TECHNOLOGY AS A NEW CONDITION OF THE POSSIBILITY OF SCIENTIFIC KNOWLEDGE

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The epistemological meaning of technology in scientific research has fully changed in recent decades. At the beginning, the classical relationship between science and technology established a subordination of the latter to the former. Thus technology was considered applied science which helped the scientific process by manipulating the natural conditions of the scientific object. In fact, the influence of technology in the search for scientific objectivity did not imply any important variation of the epistemological framework of scientific knowledge.

Nevertheless, this conception is no longer applicable, because the relevance of technology has become much greater than before, quantitatively and qualitatively considered. The role of technology is no longer that of a certain subordination to the instrumental requirements of science. Technology possesses nowadays a central position in the making of scientific knowledge, and largely conditions the progress of science. Practically in all scientific fields the use of sophisticated technological means is a *conditio sine qua* non of the development of the scientific enterprise. In this respect, it is possible to assert that technology is undoubtedly a condition of the possibility of scientific knowledge. Without technology it is impossible to develop science today. This new situation involves some relevant consequences that are to be taken into account for the understanding of the present epistemological status of technology. This brief paper, divided into three sections, is devoted to the explanation of this meaning of technology.

1. TECHNOLOGY AND THE EPISTEMIC CONTENTS OF SCIENCE

First of all, the influence of technology has become a determining ingredient of the epistemological constitution of scientific objects—for instance, in nuclear physics, cosmology, biochemistry, etc. The point is not that science uses technology as an instrument; this is indeed true, but it is a trivial remark. In fact, the present use of technology modifies the traditional relationship between the

theoretical and the pragmatic goals of scientific reason. We could say that technology becomes an "epistemological mediation" of science. It is not only an instrument required by the present complexity of scientific research. That is obviously true, but the meaning of technology is not exhausted by saying so. It is necessary to point out that technology is an epistemological mediation. The difference between the two terms, instrument and mediation, is clear. An instrument means something that is used in order to obtain some specific results, and it is abandoned once these results have been reached, until the next time when it can be necessary to the goals of the scientific enterprise. In other words, an instrument is a means, so to speak, to use and leave aside. But a mediation is something else, namely, a means which is *permanent*, in such a way that the concerned activity is determined by it. Accordingly, a mediation influences the nature of activity to a decisive extent. It is not a feature to use and leave aside, but rather a trait conditioning the results of the concerned activity. In short, an instrument is subordinated to the concerned activity, but a mediation *specifies* this activity in a very relevant way.

On the other hand, note that we do not assert that the taxonomy of the different scientific goals, both theoretical and pragmatic, changes; but the traditional relationship between them is deeply altered. Indeed, the theoretical framework of scientific reason is invaded by the pragmatic scope of technological inputs. Needless to say, the aim of technological reason is primarily pragmatic, namely, the manipulation and the transformation of the natural object to be adapted to the requirements of scientific objectivity. Accordingly, the search for scientific objectivity is no longer a pure theoretical search for scientific truth, but it is especially influenced by the aims concerning the sway of reality. That is to say, the fact to remark is that the technological aim, because of its increased relevance, conditions the realization of the theoretical aims concerning the search for scientific truth. It is no longer the case that the theoretical scope occupies the first rank and the pragmatic one is subordinated to it; now the pragmatic goal has acquired a level at least as important as the theoretical goal, insofar as technology has become a condition of the possibility of scientific knowledge. So technology does not mean a mere instrument to use and leave aside, but rather it is an epistemological mediation between the subject and the object in the process of scientific knowledge. And the features of this epistemological mediation influence the internal structure of scientific knowledge as regards some important epistemological aspects.

