# FROM TECHNIQUE TO TECHNOLOGY: THE ROLE OF MODERN SCIENCE

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## EQUIVALENCE OR SEPARATION BETWEEN SCIENCE AND TECHNOLOGY?

Two opposite positions characterize the present way of conceiving science and technology. The most widespread renders them *identical*, as being practically one and the same thing (the so-called "technoscience"), in which the "intellectual" features of modern science dominate the traditional "manual" features of technology; so that technology itself has become "scientific" to such an extent that it is impossible to distinguish it from science. This view is tacitly presupposed in the way common sense understands the "progress of science." When we try to make this notion concrete, we almost inevitably put forth examples of *technological* achievments as instances of *scientific* progress.

Arriving at the same conclusion (but following an inverse path), certain approaches treat science itself (in its "modern" form) as so deeply affected by the spirit of technology—which consists in the proposal of dominating and utilizing nature—that it has become indistinguishable from technology. This second view is common both to several "instrumentalist" trends in contemporary philosophy of science and to some no less influential doctrines that press an essentially negative judgment about science, because (allegedly) modern science was born of the same pretension toward "manipulating being" that is the core of technology, and this implies, as a consequence, an attitude of *violence* that underlies technology. (Heidegger was the most famous initiator of this doctrine, which has found many followers in the present intellectual climate.)

Contrary to these two views is the position of those scholars who stress the different *aims* of science and technology: science aims at attaining objective knowledge and is therefore characterized by a strict *cognitive* attitude; while technology aims at producing concrete results (in the form of objects,

commodities, tools, or procedures) and is therefore characterized by a *pragmatic* attitude. This position has often been advocated in the context of discussing the so-called "neutrality of science" and in debates concerning the social or moral *responsibility* of science (where the intent is to free science of such a responsibility).

## FROM TECHNIQUE TO TECHNOLOGY

Both positions contain some aspects of truth, but both are affected by certain misunderstandings. In order to critically evaluate them, we shall start by proposing a distinction between *technique* and *technology*; to a certain extent, this is conventional, but it is not arbitrary. It is not based upon a simple linguistic analysis but reflects certain conceptual differences that may suitably be appended to a double terminology that happens to exist in our languages.

By a *technique* we usually mean a display of practical abilities that allow one to perform easily and efficiently a given activity (be it purely material or bound to certain mental attitudes). But (perhaps less often) we also use *technique* as a collective noun, indicating the very wide spectrum of such simple techniques. In such contexts, these are sometimes indicated by the old-fashioned term *technics*. That is, the whole of the many concrete efficacious procedures that have proven useful for obtaining certain results (e.g., producing certain objects, performing certain operations, attaining certain goals) are summed up as *technique*. Technique, in this sense, is the collective term encompassing a great deal of *technics*, and in this sense we usually speak, for example, of the "technical skill" of a craftsman, of a professionally able lawyer, of a pianist. Any such technique is essentially the able application of a certain *know-how*, which has been constituted through the cumulation and transmission of concrete *experiences* (that in particular also entails a careful exercise), without being necessarily accompanied or supported by *knowing why* such concrete procedures are especially efficacious.

The suffix, "ology" that we find in the word *technology*, invites us to take advantage of the theoretical aspect that is usually bound up with its use (compare theology, sociology, philology, ethnology); it serves to indicate the presence of some kind of "scientific," or at least theoretical dimension. In fact, the Greek term *techne* already included this theoretical aspect, since it was used to indicate

the capability of justifying, of "knowing why," a certain efficient procedure was efficient. I would maintain that the modern concept of technology can be interpreted as a new way of expressing the conceptual content of the Greek term *techne*.Without indulging in detailed historical recontructions, we can say that Western civilization finds what is perhaps the most decisive element of its specificity—as regards other great civilizations in human history—in that it explicitly introduced the *theoretical* demand into the domain of practice and of doing. What we might well call the "invention of the why," rising from within Hellenic civilization in the sixth century B.C.E., led in that same context to the birth of both philosophy and science in the strong sense. (They were originally one and the same.) The very demand which led philosophers to ask for the *reasons* for the existence and constitution of the cosmos (and to postulate principles and first causes to provide such an explanation) was also what moved the first mathematicians to provide the reasons (by means of *demonstrations*) for the properties of numbers and figures; other peoples had discovered them only empirically, translating them into *practical rules* of calculus. In following this impulse, it was inevitable that a search for the "why" should eventually take up the different sorts of efficient knowing that men had used in various fields; and this gave birth to the notion of *techne:* efficient action where we know the *reasons* for its efficiency and that it is founded upon them.

