SOCIAL CHANGE, SCIENCE AND ECONOMIC GROWTH

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I

International tensions between the great powers arose and are continuing mostly because of conflicts about respective spheres of interest in underdeveloped regions. Also, the gap in the level of living is increasing between the rich and the poor countries. International tensions are likely to continue, and because of escalation of the armaments race, the threat to peace is likely to increase, unless and until there is a rapid transformation of the underdeveloped countries into industrialised societies. Modernisation and industrialisation of the underdeveloped countries has, therefore, a special urgency for the promotion of world peace and, possibly, for the survival of human civilisation.

2. Modernisation can be achieved only through a social transformation which would make conditions favourable for the industrial revolution, by removing restrictions on the fullest utilisation of all human and natural resources for productive purposes, for the benefit of all the people of the country.

3. Industrialisation is possible only by the rapid replacement of human and animal labour by the use of machinery, driven by modern forms of energy like steam, electricity or nuclear power. The speed of modernisation would thus depend on the effective utilisation of modern technology based on science.

4. Before the emergence of science, there were only two domains of decision in organised society. There was, first, as there will always be, freedom of choice—of food, clothing, habitation, recreation, art, literature, moral values, etc., within the limits of social constraints and the availability of supplies. There was, second, the domain of authority, in which the nature and force of sanctions depend upon the level of authority in a hierarchy determined by custom, law or religion. With the emergence of science, the human mind became aware of "nature" as an objective reality. Science thus introduced into human affairs a new, third domain of objective reality, which cannot be changed by any authority, however high its status, nor by personal choice or preference.

5. A necessarily oversimplified view of the historical process of industrialisation is given below. About four hundred years ago, large social changes began to occur in the Western European countries, which was accompanied by the emergence of science in its modern sense. About two hundred years ago, the industrial revolution occurred first in Great Britain and then in other Western countries. About one

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hundred years ago there was a social transformation with the Meiji restoration in Japan in 1868 which was accompanied by expansion of education of a modern type at all levels, and scientific and technological developments which culminated in rapid industrialisation and economic growth. A little over fifty years ago, the "October Revolution" occurred in USSR in 1917, which transformed the social structure and gave a strong impetus to the spread of education, progress of science and technology, and industrial growth. More recently, structural changes took place in China which were accompanied by emphasis on expansion of education, advancement of science and technology, and industrial progress.

6. Social change, development of science and technology, and industrialisation have been thus intimately inter-related in the historical process of modernisation and economic growth. The transformation of the advanced or the rapidly advancing countries was brought about by the acceptance, slowly at first, and now in an increasing measure, of a scientific and rational view of life and nature. This view has also permeated in a large measure the administrative bodies of the more advanced countries, tempering the outlook of individual executives, and increasing their ability to make responsible decisions, especially within the lower levels of the hierarchy of authority. This is the foundation of the modern age.

II

7. Industrialisation, in its broadest sense, of expansion of manufactures, agriculture, transport and communications, distribution, banking and similar areas of the economy, would be possible only with the help of a rapidly increasing number of skilled workers, technicians, physicians, engineers and scientists. A strong base of science education is indispensable for this purpose.

8. Industrialisation, together with an expansion of both imports and exports, especially of semi-manufactured and manufactured articles, require the effective utilisation of domestic resources, and to do this it would be necessary to develop and expand technological and applied research. This point can be easily appreciated from the fact that even most advanced countries like the U.S.A. or the United Kingdom have to devote a third or more of their non-military research to improve the quality of products already in use in order to hold their position in a competitive world market.

9. To sustain an adequate base of technological and applied research, it is essential to promote the growth of pure or pioneering research, because it is the research scientists who can foster the growth of the scientific tradition within the country, maintain contact with the progress of science abroad, and function as the eyes and ears of the nation in the field of science.

10. It is not possible for every country to take up research in all subjects. Fortunately, much pioneering research can be and has been done, and is still being done, on a small scale and at low expense. Every country, however small, can

therefore offer facilities for this type of research. The aim of science education must be to supply an increasing number of qualified students for technical, technological and scientific institutions at all levels, and also for centres of both applied and fundamental research. This is essentially the utilitarian aspect of science education.

III

11. There is also a deeper need which is the heart of the problem of "modernisation" of the underdeveloped countries. The emergence of science during the last four hundred years was a turning point in the history of civilisation. As already pointed out, before the emergence of science, there were only two broad domains of human decisions. First, of individual freedom of choice, within the limits permitted by society, or of availability of supplies. Secondly, the domain of decisions regulated by the "principle of authority" in which sanction would depend on the status or level of the authority. This second principle is in operation in all communities in all countries; in churches and religions; in military, police or administrative systems; in public and private enterprises; in organised sports and cultural activities, etc., or in law. The decision of a law court may be upheld or reversed by a higher court of appeal, but the second decision also would be subject to confirmation or reversal by a higher court, and so on. The decision of the highest court, to which a case has been referred, must be accepted; but there is no guarantee that such a verdict would not have been reversed if an appeal to a higher court had been made or were possible. This principle of authority must be accepted for the very existence of society itself.

12. Isolated discoveries and innovations were being made from time immemorial, such as the use of fire, stone implements, or successive stages of agriculture. The modern view of 'nature' as an inter-related, integrated and objective reality, however, emerged very recently, only about four hundred years ago. The human mind became aware of 'nature' as an objective reality which is amenable to human understanding through observations and experiments. The crucial point is that such observations and results of experiments, made by one person, are subjective in one sense, and, therefore, require to be repeated and verified by other persons. It is only after such verification and corroboration by a sufficient number of independent scientists that results can be accepted as a part of scientific knowledge as a whole. Such inter-personal (or inter-subjective) agreement between observations and results of experiments is the guarantee of the objective validity of scientific knowledge. Furthermore, 'inter-subjective parity' must be accepted, in principle, for assessment of 'inter-subjective agreement' because verification and corroboration must be done by scientists, who as scientists, have equal status at a scientific level. Therefore scientists must have complete freedom of communication and of exchange of views and criticisms, amongst themselves, as equals, in scientific matters. The tradition and outlook of science requires, and in fact consists of, the acceptance of a new, third principle of objective validity of scientific knowledge, which has its foundation in nature itself, and which cannot be changed by any authority however high its status, nor by personal choice or preference.

