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MEETING OF EXPERTS ON "PHILOSOPHICAL INVESTIGATION OF CONDITIONS FOR ENDOGENOUS DEVELOPMENT OF SCIENCE AND TECHNOLOGY"

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THE PHILOSOPHICAL DIMENSION OF CURRENT PROBLEMS IN REGARD TO SCIENCE AND TECHNOLOGY

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1. A new type of approach

1.1. The philosophical dimension of current problems in regard to science and technology assumes unprecedented significance in the light of the following two considerations:

a) At the ideological level, the supremacy exercised by science - and, through science, by technology and its industrial applications - is increasingly called in question, though the criticisms made while employing similar terms, appear to be based on a variety of arguments and motives;

b) In the world context, as a result of the pressing aspirations of the Third World countries, science and technology are becoming a central concern of all contemporary societies, and primarily of those which have until now been simply subjected to intellectual, axiological and social impact of modern life.

This entirely new general situation which has come about calls for investigation. No doubt it does not call in question the value of knowledge or the specific laws governing it, but it does mean that science can no longer be defended in the same terms as previously, for the analysis of science calls for more wide-ranging reflection than was possible with traditional philosophy (even with the enlightenment brought by the sciences) in that economics, sociology, anthropology, political science and, generally speaking, culture and the future of mankind are all elements that deserve equally serious consideration and clearly cannot be left out of the picture.

1.2. From the point of view of science and technology, the new approach which is called for turns on three factors:

1. An international context, epitomized in the Vienna Conference on Science and Technology for Development, with the demonstration it afforded as to the importance attaching to science in international negotiations;

2. An industrial context, by virtue of which the significance and impact of technological achievements is such that curiosity is aroused regarding the nature of the factors at work in scientific research;

3. National contexts, and the conviction that the concept of science and technology for development should be defined in terms of compatibility with the genuine requirements specific to each society, since the impact of "modernity" has so far been experienced according to a logic not based on local considerations and directed to ends which have been unilaterally conceived.

2. The international context

2.1. The international context itself reveals a tension which clearly has implications at the conceptual level and is therefore a legitimate subject of philosophical inquiry, for the concept of knowledge no longer appears to be a purely formal one. The generous ideals of scientific humanism are in fact a far cry from the hard reality of a science dominated by the imperatives of international expenditure on "research and development", the motives behind such spending and the consequences that it has, particularly for development and peace. For this reason it was necessary once again to co-ordinate the development effort and the demand for peace, and it was also for this reason that the United Nations General Assembly decided, in a resolution of 16 September 1975, that a "United Nations Conference on Science and Technology for Development should be held in 1978 or 1979 with the main objectives of strengthening the technological capacity of developing countries". It became clear that there was a need to change tack, to rechart the course of scientific and technological research and to take action in the policy-making sphere and consequently in respect of the controls and responsibilities that have arisen as a result of inconsistencies at the practical level. In actual fact, however, the effective implications of this desire to change course remain bound up with the way in which the term "development" is understood. And in this matter the history of the resolution that led to the Vienna Conference can shed some light.

2.2. This history is also that of the obstacles encountered in the efforts to define principles to govern international co-operation in the field of science and technology and to surmount the essential obstacle that was found to lie in scientific and technological dependence.

2.3. The question of holding a world conference on the subject was first mooted in a resolution adopted by the Economic and Social Council on 1 August 1974. Admittedly, the idea of such a conference had been examined in different specialized committees and in reports of the Secretary-General of the United Nations, but the context was new in that the United Nations General Assembly had adopted, on 1 May 1974, the Declaration and the Programme of Action on the Establishment of a New International Economic Order and on 12 December of the same year was to be adopted in its turn the Charter of Economic Rights and Duties of States, Article 9 of which stipulates that "All States have the responsibility to co-operate in the (...) scientific and technological fields" for the promotion of economic and social progress, while Article 13 recognizes that "Every State has the right to benefit from the advances and developments in science and technology...".

2.4. The decision actually to convene this conference was taken on 21 December 1976, following a recommendation of the Economic and Social Council adopted the same year. At its sixty-third session (summer 1977), however, the Economic and Social Council adopted another resolution recommending, *inter alia*, that the Secretary-General of the United Nations and the Specialized Agencies of the United Nations system contribute to the preparation of the Conference and assign high priority to it in their planning. To the same end, the Economic and Social Council adopted on 4 August 1978 a further resolution inviting the Specialized Agencies to prepare documents for the Conference and to co-ordinate their efforts so as to achieve the objectives assigned thereto.

2.5. Xithout awaiting various recommendations some of which were specially directed to it (since its field of competence gives it a prominent place in the United Nations system so far as the role of science and technology is concerned), Unesco had already fully gauged the decisive importance of scientific and technological activities in solving the serious problems which beset the world in general, and the developing countries in particular. This concern can be seen in the attention it has consistently paid to the question of endogenous development. And one of the three areas singled out in the preliminary draft programme of action drawn up by the Preparatory Committee responsible for co-ordinating preparations for the Conference - viz. strengthening the scientific and technological potential of the developing countries - bears directly on this question and on the theme of the present meeting of experts. (The other two areas concern the structuring of international relations and the strengthening of the role of the United Nations in international co-operation.)