In this line, the main aspect of this change concerns the decisive role of the pragmatic aims of scientific knowledge derived from the new status of technology. To a certain extent, science is progressively becoming "applied science," in the sense of raising to a higher level a kind of knowledge whose principal purpose is not the search for theoretical truth, but rather that of finding an effective response to questions concerning the manipulation of the objects being researched in order to increase the power of humans over reality. It means, so to speak, that the investigation of scientific truth as such is now subordinated to the possible technological use of its results. So the search for theoretical scientific truth does not constitute now the dominant aim of the cognitive enterprise; pragmatic applications dictate the query to be investigated up to a certain point. Observe that we do not assert that the search for truth as such is not important, but its role is profoundly tied to pragmatic aims and is *subordinated* to them.

This situation differs from the traditional relationship between theoretical truth and pragmatic truth, as will be explained below. The priority of the former over the latter seemed well established, but now this priority is not so clear in practice. Under the term, "pragmatic truth," we refer to the search for an epistemological content which is directly concerned with the modification of the object in order to fulfil a specific practical end. In other words, the main question to answer from this point of view is not "what is the object?" (theoretical truth), but "what practical purpose can the object serve?" (pragmatic truth). In this way, the investigation of a pragmatic truth is primarily related to the use of the object for the possible modification of an empirical domain. As a consequence, the principal significance of theoretical truth is no longer primarily connected with a theoretical requirement, but it takes its relevance from its possible contribution to the realization of a practical end. This situation supposes an important change in the internal relationship among the different kinds of epistemological objectives of scientific reason.

2. TECHNOLOGY AND SCIENTIFIC TRUTH

In the second place, this can involve a transformation of several important contents of scientific truth, especially as regards the meaning of scientific testing. As is well known, testing is a key condition of the scientific process and refers to the range of corroboration of a certain statement. Until now, the process of testing

was principally conditioned by the aim of obtaining the occurrence of an established prediction. However, the greater importance of pragmatic aims will influence the process of testing in such a way that the specific features of testing can determine the content of the theoretical prediction to test. That is to say, what we want to remark is that, as a consequence of the new epistemological situation described before, there will be established a feedback relationship between the content of theoretical predictions and the effective forms of testing. In this feedback both conditions operate with a similar force, so that it is unavoidable to recognize a reciprocal influence between them. In this sense, the process of testing acquires a special relevance which it did not possess before, because its specific realization becomes a significant ingredient of the content of the possible scientific truth to test. This situation clearly differs from the traditional signification of testing, where the influence of the conditions of testing over the content to be tested was practically nonexistent, testing being completely adapted to theoretical conditions and exhausted by them. But now, because of the feedback that we have pointed out, it can modify the theoretical content up to a certain point. Note well that we do not mean that it involves a full determination of the theoretical content by the testing conditions—that would be impossible—but we only point out the reciprocal influence between them. And this is an important change with regard to the earlier historical situation, because this feedback did not exist then.

In order to clarify this assertion, we could say that the traditional relationship between the two aspects did not modify the natural object to be investigated; for example, this is the case with telescopes and the planets. On the contrary, the present situation causes a clear modification of the natural conditions of the object: this is the case, for instance, with the search for new elementary particles. Be that as it may, the present conditions of scientific testing modify either the standard presentation of the object or the "natural" situation in which it appears to the scientific searcher. Nowadays you do not face a situation in which the selected characteristics of the object are introduced into channels of cognitive amplification without altering the physical structure to observe; now, these channels inevitably produce a qualitative variation implying a transformation of the object—an example is the cyclotron.

Obviously this process is more evident in those sciences in which the technological requirements have increased to a significant extent. And of course it

is not the same in all sciences. Especially, in this respect, is it necessary to take into account a range of technological influence in the development of such sciences as subnuclear physics or recent biochemistry. Needless to remember, for instance, the discovery of elementary subparticles, which before were*found* in a theoretical way and tested afterwards; now, in virtue of sophisticated technological preparations, we can discover more and more new physical properties. This process is also significant in cosmology. Here, because of the necessary use of computers for simulating the earliest time conditions of the universe—and in spite of the striking adaptation of computer programs to the requirements of cosmological theories—it is impossible to avoid the feedback between technology and theoretical scientific procedures. In this manner, the development of cosmology is technologically conditioned to a decisive extent. In this last example clearly appear both the role of technology as a condition of the possibility of science (in this case, cosmology), and the feedback process entailing the epistemological consequences that we are trying to describe.

