

THE SOCIAL TRANSFORMATION FOR NATIONAL DEVELOPMENT

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1. Introduction

1.1. The problem of improving the material and cultural conditions of the poorer countries of the world has been engaging serious attention during the post-war period. The desire for political independence is rapidly increasing and will continue to grow in the countries still under colonial rule. Also, more and more countries are becoming and will become politically independent. With the gaining of independence, it is being increasingly realized that political freedom is necessary, but is not enough. In most of the underdeveloped areas, attention is being given increasingly to economic development to improve the level of living, by increasing the flow of goods and services and by expanding facilities for cultural amenities. It is also being increasingly appreciated that rapid economic growth can be brought about only by an increasing accumulation of capital to supply modern tools and machinery for new and expanding productive activities which would, in time, solve problems of unemployment or under-employment, and would also continually improve the level of living. Such accumulation of capital would call for increasing domestic savings, and the utilization of such savings for productive purposes. The choice of productive activities (that is, of investments) must also be such as to secure the best possible rate of economic growth over a time horizon of a generation or more.

1.2. How to bring this about? This is where the question of social transformation becomes relevant. Some broad general principles may perhaps be stated with confidence.

2. The Structural Transformation

2.1. It is necessary to give opportunities for participation in productive activities to the largest number of people, and as soon as possible, to all such people as are capable of undertaking such work, and also to utilize available resources in the most effective way for the benefit of the nation as a whole. To create fullest opportunities for rapid growth, it is necessary to remove all barriers to the effective utilization of productive forces, by the people, for the benefit of all the people of the country.

2.2. There are many facets to the problem, some of which are general and some peculiar to particular countries. It is not possible to arrange them in any clear order of priority. In fact the heart of the problem is to make changes in all necessary directions at the same time, in a balanced way, so as to bring about the structural transformation as quickly as possible.

2.3. The transformation of the social structure cannot be an entirely internal process. Outside influences have been and will continue to be at work. Colonial rule and economic exploitation of the underdeveloped countries have themselves given rise to reactions promoting the desire for political independence and for improvement in the level of living in the underdeveloped areas.

2.4. A new factor, of conscious international cooperation in improving the social, political, and economic conditions of the underdeveloped countries, has also emerged during the last ten or fifteen years through a quickening of the world conscience on humanitarian grounds and also in the enlightened self-interest of the more advanced countries. Isolation is no longer possible, physically, psychologically or organizationally. The influence of information, ideas, advice and aid from outside would be an increasingly important factor.

2.5. A structural transformation of the whole society is, however, indispensable to make conditions fit for rapid economic growth. Without such transformation, any amount of help from outside would be ineffective. The experience of many countries during the post-war period would corroborate this.

3. The Scientific Revolution

3.1. It is also necessary to develop the outlook of science and the experimental attitude of mind in order to acquire knowledge of natural and social forces and to invent new techniques for initiating material and social changes. This is the only way in which decisions can be made increasingly in a rational manner, in accordance with principles of objective or scientific validity based on relevant data and correct reasoning, instead of on the sanction of authority based on status and power or custom and conventional or revealed rules and laws. This may be called the scientific revolution.

3.2. The need of what I have called "the scientific revolution" is recognized, but has not received sufficient attention. I have considered some aspects of this problem in an attached note on "The Scientific Base of Economic Development."

4. Modernization of Society

4.1. The social transformation and the scientific revolution are both necessary. These are but two aspects of modernization which can be distinguished but not separated. The social transformation and the scientific revolution in combination leads to modernization. The task of international cooperation is to promote and help, in every possible way and in a peaceful manner, the modernization of the underdeveloped countries.

4.2. *Urgency of the task*: The scientific and industrial revolution took place in West Europe and North America roughly over a period of three or four hundred years. It is not possible to wait for such a long time for the underdeveloped countries to attain a reasonable level of living. The historical process of transformation must proceed five or ten times faster. Such speeding up of the process of transformation has always been a characteristic feature of biological evolution, and can be achieved.

4.3. *Different phases of the transformation*: Some of the newly independent countries are large, some are of medium size, and some are extremely small in area, or in natural resources or in population. They would have widely differing needs. The particular form and contents and components of each step of modernization would depend on the special conditions of each country and the stage of development reached by it, and would therefore, vary from one country to another or from one region to another of the same country and also, over a period of time, in the same country or in the same region.