2.6. For Unesco, reflection on the above problem ties in with reflection on the "New International Economic Order", to the establishment of which it first decided to contribute at its Executive Board session in 1974. That decision was echoed in resolution 12.1 (General Conference, eighteenth session, 1974) - which specified the steps the Organization should take in order to contribute fully in this field - and confirmed in 1976 at the nineteenth session, in Nairobi, by a text which emphasizes Unesco's role in defining the scientific aspects (alongside the cultural and educational aspects) of the New International Economic Order, and

> "4. Requests the Executive Board and the Director-General to intensify efforts aimed at assisting the developing countries to:
>
> have broader access to scientific knowledge;
> achieve the national implantation of science;
> promote scientific research adapted to their own requirements;
> develop science policies taking their national requirements and aspirations into account;
> receive, adapt and integrate the transfer of technology;
> develop endogenous technologies adapted to their needs;
>
> 5. Requests the Executive Board and the Director-General to help Member States to solve the problem of the emigration of specialists from the developing countries, paying attention to the repercussions of this emigration on the economies of the countries concerned.....".

2.7. This has been the general setting for other decisions and resolutions more directly related to the problem of science and technology in the service of development. It will suffice to recall the general programme resolution on science and technology (resolution 2.01), in which the General Conference:

> "1. Decides that:
>
> (a) the major idea which will serve as a guideline to Unesco actions in the field of the natural sciences and their

application to development consists in promoting world progress of science and technology and the effective application of scientific and technological achievements to the economic, social and cultural development of all peoples, with special emphasis on developing countries, to the strengthening of peace and friendship among peoples and to the exclusion of the use of those achievements to the detriment of the development of human society or of the human environment.

(b) Unesco will actively promote the development of international co-operation in science and technology, based on the respect of each country's specific national characteristics....".

2.8. The reflection engaged in by Unesco along the lines of the abovementioned resolutions contributed particularly to the Organization's Medium-Term Plan and to the book Moving towards Change. The ideas guiding it from the outset were not invalidated by the results of the Vienna Conference: quite the opposite. What nevertheless became clear on that occasion was that identification of problems had not gone beyond political and economic preoccupations - which were no doubt necessary but not sufficient in themselves in such an all-embracing area as that of the development of science and technology. It is therefore more than ever necessary to carry this reflection further.

2.9. An example of what is being done along those lines is provided by the Organization's programme in the field of philosophy. Since attention first became directed to the need for a new international economic order - a concept which, to a certain extent, reflects the traditional concerns of political philosophy in so far as the establishment of international co-operation requires more than good will, and perhaps more than clear-cut legal principles - the contribution of philosophy in regard to the problems raised by science and technology has come to be focussed on present-day preoccupations and the broad context in which they have arisen.

2.10. In this connection, to consider modern science in terms of its impact means simply to see it as an activity arising out of a particular environment from specific philosophical and axiological foundations and destined to extend to other environments, societies and cultures, where its effects need to be recorded. Science is seen as a manifold instrument for achieving universal transformation, attended by countless material, psychological and cultural consequences that disrupt the patterns of everyday life. Associated with technology, which is the visible face of science, it assumes the character of a dynamic, socially organized strategy sustained by that which seems to call it in question and run counter to it, and thereby impinges on the very substrata of society. Thus it is that science today does not merely illustrate anew the long-standing relationship between knowledge and power; science, in G. Bachelard's admirable phrase, is "the will to power endowed with the means of objective verification" - endowed too with irresistible efficacy in that its experimental dimension adds to the internal constraints inherent in scientific theories (the requirements of non-contradiction, simplicity and other accepted features) other constraints connected with the experimental environment itself and with the specific procedures imposed by it. For this reason, no field accessible to experimentation exists which is capable of withstanding the effect of a truly experimental science that has been subjected, so to speak in advance, to tests of reality. Whence it results that, when science is introduced in industry and when industry places its material resources in the service of science, the impact-oriented approach merely confirms by dint of micro-analyses that which is known virtually a priori, to wit, the universal effect of experimentally tested scientific procedures, applied to aspects of nature or culture considered as no more than subjects of possible experimentation - not that this in any way detracts from the interest attaching to a knowledge of social impact, for instance from the point of view of the applied social sciences, and particularly in so far as impact studies make it possible to define the practical problems arising from specific consequences of applying technology at the industrial level.

2.11. A further example may be afforded by the inquiry instituted, on as broad a basis as possible, into the relations between science and society. True, such an inquiry retains some of the features of the impact-oriented approach, but its hallmark lies rather in the attention that has been paid to evaluating the relationship between scientific perception and the level of material civilization attained by the various societies and assessing the role of science as a factor in their evolution, and so identifying value-systems that are particularly conducive to science. It goes without saying that, as has been emphasized, the relations between science and society cannot be reduced to a single model. Not only do different societies form different ideas of the relationship between science and society; they also may not all assign the same slant to scientific research. This approach reverses the impact-oriented approach in that it leads us to investigate rather the impact of society on scientific research and is thus found to throw light on the scientific "capability" of societies themselves. In a word, it tends to make us pose the problem of scientific development as an aspect of overall development. From this two questions ensue: (a) that of the moral and social responsibility of scientists; and (b) that of science policy and how science is to be steered in a direction more consonant with reasonable goals.

