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On the Nature of the Interconnection between Science, Technology, Philosophy and Culture

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I

The nature of the interconnection between science, technology, philosophy and culture may be, in fact has been, approached and understood in very many ways. First, it may be shown from the commonsensical or pre-theoretical point of view that every person combines in his world-view the basic aspects of his life, scientific, technological, geographical, historical and economic. Second, at the theoretical plane one may try to redo the same thing in a more systematic and refined way. Third, we may focus on the distinction as well as relation between civilization and culture, between the material and the spiritual aspects of human life. Fourth, one may try to explain the importance of the man–environment relationship, and in the process, show that even the higher forms of culture cannot be completely free from environmental conditions. Fifth, one may argue that even the abstract disciplines like mathematics are influenced by practical and social considerations. In this connection, the relation between the natural sciences, humanities and mathematics may be briefly indicated. Sixth, comments may be offered to show that there is close relation between the environment, human nature, medicine, ethics, language, technology, and philosophy. Finally, one may argue to establish the point that philosophy, science, technology and culture are, in fact, an interwoven fabric of human civilization and that their specialization, differentiation or compartmentalization is mainly due to theoretical needs for specialization. Rightly understood, even these theoretical needs have their unmistakable practical underpinnings. All branches

of knowledge, rightly viewed, are complementary quests for and an enlargement of human freedom.[1]

Let us first examine the issue from a *commonsensical standpoint.* In our daily life, in our pre-theoretical and pre-reflective moments, we are all scientists in a sense; we make use of technology, we are accultured in some way or the other, and we stand committed to some or other world-view or philosophy. It becomes clear, on reflection, that everyone is his or her historian. Endowed as we are with memory, we cannot but recollect what has happened to us as well as to the people around us over a period of time. Psychologically speaking, human memory is classificatory and organized. Even our memory-failure or inability to recollect something of the past has its place within our memory. In brief, historicity is an integral part of humanity, i.e. native to human nature itself.

Similarly, it may be pointed out that we are our own economists, our own geographers, our own technologists, and so on. If economics is construed as the study of the relationship between human aims and the limited resources available for the purpose of realizing the same, we are all engaged, consciously or unconsciously, in some or other economic pursuit. Human existence without aims is nearly impossible. Equally impossible is to conceive of human life which, relative to its aims, knows no resource-constraint. Therefore, humans are destined to be economic beings.

We cannot live and progress successfully in the world without defining, articulately or inarticulately, our relationship with our environment, immediate or not so immediate. Our body–mind complex, open to information inflow, is always, to a greater or lesser degree, environmentally informed.[2]

Technology is not something outlandish. That we know what fire is and put it to different uses is evidence of our being wedded to what may be called fire technology. That we wear clothes on our body, live in a house, try to protect our body from the bad effects of heat and cold, that we cook our food, rather than eat it raw, are among the direct evidence of the indispensability of technology to our life and living.

Just a little intellectual probing makes it clear that underlying the uses of technology is our scientific understanding. Without the laws or principles of science different forms of technology are not possible. Our experience of the world around us, of our own selves as well as of other selves, exhibits some patterns. These empirical

patterns or generalizations constitute the sub-structure of science. Given refinement and reflection, we construct, on the basis of science, some higher-level principles purported to explain, in a somewhat abstract manner, the phenomena and processes studied in specialized sciences. These higher-level principles are not necessarily addressed to natural phenomena.

Also of concern to us are the rules and regulations which ensure a civilized life, a peaceful polity and orderly development. Often these principles are known as laws and religious injunctions, prohibitive and prescriptive. All that we do and need are not necessarily practical or instrumental. We have in us many impulses which, superficially speaking, are useless. The love of beautiful things, the liking for musical sounds, the will to improve the quality of our motivation and action, are among the innumerable cultural traits of human nature. If civilization is basically concerned with the material aspect of our life, culture primarily consists of the qualities of our very being, freedom and the different forms of its articulation.[3] Civilization has been likened to a golden ring and culture to its shine. In other words, culture need not always be imparted from without. Like historicity, culture is native to human nature.

II

The second important way of understanding life, science, technology, philosophy and culture may be called *theoretical.* One and the same domain of phenomena may be theorized in different ways. For example, history may be narrativistic, i.e. like a story, theory-loaded or ideological, typological, local, regional, and even universal. Both level-wise and scope-wise history may be of different types. Even at its narrativistic base-line, history is not free from minimal theoretical underpinnings. The point may be clarified by highlighting the distinction between chronicle and history. The text of history is not like a thing-in-itself. It always bears the imprints of human interpretation and its cultural context. Just as we draw a distinction between micro-economics, a similar distinction is evident between (*a*) the history of micro events like individual action, specific in respect of its space-time address; and (*b*) macro events and processes spread over a period of time and a geographical area.

Further, historians of a positivist persuasion are in favour of describing their subject-matter as objectively or faithfully as possible. They try to keep history as a value-free discipline. In contrast,

theory-intoxicated and ideologically motivated historians find no 'hard' facts in history. All facts, to their mind, are open to alternative, not necessarily antagonistic, formulations. For example, history may be viewed as an account of class-struggle or of racial strife. Also, history has been written in terms of conflicts between different nations and imperial powers.

When we come to the question of writing a history of science and culture, the narrativistic account and the micro approach prove hopelessly inadequate. Instead we are obliged to follow typological and macro methods.

The diversity of approaches are evident in the field of economics, economic history, technology and technological history also. One very influential approach is basically an economic one in character and is formulated in terms of the prevailing mode of production—pastoral, agrarian or industrial. Implicit in this approach is the role of technology of the concerned mode of production. Although this approach is generally attributed to Marx, Engels and their followers, its distinct elements are discernible in the writings of pre-Marxist anthropologists such as L.H. Morgan.

Another school of opinion is in favour of interpreting the history of technology in a secular manner, keeping the economic factors more or less out of its ambit. In many models of technological history, economic factors are assumed to be exogenous and as such are substantially ignored.

An opposite tendency is also evident in the field of economic history. Several models of economic history have been built in terms of some macro variables like income, savings, investment and employment. The absence of technology as an input or variable is conspicuous. This approach may be called purely economic.