4.4. *International cooperation*: The most significant fact of the present age is the rapidly expanding contacts between different countries of the world. This tendency

is bound to become stronger in future, increasing the scope of international affairs in every direction. At the same time, what George Washington had said about "no country being able to go beyond its own self-interest in international affairs," would continue to remain valid. The real need is, therefore, to discover new areas of mutual self-interest, and to expand spheres of common interest on both bi-lateral and multi-lateral basis to the fullest extent.

4.5. It is also clear that even the most advanced countries still have unlimited scope for both social and scientific progress. For all countries, large or small, advanced or underdeveloped, international cooperation is necessary and beneficial. The smaller and the less-developed a country, the greater however will be the need and importance of such cooperation.

5. Problems of Internal Reforms

5.1. There is general agreement about some of the most important contents or elements or aspects of the social transformation, such as :—land reform; removal of social, economic and political barriers; mass education and technical training; increasing equality of opportunities; the possibility of a labourer or an initiator securing the fruits of his labour; or the need of medical and health services and cultural amenities etc. There is much in common in respect of such components or aspects of social transformation in the case of all under-developed countries, with, however, the need of adaptations to suit the special conditions of each individual country. Some of these components or aspects are briefly considered below.

5.2. *Land reform* : Historically, land reform has been a most important factor in the economic development of all advanced or rapidly developing countries. Agriculture and industry must advance at the same time. It is, however, generally agreed that an agricultural surplus (or, the surplus from extractives) is essential for industrial development. Changes in land tenure and legislation would, therefore, be one of the requirements of the highest priority in most, if not all, underdeveloped regions.

5.3. The aim must be to secure the fruits of his labour to the cultivator so that he has the incentive to improve the land and to introduce more advanced technological methods. Tenancy law should protect the tenant against eviction so long as he is using the land efficiently, and to secure to him the right of fair compensation upon termination of the lease for all unexhausted improvements made by him. It is also necessary to eliminate the unproductive consumption of the surplus from land by intermediaries and landlords, who have no productive functions, by abolishing their rights.

5.4. The question of economy of scale of production may, admittedly, introduce difficulties. The breaking up of large farms may lead to a reduction of the surplus; however, the beneficial effects of greater equality of income and wealth may compensate for the other loss. Also, in countries where there are too many cultivators, often with scattered plots, further breaking up of the holdings may easily have adverse effects on the efficiency of production. In such a situation it may be necessary to promote consolidation of holdings either voluntarily through cooperatives, or by legislation, or both. Redistribution of land has limits and is a complicated question. It is wise to recognize that steps taken at one stage may have to be reversed at a later stage. Appropriate measures must be devised to suit the needs of each country at any particular stage of development. The basic aim would always remain the same, namely, to increase the agricultural surplus, and to use it for productive purposes, as effectively as possible, in speeding up the growth of the economy as a whole.

5.5. *Removal of social, economic, legal and political barriers* : The underdeveloped countries have the very difficult task of achieving a far faster rate of growth than had been achieved by the most advanced countries during and after the industrial revolution. It is indispensable that every one in the working age-group should be fully utilized to increase the national product. It is necessary, therefore, to remove all social, economic, legal and political barriers which prevent individuals, or groups and sections of individuals, to become fully productive. Conditions are worst in a country stratified by caste, colour, creed or language, and where whole sections of people are sometimes deprived of opportunities by customs, law, or social and political pressures by ruling groups. Removing all such barriers is an essential condition for rapid growth.

5.6. *Equality of opportunities and vertical mobility* : Removal of social and other barriers, in principle, is necessary but not sufficient. It is essential to help every one to make himself fit for the highest type of productive work of which he is capable. Opportunities for education and training and for productive work must be made as widely available as possible. Great inequalities of wealth and income often lead to denial of opportunities to the poorer people, and, unless removed, give rise to a sense of frustration among the under-privileged and hamper the growth of national solidarity. Sufficiently rapid economic progress would be difficult or impossible in societies in which there is lack of vertical mobility and where small sections try to preserve their privileges based on heredity, custom or law without any relation to their productive contributions.