(a) After physics, whose advances marked the intellectual climate of the atomic age, biology in its turn is now holding the attention of philosophers and moralists, for sometimes it even purports to furnish a model for government, until such time as it is ready to invade the main sectors of industrial activity. In this connection, the following points deserve to be mentioned:

- Biology has been at the centre of the discussion which has developed - more along ideological than scientific lines - on the relations between science and society, in response to certain experiments in the field of genetic engineering.

- It was also in regard to biology that the general problem arose of a "code of ethics" which should supplement the internal and external constraints bound up with scientific activity itself - and hence with research - by constraints of another kind.

- In that connection the problem of the individual responsibility of scientists, already expressed in various forms since the Second World War, came to be defined in terms of the social commitment of the scientist.

- It was also in that connection that the danger most clearly emerged of certain interpretations entertained in experimental and applied research in the field of genetics, a field particularly conducive to ideological temptations and speculations in regard to questions of I.Q., heredity, the relationship between I.Q. and social class, etc.

(b) Consideration of the problem of scientific policy, on the other hand, is becoming marked by a growing awareness that science is no longer to be seen in terms of the theory and practice, in accordance with certain norms, of a "pure" form of knowledge, separable from its applications, but on the contrary as an essentiel tool for development, capable not only of serving production but also of becoming part and parcel of production, especially since the emergence of "R and D" set the seal on the symbiosis of knowledge and production under the pressure of economic necessities. However, in the present state of international relations (transfer costs, inadequate legal procedures, etc.), the relative strength of the parties concerned and the existing machinery for meeting these necessities are such that the receiving countries do not get what they would choose but what they are given. The reference to specific local needs itself becomes no more than a calculated, deliberate political ploy, consciously devised as a means of accentuating the priority given to the needs of the foreign partners. Hence the structural importance of international relations and their political significance and repercussions.

True, the time is no more when science developed through the co-operation of individual research workers exchanging correspondence and publications and when science itself was of scant importance for nations whose power was being built up on another basis. True, the links between knowledge and political power had long been suspected: Alexander is known to have rebuked Aristotle for dispensing esoteric teaching and Descartes considered that rationality also demanded that knowledge be placed under the public eye, whereas those who would use it for non-scientific ends seek on the contrary to cast a veil of secrecy over it. It is known lastly - for the problem has long been explicitly posed, Descartes himself having already asserted that "the public should pay for public work", in other words, that it is for the State to secure the funds for research -, that interest on on the part of the public authorities is a necessary condition for scientific development. What is new, however, is the politicization of science, suddenly and unexpectedly placed at the centre of the most weighty discussions concerning the life of a human society. Obviously, the point at issue it not only the political use to which scientific institutes, laboratories and journals can be put, but also and above all the consequences of political choices in regard to science in that it is no longer possible now to think of science without giving thought to the problems of peace and development, for science and the institutionalized structures of science themselves are dependent on the new relations that have arisen between science and society, particularly under the impact of two world wars, with these relations being more tied to the networks of domination and the structures of power than was hitherto the case; in particular, the new relations between science and society present a challenge to traditional optimism in so far as the dream has fled of a science that was to allow us to master and gain control of nature, and we are faced in its stead with man's subjection to a process which, far from being itself under control or even having clearly identified goals, seems indeed to proceed under its own momentum.

2.12. Thought thus comes naturally to be given in this connection to the problem of the trend of scientific and technological development, and this in the following terms: given an established trend which causes a problem, is it possible, at a time when planning methods are becoming universal, to steer development towards acceptable ends, and, if so, how? This approach is diametrically opposed to the classical type of approach, for the problem of the independence of research is posed in different terms, so different that Galileo's time-honoured thesis ("Regarding these arguments and others of the same kind, which are not directly de fide, no one doubts that the Sovereign Pontiff always has absolute power to accept or to condemn them, but it is in no creature's power to make them true or false other than they may be by their nature and de facto") can be seen to correspond to a more complex reality and, on that account, to lend itself to a sociological and historical analysis which - in view of the manifold factors that affect, not the truth or falsity of scientific utterances, but the function performed by science and technology in respect of social domination and the mobilization of resources for questionable ends - goes beyond the criteria adopted by the founders of classical science.

Considered in fundamental terms, it is natural to deal with this issue in a more general framework than that of the problem of science and technology alone, even though this problem is of cardinal importance in this respect. This accounts for the link between the problem of science and technology and that of endogenous development - understood not in terms of self-sufficiency but as an effort on the part of each human group to achieve, on the basis of its own forces and resources, a form of development in keeping with its cultural and scientific personality and its role as a dynamic partner in the relations of exchange and assistance that govern the international community. In other words, development forms part of the process of the assertion of intellectual and cultural identity, and presupposes independence and sovereignty without which interdependence and solidarity are meaningless; but this in turn means that the conceptual arsenal of political philosophy as a whole stands in need of renewal.