Our own perception is that neither economic nor technological factors operate in a mutually exclusive manner: they interact and interpenetrate. Their interface is unmistakable.

But more important in this context is to note how these two sets of factors are closely related to their cultural background. The pure economic theory of history or the pure technological theory of history is an ideal-typical accentuation of relevant factors, consciously disregarding other factors only for limited heuristic purposes.

This only highlights the possibility of alternative conceptions or formulations of history. These alternatives are not always antagonistic. Positively speaking, the plausibility of these alternative approaches does not clash at all with one's integral programme of writing the history of a civilization which comprises economic, scientific, technological and cultural events and processes within its comprehensive scope. Perhaps the time has come to neutralize the ill-effects of excessive compartmentalization of human knowledge and the need for an integral or system-theoretic approach is increasingly felt. Like the life of an individual, the life of a civilization is in a way organically textured. Its vertical and horizontal threads, warp and woof, may be discerned and described. But its holistic or textured presentation appears to be more instructive.[4]

Perhaps a word of caution is called for here. In the name of integration, a system-theoretic approach, or holism, one must not lose sight of the specifics of the different areas of life—individual and collective, theoretical and practical. Disregard of this caution often lands us in metaphysical generalizations not relatable to factual findings. Both the end of theoretical enterprise, general principles and specific details, deserve careful attention, rational integration and critical scrutiny.

III

Our third point, to start with, is concerned with the *relation between civilization and culture.* At the pre-reflective level these two terms are often used in an interchangeable manner as if there is no distinction between them. Moreover, these two terms are highly general and, understandably, do not take due note of the distinction between different branches of knowledge.

For the purpose of refined understanding and analysis, it is advisable to try to identify the distinction between the meaning of *civilization* and that of *culture.* The commonsense meaning of *civilization* highlights the difference between the *barbaric* state of society and the state of established *civil* society. Also, it draws our attention to the *pre-social* stage of human living and the *social* one. One gets the impression that without some institutional form of social life, the conceptual transition from the *pre-social* to the *social,* from the *barbaric* to the *civil* state of society cannot be made intelligible. This transition is said to be *conceptual,* rather than *historical,* because of the non-availability of historical data in support of the view. But it is easily conceivable that the life and survival of ware contingent upon some normative dispositions and law-governed conduct.

Judged by these criteria, even a barbaric society may claim to have elements of civil society or civilization within it. It is to be remembered in this connection that the Hellenic peoples used to describe all non-Hellenic peoples, especially the ancient northern European ones, as barbaric. A pejorative sense was attached to the word *barbarism*. In a descriptive sense it denoted the non-Hellenic peoples. Somewhat similarly, the peoples of the Indus Valley and the Indo-Gangetic Valley used to refer to the Indian or Greek peoples as (phonetically) *Yavans*. Later, even the peoples of non-Ionian origin like those who came from Arab, central Asian and the trans-Caucasian areas were known as *Yavan*. Even here a pejorative sense was attached to the word *Yavan*. One need not attribute much importance to self-laudatory and other-critical ethno-centricism, because their factual contents are often found to be very thin.[5]

Both etymologically and semantically *culture* is due to some sort of tillage or cultivation. It is in terms of the acts of cultivation that what is *culture* is distinguishable from what is *natural*. It may be looked at in another way. Culture is rooted in some or other *cult*. The suffix *ure* stands for the *result* or *function* of some action and process, as is evident from such words as *scripture, enclosure* and *composure*.

Different ways of understanding the distinction between *civilization* and *culture* are available. For example, metaphorically speaking, civilization has been likened to a ring of god and culture to its shine. The former seems to be more material and the latter is less so, or spiritual. In a philosophic vein it has been said that civilization is what we do *possess* or have, and culture is *what we are*. The former primarily stands for means of living, individual and communal, such as houses, roads, ponds, tools, utensils and dresses, while the latter primarily denotes the finer things of life such as an altruistic disposition, moral compassion, aesthetic feeling and what flows out of them. In brief, one might say, whereas civilization is basically concerned with the material aspects of life, culture deals with the spiritual aspects. Closer scrutiny reveals that even this line of distinction is not hard and fast; it keeps on changing and is 'a matter of more or less', not exactly ascertainable. Where or at what level the materiality of civilization ends and where or at what level the spirituality of culture begins can hardly be observed.

Though provisional and conceptual, the distinction between civilization and culture helps us to define better the relationship between science, philosophy, technology and culture.

In a general way it may be said that each one of these forms of culture is peculiarly human. What is peculiar to human beings? Certainly it is not the body. Many non-human creatures have bodies,at least some of those bodies are proto-human bodies and their bodies are also environmentally informed. Broadly speaking, there are two ways of gaining information. First, information may be a natural inflow into a living organism, and second, information may be augmented, expanded and transformed by some internal powers like end-consciousness, means-consciousness and intelligence to conjoin the two. The second form of information gathering or information expansion is peculiar to human beings.

In what is this peculiar human ability or cognitive capacity rooted? Many hypotheses have been offered. Experience, consciousness, reason, the ratiocinative capacity, sign-using capacity and tool-using capacity are among the key terms around which the different hypotheses have been framed. It may be shown that these different capacities have a generic unity of their own.

The basic point may be explicated in terms of the fundamental notion of *freedom*. Humans are free in a sense unknown to other creatures, including the bipeds. First, human experience is exceptional because of its highly categorized or organized nature. We have five external organs. Besides, if we are to believe the Indian psychologists, we are endowed with an additional internal sense called mind, *manas*. To the last is ascribed the coordinative competence of the sense-information gathered in and through the five different external sense-organs. Further, human memory is longer and subtler than that of non-human creatures. It enables us to expand endlessly, the horizon of our environment or world.