5.7. *Horizontal mobility* : The social system may also hamper the utilization of resources because customs or caste restrictions prevent labour from moving into new occupations, or labour is tied to the soil, or land may be concentrated in the hands of small sections of the people who are unwilling to divert it for more productive use for reasons of social or political prestige. A small number of producers even in underdeveloped countries may sometimes band together to prevent the free entry of others or the introduction of new techniques. All such restrictions must be removed to increase the horizontal mobility of resources.

5.8. *Possibility of securing fruits of labour and enterprise* : The elimination of concentration of social, economic or political privileges in the hands of small sections of the people would promote both vertical and horizontal mobility, and make it possible for every one to secure a fair share of the fruits of his labour and enterprise. This is one of the most important consequences of the social transformation and is particularly helpful in promoting rapid economic growth. Appropriate legal and institutional changes must be made to achieve this.

6. National Integration

6.1. *Sectional interests and barriers* : A characteristic feature of underdevelopment is the segmentation of the country into innumerable regions, castes, tribes, languages, religious communities, occupational and other groups which focus attention on the welfare of small sections of the people without any awareness of the best interests of the country as a whole. It has to be recognized that rapid progress is impossible without painful adjustments and damage to sections of the people whose interests are based on special privileges or old techniques; and that old beliefs, customs, and social institutions have to be discarded, and all barriers of caste, customs, creed, colour, language and sectional interests must be ruthlessly eliminated. The greater the prevalence of such social barriers in the country, the greater are the sectional rigidities within government administration, and the fiercer are the inter-agency jealousies and fights which continually delay decisions and hamper speedy action.

6.2. *Integration*: The removal of social and economic barriers is an indispensable condition for the emergence of the sense of national solidarity without which national development is impossible. It is not possible to isolate the scientific, or the social, or the industrial aspects of the transformation from one another. Advance must be made at the same time on all fronts. This creates difficulties but also has its advantages. Progress in one direction stimulates and promotes progress in another direction. It is the task of leadership to maintain a proper balance between the different aspects and phases of the process of modernization in its full sense. The aim continually must be to create a society from which social, economic and political privileges have been completely eliminated. To bring about such a transformation would call for wise leadership with a clear appreciation of aims and objectives, a rational and experimental attitude of mind with confidence in the outlook of science, and willing to pay the price of much painful adjustments.

7. Danger of Superficial Imitation of Advanced Countries

7.1. Because of the sense of urgency for economic growth which is strengthening everywhere, there is a peculiar danger of adopting, in a superficial way or at too early a stage, methods, and forms and institutions, which are working successfully in the advanced countries. It has to be kept in mind that existing social and political institutions, or high levels and standards of quality or performance, were established in the advanced countries only with the gradual growth of the economy. Such institutions may not be useful at an earlier stage of development, and may even hamper progress. For example, in underdeveloped countries, there is sometimes a tendency to adopt too expensive or too sophisticated schemes of education, care of health, public buildings and construction, wages or salaries of government employees or labour legislation.

7.2. *Education and training*: Mass education to spread literacy both among children and adults has special urgency; here all possible help should be utilised, for example, by using the services, for a small part of the day or the week, of those who are already literate. Because the numbers involved are very large, the adoption of too high a standard for teacher qualifications, school buildings etc., at the primary level, would make the cost prohibitive. At the secondary stage, more attention would have to be given to the qualifications of teachers and other educational aids; but scales of pay or cost of buildings should still be kept in balance with the general level of living of the students and the parents themselves. At the tertiary level, still higher standards would have to be adopted for staff qualifications and there would be need of more expensive teaching aids; but the expenditure must be kept within the limits of what the country can afford. It is at the stage of advanced studies and research that standards should be really high and comparable with the advanced countries; however, as the number of advanced and research workers would be very small in the beginning, this would not involve any large total expenditure.

7.3. The educational system should be viewed as a pyramid; the lower the stage the wider should be the base (that is, the number of persons under instruction) and the lower the scales of expenditure compared to advanced countries, while at the highest stage of advanced studies and research the number involved would be extremely small but scales of expenditure may approximate to those of advanced countries. Adoption, at too early a stage, of standards and scales of expenditure of advanced countries at lower levels would lead to severe restrictions in numbers usually coupled with admission of students on the basis of family income; this must have most undesirable social and psychological consequences. When resources in men, materials and money are inadequate, to increase the number of students in accordance with the pressure on admissions, would necessarily lead to window dressing and a dilution of standards in practice. This can seriously hamper progress; the only remedy is to adopt a system which would be in keeping with basic aims and yet within the means of the country.

