means of the exploitation of a forest, timber say, may be valuable for a human group. If, in addition, a group, say, a firm, obtains economic benefits from the exploitation of the forest, it will also judge it to be valuable. However, if the exploitation is carried out in an irrational manner, in a way that results in the deforestation of a valley, the logging process may be judged undesirable by other groups. The substitution of particular traditional crops with others using genetically modified seeds may be valuable for certain social sectors, for economic reasons, for example, but undesirable for other groups, say, because it negatively and irreversibly affects biodiversity, or because cultural practices of some human community are disturbed.

All this means that human beings are capable of *making decisions* and promoting the realization of certain states of affairs based on their representations, interests, valuations, desires and preferences, all of which are constitutive elements of technical, technological and technoscientific systems. Nevertheless, the confrontation of interests and values leads generally to severe conflicts where the operation of technoscientific systems and the evaluation of their consequences are concerned. A fundamental ethical problem of technoscience, then, is whether it is possible to establish norms of harmonious coexistence and peaceful resolution of conflicts in a world where very different groups, with diverse interests and values, have to interact on a day to day basis.

From this point of view it may be better understood why the ethical problems that technoscience raises are not reduced to solely the possible use of knowledge or artifacts, but, given that technoscientific systems are systems of intentional action, that ethical problems arise regarding the intentions of the agents, the aims they seek to achieve, the

means they employ, the results that they actually produce (intentionally or not), as well as with respect to those agents' desires and values.

For example, suppose a pharmaceutical company decides to test a new drug, whose side-effects are, as yet, unknown, on human beings, without warning the experimental subjects about the risks that they are running, and concealing from them the fact that the possible side-effects are not known. The pharmaceutical company's decision, as well as the scientists' corresponding actions, may be ethically condemned because they seek a certain end, say, of marketing a drug and obtaining economic benefits, and, for that reason, use people simply as a means. In addition, by having pertinent information concealed from them, the experimental subjects see their capacity for making an autonomous decision restricted, for instance, that of freely choosing whether to participate in the experiment or not. Moreover, those individuals run the risk of suffering as a result of the drug being administered to them, but there is no acceptable ethical justification for their suffering in that way.

In this case, the negative ethical judgment levied against the pharmaceutical company's directors and the scientists for having carried out the experiments is based on the fact that they violate three ethical principles:

a) the principle that establishes that people should always be treated as an end and never only as a means;
b) the principle that indicates that people should be respected as autonomous agents, that is, having the capacity to make decisions, and perform actions based on decisions that they make themselves, without being deceived or coerced by anyone else; and
c) the principle that prohibits harming a person in the absence of sufficient reason to justify doing so.

The first two norms are known as Kantian norms because they are derived from the ethical ideas of Immanuel Kant (1724-1804). Later we will return to examine these principles. With respect to principle (c), it should be acknowledged that situations exist whereby it is reasonable to think that an instance of harm is justified. For example, when surgery is proposed for an individual because he suffers from some condition that cannot be remediated by any other means. Harm will be done to him, but it is justified because the expected benefit –the restoration of his health– will far exceed the temporary harm inflicted upon him.

We may suppose an analogous situation in the context of "pure science", where the end is not the marketing of a drug, but solely the acquisition of knowledge, say, to determine whether the drug is effective in combating a certain illness. Let us suppose that the study is carried on in an academic laboratory, free of commercial ends. Whatever the case, if experimental subjects are not duly informed of the ends being sought, of the risks that they run, and of the fact that there may be possible side-effects as yet unknown, and that, as a consequence result, they might suffer severe harm, then they continue to be used solely as a means and, thus, the decision and actions of any scientists who acted in this manner would be ethically reprehensible.

A scandalous historic case, where knowledge that could be alleged to be scientific was pursued, was the research project known as the Tuskegee Syphilis Study, in which, over the course of 40 years (1932-1972), the evolution of syphilis was tracked in around 400 experimental subjects, all African-American, living in the area of Tuskegee, Alabama, USA, who were not only not informed of the purpose of the study, but who were deliberately given false information, were denied the standard treatment using penicillin, commonly available from 1943 on, and were impeded from receiving treatment from any other source. The experiment ended, in 1972, only when the case was divulged in the press and received an indignant public reaction.

Upon being made aware of the details of that horrendous experiment, the United States Congress formed a National Commission for the Protection of Human Subjects of Biomedical and Behavioral Research, which, in 1979, published a report on "Ethical Principles and Guidelines for the Protection of Human Subjects of Research", commonly referred to as "The Belmont Report".

This document proposed the following three basic principles for the evaluation of research projects involving human subjects:

- **Respect for Persons** - Individual research subjects should be treated as autonomous agents. Persons with diminished autonomy (such as prisoners or inmates of mental institutions) are entitled to protection.
- **Beneficence** - Research involving human subjects should do no intentional harm, while maximizing possible benefits and minimizing possible harms, both to the individuals involved and to society at large.
- **Justice** - Attention needs to be paid to the equitable distribution within human society of benefits and burdens of research involving human subjects. In particular, those participants chosen for such research should not be inequitably selected from groups unlikely to benefit from the work.

On the basis of the foregoing discussion, it is possible to conclude that the comprehension, formulation and eventual resolution of ethical problems of science and technology to a great extent depend on the manner in which these are understood. A conception of science that reduces it to knowledge, and an idea of technology as applied knowledge, for example, slant the analysis in favor of the thesis of the ethical neutrality of science. On the other hand, if science is understood as a set of intentional systems whose principal product is knowledge -in order to attain which certain means are put into play, and which responds to specific interests-, and if technology is also understood as comprising systems of intentional agents, who utilize means in order to achieve particular ends, and which in fact, generate certain results, then neither science nor technology may be conceived as neutral from an ethical point of view.

Given that the ethical problems raised by technology do not arise solely from the use of artifacts, but appear by virtue of the intentions of the agents who form part of the technical systems, of their aims, desires and values, as well as from the results that they actually obtain, including non-intentional results, then the need arises for evaluating the technical systems from an ethical standpoint.

With respect to technology and technoscience, it is important to analyze the aims and values in terms of which knowledge is generated, developed and applied by those systems. It is also necessary to decide which agents should perform the evaluation. Should only the experts related to a specific individual system participate in its evaluation? In section 7, the concept of efficiency of a technical, technological or technoscientific system is analyzed, and it is shown that there are reasons based on the nature of the technoscientific systems themselves, and from their relationship with the surroundings, which support the thesis that it is not ethically acceptable that only the experts participate. However, let us continue with a brief review of the nature of values and their role in science and technology.

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