IV

Situated in a specific environment and shaped by a particular civilization, humans are free to scale the higher reaches of culture. Being embodied as we are, we do belong to a particular territory. Physical geography is indeed very important to our lives. Just as the proverbial fish cannot live out of water, humans cannot live long out of land. Even migratory birds return to their original habitat. It is human freedom which can partly undo the effects of migration. In the case of humans, the migrants psychologically long for the land to which they originally belonged and almost universally carry in them a nostalgic and lingering memory of it. It is hard to erase

race memory. Even the nomadic tribes which left India long ago and now roam about in Europe, can well recall their Indic myths and lexicon.

In the man–environment relationship, two things deserve special mention: (*a*) the effects of geography on human nature, and (*b*) the human capacities which are more or less free from the effects of geography or environment.

For example, our eating and clothing habits largely depend on the climatic conditions in which we live. The Eskimos cannot be expected to eat the sort of food which we, the tropical people, are used to. The converse also stands true. The geographical difference between people of the temperate zone and those of the tropical zone is also considerable. Forest resources, water resources and mineral resources make a lot of difference to our modes of living. Mere notional availability of resources is not enough. Their actual usability is of prime importance. For instance, river waters of extremely cold areas which remain frozen for the most part of the year cannot be as useful as those in countries with a warm climate.[6]

Climatic conditions make a lot of difference to ways of living. Even if other living conditions are the same, peoples of the temperate zone are found to be more hardworking than their brethren who live in tropical areas. Those who live in highly warm conditions get easily tired and exhausted. However, this point needs qualification. The effects of climatic conditions on human life can be considerably neutralized by the use of appropriate technology. If we do not clearly bear in our mind the importance of this qualification, we are likely to commit the fallacy of Montesquieu and others who maintain that civilization and even culture are almost a direct function of climatic or geographical conditions. This fallacious view has been pressed to the absurd extent that outside the temperate zone civilization and culture of a high order cannot develop at all. This approach partly accounts for Eurocentricism and the rise of racialism. The emergence of developed civilizations and the records we have of them expose the hollowness of this view.

Moreover, it fails to take note of the neutralizing effects of technology on civilized life. By using different types of clothes we can protect our bodies from the effects of climate. Besides, the technology of making dwelling houses cool in warm weather and warm in cold weather is known to us since pre-historical times. Knowledge of different types of fuel and their uses, knowledge of

building different kinds of houses, and of the different materials used for the purpose, and knowledge of choosing suitable sites for construction of villages and towns are among the basic technological determinants of human habitation and living.

Other than the modern technology of airconditioning, various forms of heating and cooling were known to the people of antiquity and of the medieval age. Even today, the relatively poor Eskimos of the Arctic zone have their own ways of making warm shoes and dresses, of building dwelling units and constructing canoes to go to the sea for the purpose of fishing and killing whales. Comparable technologies are also available in our own country. Those who live in the cold conditions of the high reaches of the Himalayas make use of their indigenous technology for survival. Needless to add, their food habits and dresses are quite different from ours.[7]

Let us take another example. Modes of transport are also bound to be different according to different geographical conditions. Boats for inland water transport are quite different from those used by fishermen operating in estuaries or coastal areas. Still different are the types of wooden boat, *dhous*, for example, used for deep-sea crossing. Convincing evidence is available that both on the east and the west coasts of India there were a number of ports and shipyards in the ancient as well as medieval periods. The technique of building deep-sea boats and that of navigating them properly are still available in India.

V

Not only our ways of living but also our modes of thinking, forms of feeling, and their articulation are, to some extent, moulded by our geographical conditions.

From the cave paintings of the ancient or pre-historic men we get an idea of where they lived, the sort of tools they used to kill their prey and also of the kinds of animals they ate. From the inscriptions of the different periods we come to know of the various expeditions undertaken by the kings and what their aims were. Some inscriptions give us a clear idea of the kind of transport used on land and sea in such expeditions. Archaeology and numismatology are not only a very important part of history but also a gateway to epistemology. An idea of abstract forms of knowledge like cosmology, theology and praxiology may also be gained from the relics of the past. For example, from the Ashoka inscrip-

tions we learn not only of his Kalinga expedition but also of his conversion to the Buddhist philosophy of peace and non-violence.

From the architectural styles of temples, *stupas* and *viharas* one can form a clear idea of the builders' geometrical knowledge. The significance of the use of circles, squares, rectangles and triangles, is by itself an area of interesting study. Incidentally, this also indicates the concrete relation between abstract disciplines like arithmetic and geometry, on the one hand, and architecture and town planning, on the other.[8]

It is well known that Vedic mathematics, especially geometry, had a very important relation with the construction of different forms of the altar (*vedi*). Comparable was the relation between the Egyptian (Greek) geometers and the technique of measuring correctly plots of land on either banks of the Nile after the previous land-demarcation marks were repeatedly washed away by floods. Systematic methods of counting and measuring are an inseparable part of civil life. The Babylonians are said to have developed a sexagesimal system of expressing numbers in cuneiform writing. The Egyptians, credited with having developed a system of numeration using hieroglyphic, hieratic and demotic notations, apparently experienced, like the Babylonians before them, a lot of difficulty in dealing with fractions. Indians are attributed the credit for the introduction of the decimal place-value system, a modern form of numerals with the symbol of zero. Some of the Sanskrit synonyms of 0[zero] are *śūnya, vyoma, ākāśa* and *pūrṇa*. 0[zero] is accorded the supreme ontological status by the Buddhists of the *Śūnyavādi* persuasion. Zero had two types of use, as a word-numeral and as a symbolic. This accounts for the development of simplified methods of fundamental operations and for calculation by the rule of three. These Indian innovations appear to have been accepted by Arabic scholars under the patronage of the Abbasid Khalifs at Baghdad towards the end of the first millennium AD.

The science of first principle cosmology also had a lot to do with the human encounter of such forces or elements of nature as earth, water, fire or energy (or sun as its source) and air. Not only in ancient India but also in Greece and China, we come across references to one or several of these principles being responsible for all that is there in the universe.

Perhaps the more interesting part of cosmology is not the recognition of the variety of beings and things but their unity, being.