7.4. *Medical care and technical services* : A similar situation can arise even more easily in the field of medical care. Adoption of the high level of university education for physicians in the advanced countries as the only standard at an early stage would necessarily mean that most of the people will be deprived of medical services in underdeveloped countries for a very long time. A two-tier approach with a junior cadre of medical personnel with, say, three or four years' training, together with a much smaller number of physicians with university training, would make it possible to spread medical services much wider and much faster. This would be equally true in many other lines of technical work. A two or even a three-tier approach with a higher, a medium, and even a third level of workers who have had a very quick and specialized training, would be not only within the means of the underdeveloped countries but may be even more effective, because, in the still backward conditions of the country, the lower level workers would be much nearer to the general population and would be able to work in closer touch with them. This would be particularly true in agricultural extension and other services which would bring the technical workers into contact with large sections of the population.

7.5. *Government expenditure* : Government expenditure often tends to become unduly large in underdeveloped countries owing to the adoption of the much higher standards of advanced countries. This leads to unnecessarily high scales of wages and salaries for government employees or costly public buildings; which, in its turn, would increase the feeling of separation between government and the people, and hamper national integration.

7.6. *Labour legislation* : As production becomes modernized and factories and enterprizes grow in numbers and in size, it would be necessary to develop labour legislation and regulations to ensure that labour secures a fair share of the surplus, and also to ensure working conditions being maintained reasonably safe and healthy. Legislation in imitation of the more advanced countries, at too early a stage, may, however, lead to increasing inefficiency of performance, especially, in countries with surplus labour, and may increase costs of production so much as to have serious adverse effects on exports. The most important thing is to establish a definite link between remuneration and output in the case of all types of work of which the volume and quality can be estimated even roughly. It is necessary to recognise that trade union movements can gain in real strength only on the basis of increasing productivity.

8. National Leadership

8.1. The transfer of modern technology from the advanced countries also calls for much adaptation to suit the needs and local conditions of underdeveloped regions. To profit by the experience of the advanced countries and yet to introduce modern technology and modern social and political institutions in a way suitable to the particular stage of development of the country is a matter of crucial importance in the process of modernisation. Ultimately, success would depend on the growth of a rational outlook and the experimental attitude of mind, first, among the leadership at all levels and then gradually among the general mass of the people.

8.2. It is extremely important that the advanced countries should help and encourage in every way all progressive groups within the country in promoting the process of modernization and refrain from offering technical or economic aid in any way which would hamper the social and scientific transformation.

THE SCIENTIFIC BASE OF ECONOMIC DEVELOPMENT

1. Phases of Economic Development

1.1. The essential characteristic of an underdeveloped country is an extremely low level of living, that is, inadequate supply of food, clothes, housing, drugs and other consumer goods, and also lack of facilities for education, care of health, social security, cultural amenities, etc., for the nation as a whole. It is possible to make available small quantities of consumer goods by direct imports or by domestic production, on a small scale, with the help of imported machinery. In most of the underdeveloped countries it is, however, not possible, for lack of necessary foreign exchange, to import or to produce, with imported machinery, enough consumer goods for the people as a whole. In India, the first textile mill was established in 1817; and India gradually became the second biggest producer of textiles, next only to America. One hundred and fifty years later, India would still remain underdeveloped. The production of textiles or small quantities of other consumer goods for a small part of the nation cannot, by itself, lead to industrialisation and economic development.

1.2. Economic development can occur only by increasing the per capita production of the nation as a whole, through an increasing use of machinery driven by steam or electricity as a substitute for human and animal labour. In countries with appreciable natural resources, it is necessary to establish the basic engineering and power industries to enable the manufacture of both consumer and capital goods within the country. Establishing a minimum complex of such basic industries would take at least ten or fifteen years, for which planning must start ten or fifteen years in advance.