The process is common in science just because the presence of technology in scientific processes is continuously increasing. The quality of it, however, is diverse, because of the nature of different scientific objects. So, for instance, it is not the same in the physical sciences as it is in the human sciences. As a rule, the limit of this influence will be determined, so to speak, by the quantity of technology capable of being supported by the object without transforming it into a different scientific object. Therefore, it is not hard to understand that the situation cannot be the same in cosmology as in the human sciences (psychology, educational research, etc.). But as long as technology, as a rule, becomes a condition of the possibility of science, these consequences will gradually appear.

3. TECHNOLOGY AND SCIENTIFIC REALISM

In the third place, the process of technification of science also involves some important consequences for the concept of scientific realism. Maybe it is the global effect of the growth of technology in the process of scientific knowledge. We can say that the scientific object is always elaborated by means of certain operations (see Agazzi, 1974, pp. 350ff) which prepare physical reality to be investigated in accordance with the specific features pursued by each science. The nature of these operations can be very different, depending on the kind of scientific knowledge we are considering. Accordingly, there is always a necessary transformation of reality in order to obtain scientific objects. The epistemological

function of these operations is twofold: on the one hand, they are responsible for the structure of scientific objects; on the other, they constitute the grounds assuring intersubjectivity in the development of the scientific enterprise.

In this respect, it is possible to consider the technification of science as an aspect of these operations, and one which is wholly unavoidable. So the epistemological impact of technology is obvious: scientific knowledge continues to know reality, but it is *a technologized reality*. The unavoidable preparation of the scientific object becomes a technological preparation as long as technology is a condition of the possibility of science.

This finally raises the question: Can scientific realism become a sort of *technological realism?* Remember, in this respect, that epistemological realism includes two main characteristics, the ontological independence of the reality to be investigated, and the knowability of the world as a real possibility. Accordingly, technological realism would imply in turn two main implications as regards the signification of scientific realism.

First, the relative ontological independence of the scientific object will be related to the limits imposed by technological means (without ignoring other possible fields of scientific objectification other than those defined by technology). Therefore, properties of reality to be known by science will be properties to be considered primarily by technological manipulation. So it is necessary to introduce a term, *technological compatibility*, as a relevant characteristic for rightly understanding the contemporary meaning of epistemological realism in science. And this allows us to speak of *technological* realism. Technological compatibility reveals both the fact that technology is a condition of the possibility of science and also the consequences of that fact in the elaboration of scientific objects.

But technological compatibility also implies that the content of the scientific object is especially conditioned by the technological means to be used and this feature is another new factor to take into account for the meaning of realism. Of course, we do not claim that the introduction of technology has just begun; only that its influence nowadays reaches an extent which determines the elaboration of scientific objects. That is why it is not hard to justify the term, "technological compatibility." So, technological realism is linked to the technological compatibility of the scientific object. Among the necessary

operations—material, theoretical, mathematical, etc.—which elaborate the scientific object, technological operations possess a decisive relevance which may enlarge the content of scientific objects to a certain extent.