While the ancient cosmologist was empirically obliged to recognize the individuated variety of objects, he was equally interested to discover a cosmic principle like *ṛta* or universal law underlying all that exists and moves. The contemplation of the relation between 'multiverse' and universe, 'chaos' and cosmos, was distinctly metaphysical and speculative in character. At the same time, it is to be noted that the speculation was inspired by the experience of variety, on the one hand, and the search for unitarian principle(s), on the other.

It is not surprising that a *ṛta*-like principle is also found in western thought. Often it has been referred to as the principle of harmony. harmony is all-pervading—natural, social and even cosmic. Some forms of harmony are perceptible and some forms are understandable. Still other forms are hidden and scientists are obliged to postulate them. Without these postulations, the search for law-governed orderliness in music, mathematics, physics and metaphysics make no sense.

The very possibility of understanding the laws of nature and society presupposes their existence in the form of harmonic structures. The mathematizability of the different areas of the physical universe, terrestrial or celestial, cosmic or atomic, is not arbitrary. Some or other forms of orderliness are objectively grounded in nature. Otherwise, we are forced to fall back on a contrary and untenable assumption, viz. all scientific orderliness is man-made, an imposition or dictation of the human mind. Had all objects of nature been amenable only to one particular form of mathematization ,the human mind could be spared the trouble of innovating different types of numbers and different branches of arithmetic, algebra and geometry. Positively speaking, what forms of language, mathematical or literary, we are required to use, largely depends on the characteristics of the objects concerned. Different domains deserve different forms of treatment, theorization, systematization, and if possible, axiomatization. Mathematics was found to be necessary not only for cosmological theories but also for accurate expression of atomic theories. Concepts like *aṇu* and *paramāṇu* and their combinations could not possibly be handled without the notion of the infinitesimal. It has been claimed that the idea of the infinitesimal was used not only in the context of material atoms but also with reference to the nature of *Brahman* and that of *self* (*ātman*).

Brahman has been described as smaller than the small and the *self* as small (*anu*).

In India, the concept of infinitesimal calculus has also been used by astronomers for expressing the instantaneous motion of a planet, the 'position-angle' of the ecliptic with any secondary to the equator, the surface and volume of a sphere.

It has been rightly observed that the dual concepts of infinitesimals and infinities have raised foundational problems in the history of mathematics. From the discovery of irrational numbers or incommensurable magnitudes (both in India and Greece) to the contemporary debate between intuitionists like Kronecker, Brouwer and their followers, on the one hand, and formalists like Cantor, Hilbert and their followers, on the other, it is no wonder that the history of infinitesimals with particular reference to its philosophical implications is being seriously studied. It is generally agreed that infinities and infinitesimals are not merely of heuristic significance and that they do have ontological warrant. Their use enables us to grasp the complexity of natural phenomena and their otherwise available purely empirical investigations.[9]

The history of mathematics may be studied both as an *autonomous* discipline ignoring its interaction with non-mathematical disciplines and as an *integral* part of other branches of knowledge, natural and social. Researchers in any interdisciplinary programme would be well advised to follow the second approach. Mathematics is not an outlandish subject. It is very much a part of our daily life as well as an intellectual pursuit. In this connection I would like to quote two passages from the writings of two very eminent mathematicians.

> Most people, mathematicians and others will agree that mathematics is not an empirical science, or at least that it is practised in a manner which differs in several decisive respects from the techniques of the empirical sciences. And yet, its development is very closely linked with the natural sciences. One of its main branches, geometry, actually started as a natural, empirical science. Some of the best inspirations of modern mathematics (I believe, the best ones) clearly originated in the natural sciences. The methods of mathematics pervade and dominate the 'theoretical' divisions of the natural sciences. In modern empirical sciences, it has become more and more a major criterion of success whether they have become accessible to the mathematical method or to the near-mathematical methods of physics. Indeed, throughout the natural sciences an unbroken chain of successive pseudomorphoses, all of them pressing toward mathematics, and almost identified with the idea of scientific progress, has become more and more evident. Biology becomes increasingly pervaded by chemistry and physics, chemistry by experimental and theoretical physics, and physics by very mathematical forms of theoretical physics. [John von Neumann, *The Mathematician*, 1945]

Von Neumann's own works in the wide areas of quantum mechanics, probability, self-reproductive machines and (game-theoretic) economics convincingly show the interfaces of seemingly unrelatable disciplines.

The same may be said of the works of Wiener:

> While the historical facts in any concrete situation rarely point a clear-cut moral, it is worthwhile noting that the recent *fertility of harmonic* analysis has followed a refertilization of the field with physical ideas. It is a falsification of the history of mathematics to represent pure mathematics as a self-contained science drawing inspiration from itself alone and morally taking in its own washing. Even the most abstract ideas of the present time have something of a physical history. It is quite a tenable point of view to urge this even in such field as that of the calculus of assemblages, whose exponents, Gantor and Zermelo, have been deeply interested in problems of statistical mechanics. Not even the influence of this theory on the theory of integration, and indirectly on the theory of Fourier series, is entirely foreign to physics. The somewhat snobbish point of view of the purely abstract mathematician would draw but little support from mathematical history. On the other hand, whenever applied mathematics has been merely a technical employment of methods already traditional and jejune, it has been very poor applied mathematics. The desideratum in mathematical as well as physical work is an attitude which is not indifferent to the extremely instructive nature of actual physical situations, yet which is not dominated by these to the dwarfing and paralyzing of its intellectual originality. Viewed as a whole, the theory of harmonic analysis has a very fine record of this sort. It is not a young theory, but neither is it yet in its dotage. There is much more to

be learned and much more to be proved. [Norbert Wiener, *The Historical Background of Harmonic Analysis*, 1938]

From the above two quotations we get a fairly clear idea as to how mathematics is related to other disciplines, both scientific and humanistic.