1.3. To increase modern industrial production would call for an increasing supply of engineers, technologists, and technical personnel. The only way to ensure this would be to establish and increase the number of schools, training colleges and universities, and also to train teachers for such institutions. This would take at least fifteen or twenty years; so that planning for this purpose must start fifteen or twenty years in advance.

1.4. The best way of utilising the raw materials and natural resources available within the country, for both domestic consumption and for exports, can be found out only through applied scientific research.¹ Applied research, in its turn, must be based on advances in fundamental research. Also, to establish an adequate base for applied research it is necessary to promote the spirit of pure research and supply the stimulus of scientific criticism. This would be possible only when at least a certain minimum number of scientists are engaged in fundamental research, and opportunities for pure research are becoming increasingly available. It is therefore necessary to promote the advancement of both applied and fundamental research. To establish a minimum base for scientific research would take more than a generation of twenty-five or thirty years; this, being the most slowly maturing sector, must be given the highest priority.

2. The Scientific Base of the Advanced Countries

2.1. The scientific base of the modern age can be appreciated by even a brief review of the recent history of the advanced countries. Four hundred years ago the generally accepted view was that the earth was at the centre of the universe; the position of human beings was unique and supreme; and the highest sanction of truth was either divine revelation or abstract logical reasoning in the mind of man. In the sixteenth and the seventeenth

¹ Even the most advanced countries are obliged to devote large resources to research for the improvement of products already being manufactured and also to develop new products in order to hold their position in the world export market. It is not possible for the underdeveloped countries to start or expand the export of fully or partly manufactured products by simply borrowing the current technology from advanced countries; it is essential also to develop applied research for a continuing improvement of technological methods.

centuries, there was a complete revolution in the picture of the physical world ; the earth was seen as a small planet moving round the sun; and the method of empirical observations and experimentation was gradually established in both physical and life sciences.

2.2. Progress was at first slow in the sixteenth century. A few selected names may be recalled to indicate the gradual transformation of ideas. In astronomy, Nicholas Copernicus (1473-1543) supported the view that the planets including the earth itself were revolving in orbits round the sun; Tycho Brahe (1546-1601) supplied astronomical observations of unprecedented accuracy to make the next steps possible; Johann Kepler (1571-1630) formulated the descriptive laws of planetary motion; and Galileo Galilei (1564-1642) made conscious propaganda in favour of the new philosophy of the universe. In anatomy, Andreas Vesalius (1514-64) published his observations on the human body in 1543; in physics, William Gilbert (1544-1603) gave an account of magnetism based on trustworthy experiments in 1600; in physiology, William Harvey (1578-1657) described the circulation of the blood in 1628; John Napier (1550-1617) supplied a convenient tool for computation by the use of logarithms; and Rene Descartes (1596-1650), a philosopher, contributed the powerful concepts of coordinates for geometrical representation and of mathematical functions. Francis Bacon (1561-1626), firmly stated that the only true method in science was to proceed from particular sense observations to wider generalizations (*Novum Organum*, Book I, xix), and clearly recognised that "the true and lawful goal of the sciences is . . . that human life be endowed with new discoveries and power."

2.3. The concept of an objective world of physical reality gradually took firm shape in the seventeenth century in the hands of gifted astronomers, mathematicians and scientists. A few names may be mentioned from among those who were born in the first half of the century; Pierre Fermat (1601-1665), Christian Huygens (1629-95), Blaise Pascal (1623-62), Robert Boyle (1627-91), John Ray (1627-1705), Robert Hooke (1635-1703), Issac Newton (1642-1727), and Gottfried Wilhelm Leibniz (1646-1716). The rate of advancement of science increased progressively in the eighteenth and the nineteenth centuries, and during the last few decades has opened new frontiers with almost unimaginable possibilities.

2.4. The advancement of science prepared the ground for the industrial revolution in Europe in the eighteenth century, first in spinning and weaving, next in the use of iron and steel, and then of electricity in the nineteenth century, which stimulated the growth of the capitalist economies in West Europe and North America. The spread of the scientific outlook also prepared the ground for the age of reason and the French revolution, which occurred at the end of the eighteenth century, and promoted the growth of nationalism in Europe, in its modern sense, in the nineteenth century.