The term *techne* is often translated as "art," but today this is imprecise, since for us art concerns essentially the beautiful or aesthetic expression. Plato, Aristotle, and the great doctor-philosopher Hippocrates all tell us that the characteristics of *techne* are parallel to those of *episteme*—that is, *science*—insofar as both are types of knowledge which demonstrate the reasons for what is observed empirically. *Episteme* focuses attention on the *truth* of what is known; with *techne*, the focus is on efficiency. The first concerns *pure knowledge;* the second, *knowledge of doing or making*. If it is true that the domain of the pure and simple knowledge of doing or making (that is, knowledge of *how* to do something that does not necessarily imply knowledge as to *why* the end is achieved) can be called the domain of *technique*, then we ought to find another term to designate that further dimension wherein efficient operation is conscious of the reasons for its efficacy and is founded upon them; that is, where operation is nourished by its grounding in theoretical knowledge. This new term is *technology*. Hence, in this sense we can say that the idea of technology is clearly prefigured in the Greek notion of *techne*.

But this is only a prefigurement. The constituting of technology, in the full, modern sense of that term, is a consequence of *modern* science; it is this science that furnishes the theoretical grounds for efficacious doing. (The traditional science or *episteme* was used for the theoretical foundation of the ancient *techne* and was essentially constituted by philosophical reflection.)This new science not only rapidly led to detailed knowledge of the natural world, which allowed for more adequate explanations of the success of many techniques already used; it also inaugurated a process by which newly acquired knowledge was immediately applied toward the creation of *new* techniques and was even *sought* for the sake of some technical application. To clarify the import of this change, much would need to be said. We shall limit ourselves to certain summary (and thus somewhat approximate) considerations.

The Greek idea of *techne* expresses a demand for a theoretical awareness which, so to speak, *justifies* conceptually that practical knowledge which is already established empirically. *Techne* consolidates this practical knowledge and affords it a certain extension—due to the inherent generality of theoretical knowledge—but is not bound to *produce* new know-how, or to improve its efficiency. It could be said that behind the search for the why, which characterizes *techne*, is found the very same *contemplative* demand which characterizes *episteme*; it is a demand for intelligibility rather than efficiency. This contemplative and *disinterested* conception of knowledge is inscribed in the episodes and anecdotes of the tradition as much as in its thinkers; the idea of a knowledge that must be placed *at the service* of practice is foreign to classical cultural sensibilities even if there are some concrete exceptions (for example, the "engineering" aspects of the works of Archimedes or Eratosthenes). This way of conceiving things goes hand in hand with a certain way of conceiving the world and nature: they are an object of understanding and not of intervention—a reality to which it is fitting, wise, and useful to conform oneself—and not something to be manipulated and transformed according to men's caprices and interests. A third and final element is the fact that the concrete knowledge that classical thought attained with respect to the natural world remained (for a variety of reasons which we shall not explore here) very limited—almost laughable—when compared with the heights it reached in mathematics and astronomy.

In the Renaissance, each one of these aspects was profoundly modified. Human primacy over nature came to be strongly asserted. The founding of a

*regnum hominis* was seen to indicate a supremacy over nature that was to be exercised through the use, subjection, and manipulation of nature. The idea of disinterested knowledge did not disappear, but it became strongly allied to the idea of a useful knowledge which would help humans to dominate Nature and to establish a supremacy which would guide and advance practice rather than merely reflect upon nature. Finally, the new science provides a harvest of detailed and precise knowledge which enables humans actually to fulfill a program of constructing a new type of knowledge—a knowledge that no longer remains content with *explaining* the empirical success of practices or instruments, but is able to *project* new instruments and practices that have not yet been tested or even invented. The application of scientific knowledge to the solution of concrete problems typically consists in planning and constructing a device (that is, a *machine* in the broad sense), the how and why of whose functioning is known *in advance* insofar as it was designed through the use of the available theoretical and practical knowledge. Thus, *technology* arises, on one hand, as being included in the domain of technique, while on the other, it is set off by specific traits.