VI

Medical science is another very instructive area which shows a close interconnection between physical nature, human nature or psychology, biology, biochemistry and technology in the form of surgery. If one carefully goes through the *Caraka-Saṃhitā*, it becomes clear that medical science also has a thick moral content. Medicine and ethics are inseparable. The ethos of the physician, of the nurse, of the cooperative patient and drugs of good quality are the four main ingredients for proper treatment and cure of disease. Disease itself is an expression of imbalance between human nature and its attending environmental conditions like heat, cold, availability or otherwise of drinking water, nutritious food, etc. Besides this 'external' balance between man and nature, another or internal sort of imbalance is also referred to as the possible cause of disease. If the delicate balance between *śleṣma* (cough), *pitta* (bile juice) and *vāyu* (air) is disturbed, the body is visited by some or other disease. Therefore, freedom from illness is contingent upon two types of balance—internal and external. The method of diagnosis recommended in the *Caraka-Saṃhitā* highlights the importance of the relationship between the environment and the organism and also how to keep the latter fit in terms of diet and medication when it falls sick.

To understand Āyurveda of the Indian tradition one must be familiar with three important treatises (*vṛhattrayi*), namely, *Caraka-Saṃhitā, Suśruta-Saṃhitā*, and *Aṣṭāṅga-Saṃgraha*. If one goes through these works one cannot but be struck by the authors' knowledge of anatomy, physiology, pharmacology, climatology, botany, zoology, physics, chemistry, mineralogy and also philosophy. It is interesting to note that different schools of Indian philosophy like Nyāya, Vaiśeṣika and Buddhism have their own different approaches to medical science. This shows, among other things, that even a science like medicine which is full of empirical content lends itself to different ways of philosophical theorization.[10]

Medical science, as conceived in India, is not merely a matter of

therapeutic techniques, it also has a deep humanistic aspect. When one enumerates the essential qualifications of the physician, of drugs, of the nurse and those of the patient, the point becomes clear. It is not enough that the physician knows his theoretical discipline; he is expected to be experienced, practically skilful and clean in body and dress. Second, inefficacious or substandard drugs are ethically prohibited. Third, the nurse, like the physician, must also be clean and, what is more noteworthy, she is expected to be emotionally attached to the patient. Finally, the patient himself must have the moral courage to express frankly the symptoms of his disease and he should be disciplined enough to follow the physician's and the nurse's instructions.

The philosophical underpinnings of medical science also deserve careful attention. Philosophical concepts like *karma*, causality, reasoning or debate have been accorded a very important place in medicine. Scientific debate between the proponents of different philosophical concepts is always welcome in the Indian tradition of medicine.

Apart from medicine and environment, philosophy brings out another important aspect of human biology. Earlier it had been said that the human organism is more informed by its environment than any other organism. But philosophical analysis brings to the fore that there are some native competences, primarily freedom and symbolizing capacity. Unlike the environment-inducted competences, these are more or less 'innate' or autonomous. I say 'more or less' because externally given capacities and internally initiated ones are mutually supportive and one cannot be completely separated from the other. For example, the full import of external stimuli, natural or cultural, can hardly be grasped by an organism unless its receptive and interpretative capacity are of a fairly high order. On the other hand, it may be pointed out that internal capacities cannot be satisfactorily developed without the support of appropriate external inputs, stimuli or information. The point may be easily illustrated by referring to the impaired linguistic capacity of persons who are biologically handicapped. For example, dumb and deaf persons cannot speak but they do have deep sensitivity, and developed linguistic and intellectual abilities. The classical case of Helen Keller makes it clear how on the basis of meagre external input massive internal, i.e. cultural and intellectual, output is possible. In recent times the life and works of Stephen

Hawking illustrate the same point. Unable to write, or even to speak clearly, Hawking, Professor of Mathematics at Cambridge University, is widely regarded as the most brilliant theoretical physicist since Einstein. It is universally known that persons with impaired sense organs have extraordinary internal sensitivity and capacity. The underlying psycho-biological points have been clearly brought out by linguists and bio-linguists like Chomsky and Lenneberg. The basic points to be remembered in this context are two-fold. First, in the biology of language we may disregard, to start with, the problems of speech and motor production and focus our attention on the understanding of language as a special form of pattern recognition. The advisability of this approach is proved by the recent efforts made to build a machine that can answer questions fed into it in the form of unedited English. Second, all organisms in general, and human organisms in particular, are self-organizing systems. This suggests that human organisms are more or less, but *not* boundlessly, free for the purpose of the specific organization of language processing and articulating. In brief, our biological matrix, endowed with specifiable characters determining the outcome of what is given to the concerned organism, can yield a wide range of achievements or performances.

Besides the linguistic capacity, another capacity that differentiates man from sub-human creatures is his technological capacity. It is no wonder that the two most widely known definitions of man are 'sign-using animal' and '*homo technikos*'. Interestingly enough, both these capacities are expressive and promotive of human freedom. In terms of signs and symbols man expresses his experience, objectifies and communicates the same to others, and thus enlarges his world. Similarly, in terms of his mastery of technology he performs or achieves what he cannot ordinarily get done by his own bio-psychological capacities. Both these capacities expand the human world. Besides, the freedom made available by language and technology enables man to see clearly the relationships between the different areas of their world, physical, biological, epistemological and axiological, and also the corresponding branches of knowledge. In short, language and technology, born out of human nature, enlarge and enrich its capacities in very many significant ways. Like medicine, which cures human disease, language and technology remove the limitations of impaired human capacities. In a way all these branches of knowledge make it clear as to how our realm of

freedom can be effectively expanded and viewed as the basic principle unifying different branches of knowledge, pure and applied.

VII

Liberal historians and historiographers have often described history as the story of liberty. What they mean by this is that the course of history in different cultures is marked by an increasing assertion of freedom, despite its occasional setbacks or regressive shifts. That history is not subject to any set of inexorable general laws is generally agreed upon.

But this highly general libertarian characterization of history is not uniformly evident in different areas of history. First, universal history, the history of mankind taken as a whole, is more a generalization than a description of the specific events of widely different national or local histories. Second, historians of highly abstract disciplines like mathematics and historians of culture-specific fine arts, for example, cannot for obvious reasons follow the same methodology. In the former case, *general patterns* are easily discernible, while in the latter, artistic *peculiarities* tend to arrest the historian's professional attention. Third, histories of all branches of knowledge—physics, biology, earth-science, architecture, etc.—have their own *internal* and peculiar problems and issues. The same point may be raised in the contexts of economic history, technological history, the history of ideas and history of philosophy. It is of considerable interest to note that the very general nature of philosophy and of influential ideas cannot make the concerned historians blind to their epoch-specific or culture-specific characteristics. Rightly analysed, this point indicates why all forms of history—from the very abstract to the very concrete, from the universal to the local—need to be studied in relation to their attending circumstances, physical, technological and cultural.