For this reason the meeting of experts on "the rights and duties deriving, for States and groups, from the establishment of a new international economic and cultural order" (Paris, 10-13 April 1978; final report SS-78/CONF.604/13) laid emphasis on the need to clarify concepts without losing sight of the overall implications of the problems they raise. In this connection, the approach centred on the "transfer of technology" was called in question. Not only does the transfer of technology give rise to alienation, but it also seems to lead to the dependence and destruction of societies in the Third World countries. The necessity therefore arises, according to the experts attending that meeting, of "subordinating technology, which must be a constituent element of the New International Order, to the principles of endogenous, man-centred development"; and it is even more necessary to "help to develop alternative technologies rather than merely appropriate technology, since the irresistible tide of a monolithic rationale cannot be stemmed unless the whole range of factors contributing to true development are taken into consideration". In formulating these demands, the experts sought to go beyond the finding that the use to which science has been put has so far led at best to growth without development, in other words without social justice, and put forward the idea that societies elect to develop certain sciences rather than others, to develop, that is, technologies more aligned to social structures and the conflicts by which they are beset than to the general interest - in a word, that science and technology are strategic factors in a confrontation that turns around the very nature of scientific development. Unesco has shown no hesitation in pursuing this line of thought within its fields of competence, as is demonstrated by the fact that its Executive Board noted at its 108th session (September-October 1979) that the outline programme submitted by the Director-General was based on guidelines which had been endorsed in the Programme of Action adopted by the United Nations Conference on Science and Technology for Development.

3. Factors contributing to scientific development

3.1. However, reference to socio-political and international factors alone does not preclude the autonomy of science as a co-ordinated system of knowledge. Those factors do shed new light on the questions, in what are science and technology grounded and what constitutes their ultimate aims. There is, however, something of a contradiction between the values inherent in the logic of knowledge, which tends to abolish the idea of viewpoint (external of course to the constraints of the scientific context), and the "values" attaching to the ultimate aim, which is to subject the development of knowledge to constraints that are not specifically scientific-in other words, between that specific logic which always consists in characterizing a particular field by the emergence of a "computation" from which all preconception is eliminated from the outset and the current "socio-scientistic" consensus, according to which the elaboration of small-scale simulation or forecasting models decked out with a few algebraic forms and data simply furthers domination through knowledge, since this knowledge then serves only to confirm the virtues of the "specialists" who perpetuate preferences that are more social than scientific in origin. In addition to the fact that the criticisms made by specialists, often bound up with their evaluation of purely technical and quantitative aspects (in the social sciences for instance), seldom go beyond the limits of discussions and conflicts between schools, a distinction does indeed need to be note without which any approach to the issues involved remains confused, namely that which is involved in the scission between the level of knowledge and that of action. As the problem of the development of science and technology would appear to be a problem of action, the entire matter hinges on the role that an understanding of the functioning of knowledge can play in directing action the purpose of which is none other than to develop, guide or create such knowledge. The entire difficulty, however, lies in determining what this role is without overlooking the need to guard against a confusion between levels that would be fatal to an understanding of the phenomenon and the requirements from which it issues. Circumstances favour such a confusion, however, and the effort to ascertain whether it can be avoided represents an essential philosophical task.

3.2. No society exists that does not have its own knowledge and techniques. However, modern science came into being through a specific combination of knowledge and techniques. The key concept seems to be that of "experience" and the experimental approach. Mention may be made in this connection of the well-known protrayal of Descartes as a craftsman and Galileo as an engineer. An entire epistemological tradition derives from reflection on the role of experience, and the sole difference between many schools lies in the diverging ways in which they define that notion and view its role. Is what is involved here everyday, empirical experience which is rooted in observation, or experience under laboratory conditions, which presupposes recourse to a system of interpretation and to a language that has already be n given a mathematical character? Whatever the case, the upshot is that modern science has broken with the contemplative tradition, which dissociated knowledge from action.

3.3. In more recent times, all the landmark events contributing to the contemporary breakthrough of science are characterized paradoxically by both a greater hold on reality and increased use of abstract tools. This has not been without certain consequences for our consideration of the nature of scientific theories:

- Thus, it might be said that the success of the sciences - and primarily the natural sciences - stems from their "truth". This "truth" is not established by virtue of purely philosophical considerations. It may be conceived in a purely theoretical manner or, more frequently, in "socio-cultural" terms. The very fact of conceiving experiment as essentially concerned with the verification of theory has enabled Western thinkers to assert the Western character of the natural sciences. This is an attempt to root those sciences in a cultural region and to define the culture of that region in terms of science. The line of reasoning is as follows: truth is the correspondence of ideas with things - congruity; it is but one step from this to the idea that the physical sciences provide a stepping-stone between nature and culture, between things and the intellect - and this step is immediately taken by those who, by the term "intellect", understand the interpretation that man gives of himself in a certain culture. If this culture is defined as that in which the scientific factor is central and decisive, then the culture in question is Western culture in so far as it is reputed to be the only one that has rigorously separated the idea of empirical rule from that of necessary truth, and has done so since the Greeks. Under these circumstances, the problem of truth, thus set within a particular cultural tradition, may be made the subject of a philosophical inquiry centring on the following question: if we subject experience to mathematical necessity, is the knowledge we thus gain of experience governed by the same necessity? If so, how is it that this necessity is not obvious? If not, what is the value of experimental knowledge?

- Thus it is that, owing to the formidable difficulties presented by these questions, continually mounting interest has been shown in formulating the problem in historical terms (A. Comte, A. Koyré, T. Kuhar, etc.). No doubt history itself is of no interest to the theory of science, but it may serve in describing the intellectual genesis of theories and thus in understanding the different factors affecting their development. It is consequently a useful means of critical analysis which has given noteworthy results, correcting certain shaky opinions concerning the "Renaissance", the birth of Galilean science, the development of mathematics in the 16th and 17th centuries, etc. Not only does it become possible to clarify the role of deduction, experimentation and the general conceptual background; useful light can also be shed on the process of invention or discovery, the steps leading up to demonstration or proof and the impact of dissemination, and a more comprehensive idea thus gained of the inner workings through which knowledge develops.