It is now clear why science has a closer link with technology than with technique. On one hand, technology is to a large degree—one might even say essentially—an *applied science*. (This is not wholly true, since its development also relies on purely technico-operational factors in the senses we have noted.) On the other hand, when scientific research poses certain *cognitive* problems, they can be solved by projecting and constructing appropriate apparatuses or instruments (that is, appropriate *machines*), and it is technology that does this. Between the two, then, a system of *positive feedback* is established, one of reciprocal stimulation to ever more rapid and expansive growth. As is well known, while *negative feedback* is considered in cybernetic language to be the key model for stability and control, *positive feedback* is the typical model for processes which tend toward loss of control and disintegration. I only allude to this here; I shall have occasion to return to it later.

## THE SENSE OF A BIFURCATION

In this presentation, we can see a kind of continuity; at the same time, there is a significant bifurcation between technique and technology. The continuity consists in the fact that technology remains within the framework of technique (it remains an effort to maintain efficacious procedures for producing objects or

performances); the bifurcation consists in the fact that it would be wrong to believe that by now technology has become the modern form of technique. In fact, technology is only a new *branch* of technique—the branch that might be understood as "applied science." On the other hand, there are still large sectors of technical progress that are quite independent of the advancements of science; they follow the traditional path of the accumulation of empirically discovered useful devices or procedures without any need for a scientific understanding of their efficiency—even without any real possibility of providing it.

However, this bifurcation has also produced significant changes in the relationship between humankind and the *artificial* world. In the case of technique, it was already true that the bifurcation produced an artificial world. But this was, on one hand, a domestication of the external environment in conformity with the needs of human nature (a nature that, specifically, entails a human capacity of adapting the environment to itself rather than adapting itself to the environment); on the other hand, the growth of this artificial world was slow and piecemeal, and it allowed enough time for integrating the artifacts within the natural environment and within the existing context of human conditions. In the case of technology, external nature is not really domesticated; it is rather replaced by the artifacts, and the artificial world grows with a rapidity, an amplitude, and a complexity that confer on it the characteristics of an increasing *autonomy* (though this by no means implies an automatic self-regulation). Every new advancement in technology is *local* (like the piecemeal improvements of traditional techniques), but the impacts and consequences rapidly become *global*, owing to the numberless and complex ramifications of the *technological system*. In this way, a great many unintended, unexpected, unforeseeable consequences may result from *any* new technological realization. (This fact has been abundantly stressed and analyzed in a very extensive literature.)

This peculiar feature of technology entails a change in the attitude we adopt towards our productions. In the case of technique, a man could believe himself to be adapting nature to his neeeds by using nature and "putting it to his service," but this was possible only by "obeying nature," as Francis Bacon said. Therefore, a kind of confidence in the harmony or wisdom of nature (somthing that could be supported by several worldviews) could absolve a man of the task of explicitly thinking about the "regulation" of his technical activity as distinguished from the simple determination of the "rules of the art." With technology we have

a very different situation: the artificial world has no intrinsic nature; it is*created* by humans and remains independent of nature. Therefore, if we want to imagine for it some kind of order or regulation, it cannot but be an order or regulation introduced *by humans*. Not just as the application of new and complex "rules of the art," but as applying norms that might insure a global harmony or wisdom that in the past could be delegated to nature.