An interdisciplinary historical approach to different modes of human experience and action and their theoretical articulations should take human existence in its physical setting as its starting point. In a sense, every starting point, physical, biological, or abstract philosophical, may appear arbitrary. But the main merit of taking the physical geography of man's existence as the first premise for understanding the unfolding of the history of human life, its problems, attempted solutions, and the resulting achievements, is to show clearly how even the rudiments of our reflective life,

'primitive' technology, myth, different forms of folk culture, etc., are closely inter-related. From geology and geography to theology and metaphysics, every discipline is, directly or indirectly, traceable to the concerned man's experience of his own environment.

Human life, together with its culture, is itself an *orderly* disclosure, or evolutionary product, of nature. Nature without *order* could not possibly account for the emergence of *homo erectus* and the finest flowers of its culture, science, mathematics, music and philosophy. The main areas of human experience and their theoretical formulations may be organized in many ways. However, for the expository purpose one may perhaps profitably start with the physical sciences—physics, chemistry, geology, physical geography. Man's experience of his environment throws him back to his own self, his capacities and limitations. At this second level it is programmatically advisable to look into such disciplines as the life sciences, including medicine, and technology. If through *technology* man's self-reflective nature tries to overcome its known limitations, he expresses, in and through *language*, what happens to him in his interaction with nature, conceptualizes and communicates the same to fellow human beings. It is in this way that in terms of technology we not only exceed ourselves but also share our different forms of experience, knowledge and ignorance, joy and sufferings, with other human beings.

While the 'hard' physical sciences form the bottomline of our programme, the second upper line consists of relatively 'softer' life sciences. The more analytic-minded researchers may like to accord an intermediate position to such sciences as paleontology, paleography, and palaeoanthropology. This refinement, in principle, can be carried on indefinitely. But the resulting taxonomy is not called for in the context of our research programming. For example, in between the life sciences and the social sciences one may easily carve out a 'natural' place for such disciplines as biosociology and demography. Third, above the nature-and-life-related sciences, our research programme is obliged to recognize such basic social sciences as anthropology, sociology, economics, history and their allied disciplines. It may be mentioned here once again that in a pre-theoretical way the elements of all these disciplines are available even at the primitive level of life, the pre-civil state of society. The institutions and organizations that are theoretically studied at the third level are in a way experienceble also at the first and

second levels. Even the sub-human creatures, including insects, have their own community life. The 'community life' of the ants in an anthill or of bees in a beehive is more than an empty metaphor. Obviously the forms of our community life, unlike theirs, are consciously changed and flexibly adjusted in the light of our changing needs and experience and by our thought and action.

Beyond the level of the social sciences, we encounter abstract disciplines like mathematics, music, logic, epistemology, jurisprudence, etc. Careful scrutiny suggests that some of these disciplines are value-loaded and some others value-neutral. But if rightly understood, these characterizations, though welcome for the limited theoretical purpose, are not strictly tenable. For example, the very contemplation of some elegant and harmonious mathematical structures is historically reported to have provided deep intellectual pleasure and satisfaction to many experts in the field. From the other end it may be pointed out that sensuously enjoyable music has its own stable but refined mathematical base.

Finally, philosophy is often said to be the most comprehensive form of knowledge in which all other modes of experience are reviewed in an inter-related way. But about this proclaimed primacy of philosophical modes of knowledge one may critically observe that this sort of comprehensiveness is also available, though in a very speculative or inarticulate form, at the pre-theoretical level of mythology. As mentioned earlier, Indian and Greek cosmologies are also proto-scientific attempts to explain many terms of one, water, fire, or air. In the modern forms of cosmology or philosophy the ancient forms of mythology are sought to be recapitulated and rearticulated in contemporary idioms.[11]

CONCLUSION

Our research programme may be briefly and roughly indicated in Diagram I. As has been said earlier, this diagrammatic representation may easily be further refined and improved. However, the more important point is to recognize the alternative way of representing the programme. Broadly speaking, the whole diagram may be put upside down. Instead of moving from bottom to top, one may propose to move from top to bottom. In that case the so-called higher level disciplines like philosophy and mathematics take a reverse or bottom place. Moreover, the character of 'abstract' discipline is taken in a different, i.e. commonsensical manner. This

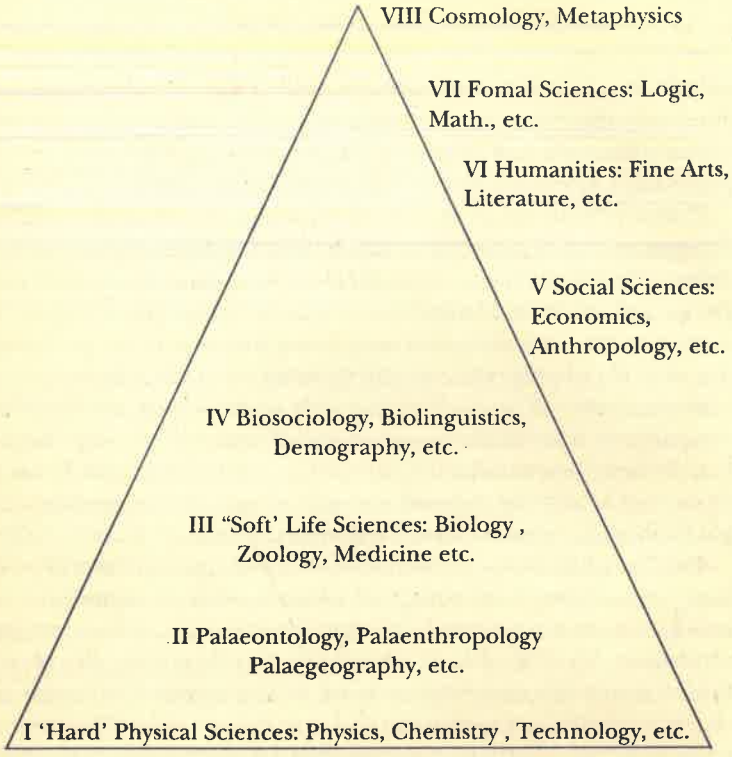

DIAGRAM I

point has been repeatedly conceded in the explication of the structure of Diagram I. Given these qualifications, the second diagram of our programme may be visualized as given on the facing page.