- Now this process of development, howsoever it be interpreted - and whether it be considered in terms of a continuous or discontinuous phenomenon, proceeding by successive jumps or exploiting each theory to the full, superseding it only when it no longer admits of innovation, i.e. the incorporation of new facts -, grounds science in the evolution of culture and of life, and in particular in those planes of reality where social processes play an undeniable role. The result is that one of the current difficulties of philosophy and sociology stems from the fact that the boundaries between their fields of concern have become increasingly blurred. There can be no sociology of science without an understanding of the internal methodology of science, nor philosophy of science without knowledge of its external conditions and of the constraints governing its development. The discursive and conceptual character of scientific activity must therefore also be conceived as a socially and historically significant activity, especially since the importance often assigned to science and technology as a factor contributing to progress relates essentially to the second aspect of scientific activity, for, from the discursive point of view, a proof put forward by Euclid or Hilbert, an experiment conducted by Hazen in optics or one carried out by Huygens or Newton, has in each case the same logical structure: what is always required of a demonstration or a verification is that it be closely reasoned and that it show conviction. What differs, however, is society in which at the present time the technological demands made on science are such that it must innovate or vanish, and which is wholly governed by the ideology of scientific progress. As a result, what generally holds for the different techniques can also be said to be true in this connection, namely that the differences that arise derive not so much from the quality of the intellectual operations involved as from the nature of that to which those operations relate.

3.4. In the context of the relationship between society as a whole and science/technology (which is the subject of another report), there is a socio-historical aspect to which it would appear more useful to give thought than to the internal development of the sciences and the processes involved in the emergence of successive scientific theories and their applications. What we have in mind is so-called traditional technology, in other words, non-industrial technology. The mere fact of taking only "technology" into consideration denotes a piecemeal view of technological reality and points to a resolve to take from the traditional sector - assuming the term to have a clear and definite meaning, which is far from being obvious - only that which is compatible with an overall picture the presuppositions of which are seldom spelled out. At the technological level it is, however, fairly easy to characterize traditional techniques by the fact that they are artisanal, seldom depend on the labour force of the entire community and are inexpensive and generally easy to adopt and turn to account by country-dwellers with small inclination to use sophisticated methods. On account of the smallness of its scale, the light equipment that it requires and its relative "simplicity", traditional technology allows the environment to retain its familiar aspect and, above all, makes it hospitable so that man can fit into it without experiencing any sense of alienation. For it is not so much the world that is mastered by technology as technology that is controlled by man: by dint of direct technological experiment and a lengthy and continuous process of interacting and coming to terms with his social and natural environment, man has built up an arsenal of specific solutions to local problems. However, the kind of approach keyed to traditional technology may be characterized by the fact that such technology is considered to be of a pre-industrial variety, and the desire to treat it as a collection of bits and pieces that can be incorporated in industrial development: it is seen from the standpoint of technical diversification, or its appropriateness to different social conditions and different environments, but always, so it appears, on the basis of convictions that are grounded in unspoken principles.

3.5. These convictions that are generally accepted out of hand are transcultural in nature. They might have been genuinely transcultural if the general situation were not such that a decisive role is necessarily played by international relations, with the imbalances that characterize them and the structural impact they have on other cultures, breaking them down and disrupting them. This fact is corroborated by data showing the situation in each society where development and growth have aggravated inequalities, threatened the environment, consolidated the centres of power and increased the state of dependence of individuals, country-dwellers and entire sectors of society. This being so, it is necessary to seek ways of "decentring" development, since if it continues to be considered in accordance with pre-established models, the end-result will inevitably be that the world we are criticizing comes to be regarded as a compulsory model for every society and our criticisms and reflexions serve only to establish more firmly the hegemony of a system of universal power and knowledge. In other words, what is still lacking is a theory in regard to the development of science and technology, and this lack is what needs to be especially noted and spotlighted.

4. Endog nous development of science and technology

4.1. Leaving aside the difficult problem of the relationship between science and technology taken in temselves, let us take as our starting-point our awareness and critical consciousness of the present situation and context. Evincing as these do a need to probe more deeply into what goes to make up the scientific and technological process of our time, they can no doubt serve as a guide in examining what are termed the obstacles to development and relating them back to their real sources. These sources can be seen not directly but, on the one hand, in the light of a comparison with the conditions which engendered modern science and technology and, on the other, as a result of past experience of internal difficulties and external obstacles. The point in dwelling on the historical acpects, however, is that this history is often conceived as a set pattern for all history - though, in saying this, we are not implying it to be either possible or reasonable to suppose that the developing countries are simply going to skip the stages through which the technologically advanced countries had to pass. This being so, the question at issue related to the pace of development, and not the basic goal implied in all the discussions (the least naïve of which are those that refer to it explicitly), especially as we must not forget that scientific analysis of the present situation - with, for instance, the advanced countries competing endlessly with one another in their race for the new form of wealth represented by knowledge - also shows that the study of relationships is incapable of yielding a hard-and-fast rule such as would indicate what conditions are necessary for scientific and technological development to recur. Historical analysis may therefore be useful but it is no substitute for history which "enacts" itself, through a conscious critique of the situation and of the consequences it implies.