## THE MYTH OF PROTAGORAS

In Plato's dialogue, *Protagoras,* the chief interlocutor, from whom the name of the dialogue is taken, narrates the following myth. When the gods decided that the time had come to populate the earth with living beings, they entrusted Prometheus and Epimetheus with the task of producing them and providing them with suitable qualities. Epimetheus took over the concrete work, while Prometheus reserved for himself the right of supervision. After having wisely distributed among the different living species the characteristics that would enable them to survive and reproduce harmoniously, Epimetheus discovered—when the moment came to produce human beings—that he had already exhausted the natural qualities. So he was obliged to produce a being that was naked, weak, devoid of any special feature, and inferior to the animals. In order to remedy this disaster, Prometheus stole from Ephaistos the fire and the arts (that is, the principles of techniques) that are related to him, and he stole from Athena the arts of the intellect (that is, the principles of science). These qualities were diversely distributed among human beings; and they, by using them, were able to secure their superiority over the animals, to produce artifacts, and to found cities. However they showed themselves incapable of living in communities; they started killing each other, splitting into factions, and dying. At this juncture, Zeus, much concerned about the destiny of the humans, charged a god, Hermes, to bring to them the political virtues of justice and modesty. These virtues were given to every man *individually;* and, thanks to them, humans were able to live a harmonious life in their cities.

In the presentation of this myth (and in the discussions that follow it in Plato's dialogue), all of the salient issues of the complex problem of technoscience are already outlined. Science and technology are really the factors of superiority that distinguish humans from other animals, and their development is due to the creativity of particularly gifted individuals. However, the*global* outcome can be

tragic if humans are not guided by something that is not in conformity with nature; they require another specific and uniquely human quality: that of *morality*.

This quality is able to produce a global positive effect because it is a characteristic shared by every human being *individually*. So, we can see that the dangers implicit in the uncontrolled use of creative intelligence (be it theoretical or practical) were already perceived by ancient philosophers, and morality was considered to be the unique remedy for them. Nowadays, technology can be considered the most impressive expression of human creativity; yet it does not contain the necessary guidelines for its positive exercise, and ethics is again postulated as the proper field in which such guidelines must be investigated and found.

## SOME USEFUL CONCLUSIONS

From these considerations, a few useful elements of reflection can be derived. In the first place, we have seen that a separation between science and technique is plausible (in the sense that we can characterize science as an eminently cognitive enterprise, and we can characterize technique as an eminently pragmatic one). But if we look at technology, we can at most admit a *conceptual* or an *analytic* distinction, without any real *separation* from science, since they are *concretely* intertwined and, so to speak, *consubstantial*. (Technology cannot exist without science, and science cannot exist without sophisticated technology.) This in particular justifies the use of the term "technoscience" for designating this new reality. In the second place, we have seen that an appeal to an *ethical dimension* emerges, with great force, *from within* technoscience itself; and this is true because the particular form of creativity that characterizes this domain does not provide us with criteria for steering, directing, limiting, or orienting the growth of technoscience.

The search for such criteria cannot be fruitfully pursued along the two paths that are often advocated nowadays. One is the path of "following" or "respecting nature." This criterion does have a certain value, but at the same time it is vague and limited—first of all because there is no real possibility of crediting nature with the privilege of being *absolutely* good; second, because our picture of nature is, after all, what we know through the mediation of *scientific* investigation ; and third and more substantially, because our present problem is

that of controlling a non-natural world, that is, the world produced by technology, which is chiefly a human creation.

The second path consists in looking to technoscience itself for the criteria for regulating its developments. This is again illusory because what we can expect from technoscience is the know-how to do something, not what *ought to be done*. What we can expect from technoscience is an indication of what it would be *possible* to realize (and the intrinsic tendency of technoscience is that of actually realizing all such possibilities). Our problem is that of determining what it is *good* to realize (or not realize) among the different possibilities that are open to us. Such an evaluation specifically pertains to a *moral judgment*.

However, as we have seen, such a judgment is demanded from *within* technoscience, and it would be inappropriate to propose that a kind of *moral court* be created, with the task of judging the productions of technoscience *from the outside*. Judging technoscience must go hand in hand with technoscientific activity; it must inspire it and control it at every stage. That is, it must represent a constant sensitivity that *intrinsically* accompanies all the projects and predictions that men develop in promoting the growth of technoscience. This is why, as Plato had already noted, it is an *individual* sense of moral responsibility that—to the extent that it is in fact exercized by *every* human being—can bring humankind to see technoscience not as a tremendous threat of danger or destruction but as a source of well-being for all humans, present and future.