Diagram I is pro-naturalist and bottom-up and the reverse is the case with Diagram II. The latter is anti-naturalist and top-down. Those who accord methodological primacy to the natural sciences are generally found to favour the approach underlying Diagram I. At the same time, many historians maintain that ideas and ideals, cognitive and praxiological, have proved more influential than physical forces and material factors of economic production in moulding the career of human civilization and culture. This difference of approach is not merely a matter of methodological primacy; it also has its ideological orientation. The scene appears

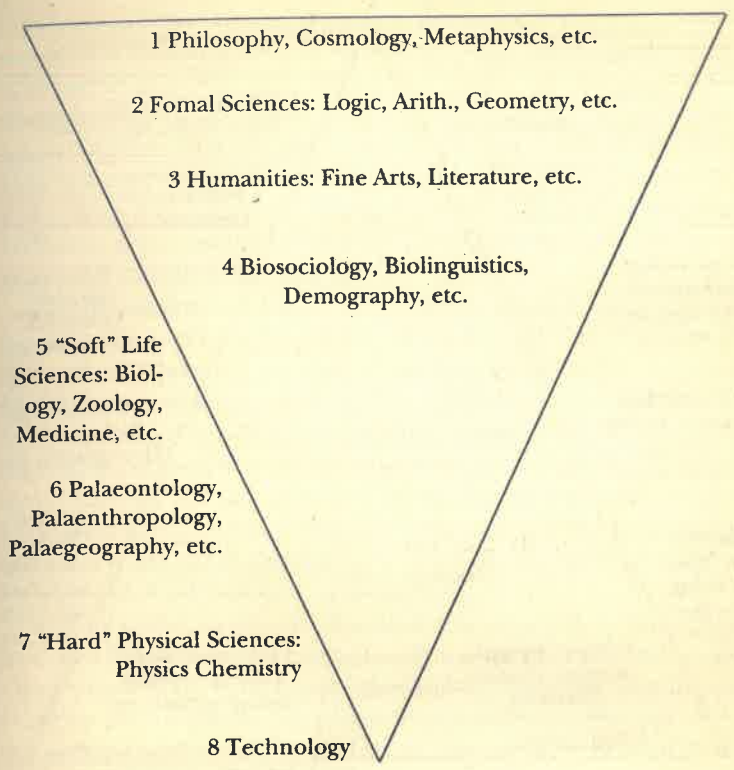

DIAGRAM II

doubly complex when we find that some of those who methodologically favour the bottom-up approach (Diagram I) are ideologically libertarian (Diagram II). In other words, the pro-naturalist historian of science, technology, philosophy and culture can also plausibly argue to show the supervening influence of ideas over the material factors of life. One may be naturalist, to start with, and yet end up in anti-naturalism or libertarianism. A sort of emergentism underlies the match between methodological naturalism and ideological libertarianism.

The substance of the third approach can be indicated by the following (somewhat complex) Diagram III. In effect, this diagram is a combination of the two earlier diagrams.

Perhaps a word of qualification is called for at this stage. Diagram III is not a mechanical mix-up of the underlying ideas of

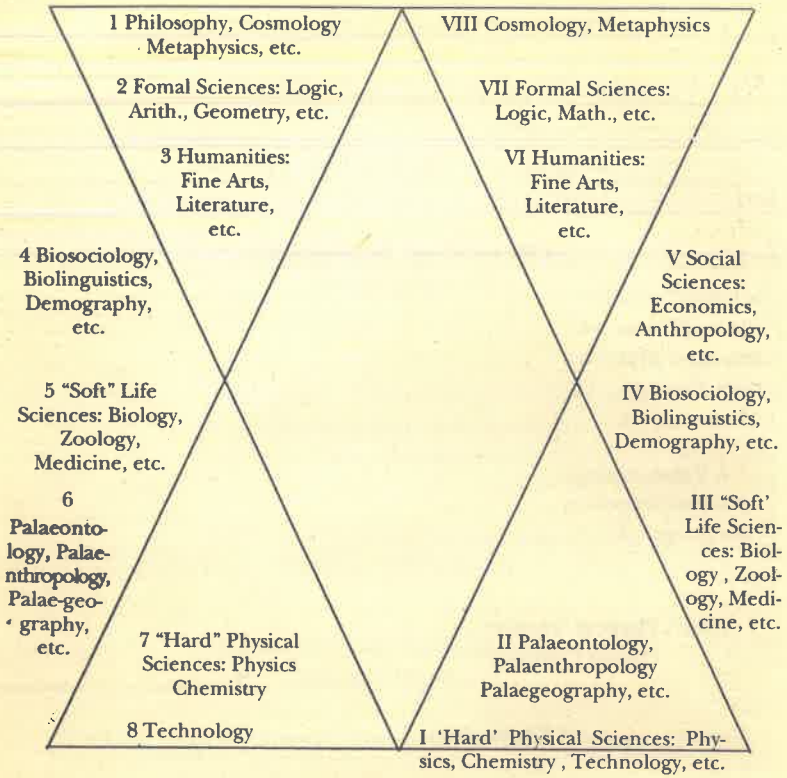

DIAGRAM III

Diagram I and Diagram II. It is qualitatively richer and structurally more complex than the other two. For when the seemingly incompatible concepts of (methodological) naturalism and (ideological) libertarianism are harmonized in terms of some or other form of emergentism, the whole approach assumes a character of added concreteness and comprehensiveness. If the underlying idea of Diagram III strongly commends itself to us, it is mainly because of its organic or coherent nature imparting clarity to the understanding of inter-relationships between different branches of knowledge and skill.