4.2. It is often said that countries which have not known the modern development of science and technology have not experienced the mental or intellectual revolution implied by the modern scientific process. "The radical revolution of science is accomplished in contemporary philosophy". The first interpretation given of this process hinges on an understanding of the "Galileo" phenomenon. Put ideologically, it consists in saying that Galileo returned to the Platonic tradition at the expense of the Aristotelian world-view. This way of seeing the matter could be discussed endlessly. But it is a fact - to keep to the essentials - that the very notion of "Renaissance" is increasingly called in question: first, historians have considerably extended our knowledge of the Middle Ages and discovered earlier stirrings of modernity; and then we have a better idea today of the part played by non-Western contributions, without which traditional science would scarcely have been able to take shape so rapidly; lastly, it is now obvious that the West itself, not being cut off from the rest of the world, was caught up from the very outset in a process of gradual growth which enfolded it and set it, with its own innovations, in a socio-historical context so broad as to give credence to the idea of science as the cultural heritage of mankind - notwithstanding the ideology of the "European miracle" which takes over from that of the "Greek miracle" and stamps the conception of science with an excessively ethnic tinge.

4.3. Alongside the "philosophical" factor, the religious factor is often brought up. Some hold that "traditional" societies have remained so because they have not partaken of a leaven equivalent to the emancipation brought about by the Protestant Reformation. Attention, bolstered by the development of sociology, has centred on more complex factors than choices of ideas or of intellectual benchmarks. Analysis of the religious factor rightly belongs, as we know, to study of the global phenomenon represented by the "spirit of capitalism", regarded as an education for rational and profitable production. This new spirit, so it seemed to Max Weber, was linked to a secular asceticism due to a form of Protestantism, namely Calvinism. Since the fusion of different causes cannot constitute an explanation, Weber's analysis has the advantage of bringing these various causes together in a simple theory. But this is where the difficulties begin: although some have held that the "Calvinist ethic" is a major ingredient of the spirit of capitalism, others have emphasized the part played by the "Talmudic ethic". This type of approach underlies many discussions of the subject, particularly those concerning, for instance, Islam and capitalism. But even as regards European capitalism, it has been pointed out that though the medieval merchant gave to the Church and to the poor, his charity lay within the confines of his interests, so that the traditional Church itself set the seal of approval, as it were, on a business community perfectly compatible with "rational bureaucratic capitalism". Furthermore, the norms of capitalist evaluation are known to have been defined by the Italian bankers back in the thirteenth century. This impression of complexity is also borne out by the fact that ideas mooted by scholars drawing their inspiration from Protestantism were also aired within other churches, and were everywhere successfully applied by other schools, some of which professed no allegiance other than to the ideas of "enlightenment", the need for progress and the necessity of gradually separating the Church from the State and, ultimately, removing society from the tutelage and influence of feudalism, in favour of emancipation through knowledge - a logical knowledge, that is, one referring to itself alone, like logic, which is, as Marx put it, the currency of the mind.

4.4. Another reason why scientific development may be lacking in one place and proceed apace elsewhere lies in the rehabilitation of active occupations which has taken place, particularly in Europe. Gone is the scorn for the mechanical arts! Gone the superiority of the doctor over the surgeon! Gone the opposition between liberal and servile, between nature and art, underlying the divorce between science and technology! Working orders cleared the land and established workshops - glassworks, forges, sawmills, spinning mills and the like, so that we find Bernard Palissy, for example, declaring that "The efficient charging of a kiln requires a singular geometry". Wide-ranging ingenuity developed, with the backing of science; and physics, in the modern sense of the word, found in the development of "machines" a basis and a stimulus for the creation of objects for mathematical and physical investigation, as in the case of the development of mechanics. A corresponding division of labour developed which gave this new scientific reality a field of application, but also of social effectuation. The precision introduced in work as a result of the use of new instruments and the requirements for a specific job of work created, alongside a labour hierarchy, the distinction between skilled and unskilled workers - the first planks in what was eventually to become the whole ideology of "expertise" and occupational qualification. However, between application to industry (or to its ancestral forms) and scientific theory, there is an intermediate field of craftwork, with both scientific and industrial aspects, located in the workshop but constantly in touch with the scholar in his study, namely the industry of precision instruments, a new form of tool, but a form in which the technicalities involved may be regarded as stemming directly from a special branch of knowledge. It was towards the end of the 16th century that the first mention was made of the manufacture of mathematical instruments among the objects produced by a trade which developed a whole ritual of observation as the ideal model for learning and perception. As Diderot was to say: "There is in the commonest mechanical arts a reasoning so fine, so complex and yet so luminous that no admiration is too great for the depth of human reason and creativity....". Truth becomes feel, the instinct for precision becomes an appreciation of uncertainties or computation of probabilities, and judgement becomes sound sense. In short, the technical phenomenon appears truly original in relation to the cognitive phenomenon, and this originality is all the more essential to grasp in itself because it has extended to all other aspects of human life.