IV

13. In the underdeveloped countries the most urgent need is to develop the experimental attitude of mind, to acquire knowledge of natural and social sciences and to use such knowledge for innovation of new techniques for productive purposes. Developing the scientific attitude of mind and modern technology would also help in removing barriers to industrialisation by breaking down superstitions and outdated custom or dogma. C. E. Ayres makes the point sharply : "The power which ideas exert by virtue of being correct is a function not of mind over matter but of technology over institutions in the long run process of history."

14. The emergence of science in West Europe was associated with an entirely new type of social change and revolution which was characterised by the fight for the right of dissent against established authority, as distinguished from religious wars, or the struggle for power leading to changes of regime in which one authoritarian system was replaced by another. The Meiji restoration in Japan and recent revolutions in U.S.S.R. and in China were strongly motivated by the desire for modernisation and industrial progress for which advancement of science and technology was accepted as indispensable.

15. The scientific revolution, the social revolution, and the industrial revolution are three aspects of the process of modernisation of every society; these three aspects may be distinguished but cannot be separated. The rate of economic growth in every country is determined both directly and indirectly by the rate of progress of science and technology: directly through the utilisation of the results of research and development for productive purposes and indirectly through institutional changes brought about by the increasing influence of the scientific outlook and tradition.

16. It is, of course, possible to make some progress in the industrialisation of a country with the help of imported hardware and imported technical 'know-how' but only up to a certain level. Industralisation at this first stage can grow so long as it is possible to provide additional inputs in the form of unemployed or underemployed labour and domestic raw materials. Much of the economic "aid" (in fact mostly usury with interest), which is given by advanced countries, is restricted to the first stage of industrialisation based on borrowed technology and inputs of idle domestic resources.

17. However, no country, is self-sufficient in raw materials, or has inexhaustable resources. With the progress of industrisaliation, every country must, therefore, enter the world market to purchase what it requires in exchange for what it can export. The second stage of self-sustaining growth must be based on increasing productivity rather than on additional inputs. At this stage the ability to make innovations is of crucial importance for which growth of scientific research and development is indispensable. Even after the scientific tradition is established in a country it is necessary to preserve the right of individual dissent, and of questioning the validity of established systems, in order to maintain the progress of science

and technology. Science is a perpetual revolution for which conditions must be maintained favourable by continuing and dynamic social changes.

V

18. In the absence of the scientific tradition, science teaching and research tend to become highly imitative of what is being done in the advanced countries. Inborn scientific talent is not lacking in underdeveloped countries; what is lacking is institutional support and ability to recognise talent. Any new line of research for which a precedent cannot be found in the advanced countries would be necessarily suspect in a society which is still dominated by the principle of authority. There would be an irresistible tendency to discourage and suppress original work and innovations, and the scientific tradition would remain weak; this is the main reason for the "brain-drain" from India and other underdeveloped countries. The progress of industrialisation in the underdeveloped countries is likely to be retarded until a radical transformation of the social structure permits and encourages the growth of science.

19. To establish the tradition of science, it is necessary for each country, however backward or small, to have, as quickly as possible, a sufficient number of men with a scientific outlook who would be able increasingly to influence the thinking of the general public and of persons who have the responsibility for making policy decisions at the national level. The basic aim of science education must therefore be to build up a community of scientific workers and to promote the social appreciation of science among the general public. It is necessary, therefore, to lay the foundations, with as wide a base as possible, for a country-wide system of school education oriented to science, and at the same time to promote advanced studies of science and technology, and research at the highest level.

20. It would be a fatal mistake to establish an expensive system of science education on the model of the advanced countries which would be beyond the means of the nation as a whole. School science must fit into the economic life of the general masses of the people. The approach must be to use teaching aids which could be made available at a low cost all over the country and, since most of the pupils will be living in villages, it would be advisable to use agriculture and rural industries as a general base for the teaching of science. The programme should consist largely of nature studies, observations, measurements and experiments which can be done with the help of simple articles and specimens, which are available locally or which can be constructed in the villages, using local labour and local materials. At the secondary school level, it would be necessary to introduce scientific instruments and equipment also of the simplest types, preferably, such as can be manufactured within the country from domestic resources.

21. At all levels, the main object of science education should be to stimulate the spirit of enquiry and the desire to make observations and measurements or carry out experiments to find out something which is not known. Every effort must be

made to prevent students from committing facts to memory, or performing set exercising as a matter of routine. In underdeveloped countries where the scientific tradition has not yet been established, such an approach would tend to make the students look upon science as something like magic or make them accept the facts on the basis of the authority of the teachers. If this happened, the real purpose of the teaching of science would be frustrated.

VI

22. Stimulation of curiosity about the external world and its inhabitants, and promotion of constructive and disciplined criticisms through scientific education does not alienate the growth of the humanities and of individual appreciation in the domain of individual choice.

23. There is no conflict, in principle, between the three domains; first, of individual choice guided by social, cultural and spiritual values; second, of decisions in organised affairs determined by the authority of an appropriate status; and third, the advancement of science through free exchange of views among scientific workers of equal status. Increasing expansion and integration of all three domains of human decisions is an essential condition for the progress of each nation, for the promotion of world peace, and progress of human civilisation.

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