If we can properly follow the rationale of the composite programme of understanding the relationship of science and technology, their human roots or presuppositions become clearer to us. To think of technology merely in terms of skill, instrumental use or application is to be doubly mistaken. First, it does not present to us the full content of technology and, second, what is worse, the partial content that is highlighted by the 'skill' view or the means value of technology is highly distorted. The cognitive aspect of technology is forgotten or inadequately realized by those who harp *exclusively* either on the helpful or on the harmful aspects of it. The point may be clarified in this way.

The distinction between theoretical physics and applied physics, for example, is primarily a matter of intellectual and administrative division of labour. It is somewhat like the distinction between experiment and experience or that between theory and practice. Experiment is a mode of experience, more or less controlled or regulated. A laboratory or instruments are not a must for an experiment. Many of our dietary experiments, for example, have nothing to do with the so-called controlled conditions of the experimental laboratory. Are the experimental conditions absolutely controlled? An element of cyberneticity is always there.

Rightly understood, our so-called free experience is not really free. Besides being problem-oriented, it is theory-oriented. Aimless observation is of hardly any scientific or cognitive significance. More or less similar or purposefully anomalous is the situation in the context of the theory–practice relationship. As hinted earlier, theory is presupposed by as well as anticipative of practice. Practice is blind without theory. It is guided by some or other theory, articulate or inarticulate. For continuation of it, to save it from possible disruption or breakdown, practice needs some cognitive or information input.

These general truths, unless suitably refined in appropriate cases and levels, are not of much help in clarifying our understanding of different areas of theory and practice. For example, on the very nature of the primitive or basic concepts and organizing principles, writers are not unanimous. Some maintain that physics and its laws provide us the basis of all other forms of knowledge. Some defend the primacy of biology. Some others think that all is consciousness at bottom. There are still other views regarding the basic theory of reality. The philosophy of different cultures abounds with such theories of uneven sophistication.

Some of these theorists are reductionists; others are not. The

extremes of reductionism, observationalism and theoreticism are often sought to be methodologically bypassed by different forms of evolutionary emergentism. Attempts are made to legitimize our commonsense recognition of such broad levels or categories of reality as matter, life and mind in terms of philosophical cosmology, monistic, dualistic and pluralistic or atomistic. An aspect of this legitimization is to be found in methodology, both experimental and speculative.

Neither methodology nor philosophy is functionally autonomous. Scientists are not at all unanimous in their formulation and choice of method. Besides, intuition and chance factors are at times found to play a significant role. Philosophers are even more divergent in their methodological and substantive commitments, no matter whether their background is mathematical, scientific, or humanistic.

Another point which deserves to be mentioned here is that in some cultures, especially the 'primitive' ones, social conditions play a big role in the conception(s) of the science–technology–philosophy relationship. The individual autonomy of the scientist and the philosopher, disturbingly enough, is seriously interfered with also in some 'modern' societies which are dominated openly or in a veiled manner by some or other political ideology.[12]

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2

Scientific Tradition in India (3400–1500 BC)

S.R. RAO

Pure science is knowledge acquired in the pursuit of knowledge itself, as distinct from technology which may be defined as a body of knowledge, the application of which or potential application, is considered to meet the desires or wants of society. But science and technology by themselves do not satisfy all the desires or needs of man. For instance, the aesthetic urges of man for some achievement in the field of fine arts and literature, which are generally included among humanities, or the desire to look for a superhuman force which can bring some relief when all the tools of science and technology known in a given society cannot give relief, are not met by science and technology. Technology is directed outward to satisfy some of the inner desires of man but not all the inner desires as elucidated earlier. Humanism, on the other hand, concerns the nature of the desires themselves and attempts to find a solution either by regulating the process of fulfilment or by the self-conviction of the individual or society that a certain amount of restraint is essential in seeking pleasure. This restraint, physical, moral and mental, is in the interest of the society as well as the individual as conceived by our ancestors. To exercise the restraint voluntarily and not through force from the state, they evolved a unique system of disciplining the mind as well as the body known as yoga. This is one of the important contributions of the Indus Civilization.

Humanism is not a body of knowledge *per se*, but an awakening of the human potential to transcend the material world and achieve an inner satisfaction. This does not, however, mean that man is not interested in material comfort at all, as is often said in the case of Indians whose Upaniṣadic thought explored the higher regions of

human mind. The process of awakening the human potential culminated in yoga early in the Indus Civilization (2500 BC) to which further reference will be made shortly.

Popogounous, a modern historian of science, while discussing the philosophical presuppositions of the interaction among the sciences feels that

> the problem of the interaction among the sciences is essentially the question of the epistemological status of each science, that is, whether each particular science is granted thematic, methodological and theoretical integrity, or whether each science is viewed as in a complementary relation to other sciences and as being a part of the general cognitive activity of man which is composed not only of the sciences, but also of philosophy, the arts and practical and social human activity.

Both the above attempts to specify what science is, are partial, for, 'science is a social phenomenon'.

SCIENCE AND ARCHAEOLOGY

Science is no doubt a systematic activity directed at the increase of knowledge, but it is not the only such activity. Practical human activity constitutes as much a source of the knowledge of the world and its processes as does the application of the theoretical formulations of science. Thus, science cannot be considered in isolation either from the other sources of knowledge or from the priorities that the social context establishes concerning the course of investigation. It is here that archaeology comes to play a very important role. Being concerned with every practical activity of man, through which it delves into the theoretical aspects also to some extent, it reveals stage by stage the development of man as an intelligent being and reviews his achievements and failures through the ages taking into account his environment also. In the process it supplies relevant data needed for the reconstruction of the history of science and technology, e.g., history of mathematics, physics, chemistry, astronomy, botany and the development of technology such as engineering, mining and metallurgy, navigation and ceramics. To a large extent it is archaeology which digs up the past and furnishes data. It acts as a bridge between science and humanism.

To understand the thought process of man ever since he became a 'knowing man' with a large brain, which is the most sophisti-