4.5. The foregoing enumeration may suffice to alert us to the status of what is regarded as the weightiest of these factors, namely the economic system. The spirit of rigour conveyed by new religious or philosophical ideas, the "return" to mathematical traditions (to Plato or to Archimedes), the change of direction giving rise to interest in observation and experiment, and the history of technology with the unprecedented importance it assigns to the mechanical arts, these are all factors which should properly be seen in the context of the capitalist phenomenon itself, with the antagonisms which have fed it, the forces it has unleashed and the special occupations to which it has given rise in the various sectors of social activity. And in this phenomenon the essential feature is certainly of an economic nature, for it is in the wake of an economic change, viz. the founding and extension of manufacturing industries, that new techniques develop. There can be no question of entering here into a discussion whose intricacies would take us too far. Suffice it to mention the much disputed question of "capitalist economic rationality" viewed in the light of three factors: (a) the calculated behaviour of the entrepreneur in an enterprise rationally organized and administered along optimum management lines; (b) utilization of the worker whose working capacity enters only in a certain sense, through his wage, into the capital by means of which he is forcibly subjected to the logic of profitability where quantity is the only consideration; (c) satisfaction of the consumer whose individual behaviour, through the overall functioning of the market, is subordinated to the functioning of the system as a whole. If this is true, entrepreneur, worker and consumer have become mere functions to be performed in a system in which all real action derives from social and productive relations - temselves based, needless to add, on combinations of circumstances which in each case depend on a specific historical environment. We are thus referred back from the economic sphere to the very much more complex gradual development of social structures as crystallized in history. And the social structure of concern to us is that which, though made up of differentiated characteristics, has welded these characteristics together to form a general situation eminently conducive to the development of modern science and technology.

Two questions arise here: the why and the how. Generally speaking, in this context any answer requires some historical probing and an awareness of present-day issues. What can be said in the first place, as an immediate answer to the first question, is that where this general situation has not existed there has not been any equivalent development in science and technology and that, conversely, wherever this situation has come about similar effects have been noted in the development of science and technology. But the second question is more difficult in so far as any mechanical relationship between the various sectors of activity, between the social and the intellectual, is rejected. For though nobody is in any doubt about the past relationship between scientific development and the changes undergone by the economic and political structure of society, the nature of this relationship is not always clear. The effect of practice on a legal theory is difficult to establish as it is; how much more difficult will it be to gauge the effect of, for instance, capitalism on development of the analytical theory of numbers. Hence the need to distinguish planes and to ensure that the elucidatory purpose of analysis is not lost to view, without reducing everything which is not economic to a mere reflection of the material basis without which it cannot exist or even be conceived. However, though modern science and technology may rest upon bases and conditions of an intellectual kind, their general growth has been stimulated by overall developments, and more particularly by investments which have done much to determine their style and what they produce.

4.6. We well know the mute reception given scientific theories which do not correspond to the interests of experts and the skilled practitioners, that is, the interests of the scientific élite. This phenomenon, which is perhaps older than may be supposed, has become quite clear owing to the following three factors.

First, the role of transnational corporations in disseminating science and technology in the developing world, their responsibility in the crisis affecting universities and national training institutions, and their effect on the brain drain consequent on the introduction of knowledge and know-how evolved elsewhere, have drawn the attention of the public to certain circles which only benefit from the technological inflow by becoming the agents of an intellectual, technical and economic extroversion which reveals and embodies the disorderly, fragmentary manner in which imported knowledge and technologies become established.

The second factor is that the people at large are accordingly kept outside the science and technology circuit which, though putting them off with its technicality and its sophistication, remains inaccessible to them on account of their inadequate training or is only accessible to them as consumers of objects in whose design the specific technical characteristics required in day-to-day work take second place to other, secondary characteristics.

The third is a more general factor: the advent of rational techniques in such consumer areas as public transport, telecommunications, the food industry, and so forth, tends to turn scientists into engineers and to demote science to the rank of social or technical "engineering", warranting the increasing commitment of advanced technology in a competition governed by laws that are alien to the logic of knowledge.

4.7. In these circumstances there can be no sidestepping the question of the factors linking the problem of science and technology to the most important problem of our time, namely development. Present development theories hold, on the positive side, that the development which has in fact taken place and given rise to the present gap between traditional societies and "advanced" societies may serve as a standard and model; and, on the negative side, they depreciate traditional societies on the grounds mainly of their opposition to modern ways. A certain type of development of a certain type of society has thus become an absolute reference, backed by economic sciences themselves engendered by a critique of the feudal economic system and by justification of modern rationality. Hence, even among the most broad-minded analysts, there is a virtually universal tendency to take facts for standards, to hold up the described system as a model and to regard other systems as phases of transition towards it. The force of this idea is such that despite efforts to view science and technology once again in relation to local resources, it is still merely in terms of transfers and financial investments that the problem continues to be posed — in both senses of the word, i.e. proposed for reflection and imposed as a fact.

4.8. Philosophical reflection must accordingly be brought to bear on this complex overall situation. Its contribution is necessary for several reasons, three of which seem essential.

The first is that there is a natural bond between philosophy and the sciences. Not only does each of the sciences have its own "ontology", an area of reality subjected to close investigation (for they have constantly been emancipating themselves from philosophy, that is, proceeding from transcending it); what is more, over and above the historical relationship between science and philosophy, certain scientific achievements (termed non-classical) and certain technologies (not encouraged) have arisen from philosophical demands transformed into fundamental and applied research programmes. Philosophy does not inhabit a conceptual vacuum proffering distraction or consolation; it points rather to a place to be occupied by the concept, a vacuum to be filled by a programme.