However, a necessary remark must be made. This transformation of scientific realism into technological realism does not suppose any failure in the basic epistemological realism of science. It is rather a new delimitation of the notion of realism that originates from recent developments in the scientific enterprise. Indeed, science continues to investigate reality in accordance with the parameters defined by its method; technological compatibility does not imply the end of the constitutive aims of scientific knowledge. It only deals with the addition of a new parameter that is required by the complexity that the development of science has reached at present. Furthermore, in a sense, this circumstance has been repeated in the history of science on a regular basis. Certainly, the progressive complexity of scientific objects discovered throughout the historical evolution of human knowledge has compelled science to incorporate many new instrumental means, logical, mathematical, material, and technological. Nevertheless, the radical change lies in the fact that, before, results of these incorporations had not produced a new element implying a necessary criterion for the constitution of scientific objects. Hence, the epistemological consequence of the technification of science is the necessity of introducing technological compatibility as one of the essential features of the operations imperative for the elaboration of scientific objects. It is clear that this signifies a new aspect of realism, not its refutation.

To conclude, the technification of scientific knowledge, in the sense here described, involves some specific consequences which are meaningful for rightly understanding the nature and the limits of science today. The main point to be remarked is undoubtedly the relevance of technological compatibility as a new condition for the elaboration of the scientific object. We use this term to point out that the epistemological content of the scientific object is determined, today to an important extent, by the technological means to be used in any particular research project. In this sense, the epistemological content depends not only on theoretical conditions but also—and especially—on the technological requirements of the investigational process. This specific influence of technological means is nowadays a feature of the scientific enterprise whose epistemological relevance is evident. For this reason, technification can imply a turning point in the

development of scientific knowledge, leading it to a pragmatic outlook through which should deeply change many traditional features. This new point of view can be summarized by saying that *scientific realism*, because of the necessity of technological compatibility, has now become *technological realism*. And this brings with it the predominance of pragmatic over theoretical truth in science.

REFERENCES

Agazzi, E. 1992. *Il bene, il male e la scienza: Le dimensioni etiche dell'impresa scientifico-tecnologica*. Milano: Rusconi.

Durbin, P., and Rapp, F., eds. 1983. *Philosophy and Technology*. Dordrecht: Reidel.

Gibbons, M., and Gummet, P., eds., 1984. *Science, Technology and Society Today*. Manchester: Manchester University Press.

Ihde, D. 1983. *Philosophy of Technology: An Introduction*. New York: Paragon.

Krohn, W., Layton, E. T., and Weingart, P., eds. 1978. *The Dynamics of Science and Technology*. Dordrecht: Reidel.

Laudan, R., ed. 1984. *The Nature of Technological Knowledge*. Dordrecht: Reidel.

Leplin, J., ed. 1984. *Scientific Reaslism*. Berkeley: University of California Press.

Mitcham, C., and Mackey, R., eds. 1983. *Philosophy and Technology: Readings in the Philosophical Problems of Technology*, 2d ed. New York: Free Press.

Queralto, R. 1993a. *Mundo, tecnología y razón en el fin de la Modernidad*. Barcelona: P.P.U.

_____. 1993b. "Does Technology 'Construct' Scientific Reality?" In C. Mitcham, ed., *Philosophy of technology in Spanish Speaking Countries*. Dordrecht-Boston-London: Kluwer Academic Publishers. Pp. 167 ff.

_____. 1994a. "Razón científica y razón técnica en el fin de la Modernidad." *Anuario Filosófico*, 27:2:683 ff.

_____. 1995. "La razionalità tecnica come mediazione epistemologica tra l'uomo contemporaneo ed il reale." In E. Agazzi, ed., *Interpretazioni attuali dell'uomo: Atti del Convegno della Académie Internationale de Philosophie des Sciences*, 1992. Napoli: Guida Editori. Pp. 239 ff.

_____. 1996. "Hypothèse, objectivité technique." *Philosophia Scientiae*, 1, cahier spécial 1, pp. 187 ff. Proceedings of the 1994 session of the Académie Internationale de Philosophie des Sciences.

Rapp, F., ed. 1974. *Contributions to a Philosophy of Technology: Studies in the Structure of Thinking in the Technological Sciences*. Dordrecht: Reidel.

Tiles, M., and Oberdiek, H. 1995. *Living in a Technological Culture*. London: Routledge.