The second reason is that philosophical reflection performs an essential articulation function whenever the realities to be taken into consideration are presented to us in a fragmentary or segmentary manner. Such reflection is meaningless unless it breaks with the purely speculative concept of philosophy and treats philosophy as a dialectic - in the oldest sense of the word, namely the exploratory investigation of possibilities through a dialogue based on working hypotheses. This immediately calls for the participation of all those interested in the subject of a given question; when the question is sufficiently general in scope, it is no longer a matter purely of social engineering or scientific and technological engineering.

The third reason is the universal interest attaching to philosophical questions, stemming from the global character of the problems. This does not mean that problems are posed in universal or global terms, but only that each question, once resolved, may be of interest to everybody. Any local solution is of direct concern to mankind as a whole, for it is vital that knowledge should cease to be used for improving a system of competition and destruction in a world of hunger and want.

4.9. However, the context for such reflection must be clearly defined. It can not be/the extremely complex and knotty subject of the transfer of technology as an object of negotiation between States (with the institutional or financial mechanisms favouring it), but the problem of technological creation, as depending also, though not exclusively, on the will of the societies concerned. Of course, some forms of technological dependence are quite clear and manifest while others are more subtle and more alienating. But the crucial question, from the specifically philosophical angle, could well be whether, on the basis of a precise definition of the relations between knowledge, technical systems and society, it is possible, and if so how, to conceive and describe an endogenous theoretical capability in response to the demand for a new direction, for greater equity in access to knowledge or in the utilization of a technology which a society adopts without mastering it, uses but would not have had the ability to invent, and acquires to the detriment of standards, structures and values whose destruction presents other problems no imported technology can ever overcome.

4.10. Such reflection may present difficulties, but not such as cannot be overcome. Ever since, for instance, philosophical theories have provided guidelines for consistent scientific programmes (mathematics provides the most striking examples), we have known that it is dangerous to reject ideas which have not yet been put to the test — though we know, by the same token, that to spell out an idea is also a necessary but not sufficient condition for it to acquire practical value.

4.11. Lastly, this reflection must also concern itself with evaluation of factors particularly conducive to fresh scientific development. It therefore has consequences in the following areas, among others.

First, it affects the problem of language since knowledge must be translated into natural forms of speech. It is not enough to teach people the common languages of intercommuncation; languages excluded from the international circuits of ideas and information must be promoted so that they too may become vehicles for the dissemination of knowledge.

Secondly, philosophical reflection of this type has a bearing on education systems as well as educational content and methods. As we know, the education systems established in the 19th century, during the Industrial Revolution and the rise of business bureaucracies, fulfilled a stabilizing role by enabling the "Establishment" to retain a monopoly of knowledge and values.

A third area to be affected relates to the optimum basic training so as to facilitate the use of technological and scientific information. Such training is needed in order to provide continuity between the individual's native culture and his scientific culture, giving him an intellectual stimulus capable of opening his eyes to the true nature of knowledge.

Fourthly, such reflection is relevant to the education and training of scientists, who should be encouraged to take part in historical and philosophical discussions on subjects connected with their branches of learning. It is important to help make them more aware of history by enabling them to observe how any scientific activity has its roots in a traditional-type activity. (One instance of this, among others, is provided by Galileo in the mouth of one of the characters in his Dialoghi delle nuove scienze: "For my part, being curious by nature, I often go to this place for my pleasure and seek there the company of those workers whom we dub 'champions' on account of their pre-eminence in the trade; their conversation has helped me on more than one occasion to find the cause of effects not only marvellous but obscure and barely credible".) Furthermore, on the philosophical plane proper, though mastery of the mental equipment peculiar to each sector of knowledge is always a necessity for tactical reasons, certain questions sometimes require of the scientist a panoramic view of his sector as a whole and of its connections with various others; all of which amounts to a strategy.

5. Conclusion

The question whether the idea of endogenous capability is possible - in other words, the task of proving that it is not a self-contradictory and unrealizable notion - entails a process of examination which cannot culminate in a mere set of prescribed rules. In the course of such examination it would obviously be wrong to overlook factual data or underlying social and historical circumstances; but it would be equally wrong to disregard the internal logic of scientific development or the specific ways in which it is geared to technical data. However, one thing is certain: in order to stimulate the spiritual or intellectual factors conducive to creativity far more is needed than the abolition of technological dependence; what is needed is to establish and build up genuine intellectual capabilities, sustained by the conviction that the crucial problems transcend those of local development. It is in this direction that philosophical reflection is required. It must gauge the true magnitude of the crisis which is shaking the foundations of all societies and all cultures as a result of world interdependence. We should perhaps start by ridding ourselves of the idea of technology for technology's sake and see how, for the development and efficient use of scientific and technological knowledge, the sequence of decisions and acts constituting a science policy can be implemented in a context - combining knowledge and action - that is defined by the actual society primarily concerned. This approach, which seems scarcely to have been considered hitherto, looks like being the only one ultimately offering a new order which, rather than constituting an economic or military hegemony, fosters the full development of all Man's distinctive innate potentialities.