2.5. The industrial revolution increasingly replaced human and animal power by steam or electricity to drive machinery for the increasing production of both consumer and capital goods. The development of engineering techniques led to a close linkage between science and technology; and during the last hundred and fifty years, industrial development is being stimulated by a scientific discovery or a scientific discovery is being stimulated by industrial needs.

2.6. For the last five or six thousand years, or more, the average per capita production remained more or less constant or fluctuated within narrow limits. The industrial revolution changed all this, and led to a spectacular increase in the variety and volume of goods produced. As a consequence of such increasing production, the standard of living of the advanced countries of West Europe and North America reached a level far higher than the rest of the world. Also, the advancement of science, technology and industry, made it possible for the western countries to become strong military powers; and, because of such military supremacy, the west was able to bring a large part of the world either into direct colonial rule or into conditions of economic or political subjugation.

2.7. The last forty years have also seen the rise of U.S.S.R., as another world power, rapidly growing, through the promotion of science and technology, in economic, industrial and military strength together with a continuing increase in the level of living. The monopoly of scientific and technological knowledge and the unchallengeable military supremacy of the western countries have now gone. The increasing parity between the "western" and the "eastern" countries in science, technology, industry, and military power is a most significant fact of the present time. Because of the unprecedented destructive power of atomic and nuclear weapons, it has become absolutely necessary to avoid a nuclear war which would be catastrophic for both sides and the whole world. Coexistence of both the "western" and the "eastern" powers has become indispensable.

2.8. There is no intention on either side to make a direct attack. The advanced countries pose no special problems because it is not possible to hold such countries indefinitely in subjugation. However, so long as there are underdeveloped areas, both power groups are likely to try to extend their influence over the less advanced countries; and this would remain a continuing source of potential conflicts. The very existence of underdeveloped countries should, therefore, be seen as a threat to peace. Rapid transformation of all the underdeveloped countries into modern viable societies is an essential condition for peaceful coexistence. Such a transformation would promote the enlightened self-interest of both power groups, and would also create conditions favourable for the advancement of human and cultural values on a world-wide basis.

3. The Role of Science in the Modernisation of the Less Advanced Countries

3.1. Modernisation of the less advanced countries through rapid industrialisation is thus an urgent need of the whole world. Is such modernisation possible or can a modern society with a viable economy, with expanding social and political freedom, and cultural amenities, be sustained without establishing a sound scientific base? This is a question of crucial importance for the present age.

3.2. In order to answer this question, it is necessary to appreciate the deeper changes in human thinking which were brought about by the emergence of science. In every sphere of organised activity in human society, authority has always been associated, and must always be associated with a system of hierarchical levels. This applies to primitive societies, matriarchal, patriarchal, or tribal; successive levels of feudal lords; organised churches and religions; military, police and administrative systems; enterprises, business and commerce; and law. A law court of appeal may reverse the decision of a lower court; but the decision of the court of appeal is itself subject to change by a still higher court. The decision of the highest court, to which a case has been actually referred, has to be accepted not because such a decision is necessarily right, but because it is the decision of a superior authority.² Society must accept this authority principle for stability and orderly progress, even in organised revolutionary activities.

3.3. This very authority principle must, however, be absolutely and completely rejected in the field of science. Modern science is based on a patient accumulation of facts, on the study of processes and their interrelations or interactions and a stability or

² It is possible, indeed, that this decision itself would have been reversed if there had been a still higher court to which the case could be referred. If a decision of a higher court of appeal is considered to be like the turning up of "heads" (in tossing an unbiased coin) when the decision upholds the verdict of the lower court, and is considered to be like the turning up of "tails" when the verdict of the lower court is reversed, then the successive decisions of the higher court would look like the results of the tossing of a coin. This would be the real guarantee that the system of law is functioning properly.

uniformity of nature³ which can be discovered by the human mind. The findings of the most eminent scientists are subject to critical check by their professional colleagues and by the youngest scientific workers, and must be rejected if there is no satisfactory corroboration. Science can advance only through free criticism on a completely democratic basis, with every research worker of competence enjoying equal status. The theoretical or conceptual framework of science must be continually revised to find a proper place for all known facts. A single new observation may call for a more comprehensive theory. The older accumulated knowledge continues to remain valid ; later discoveries must, however, be integrated with the earlier knowledge. The accumulation of scientific knowledge is increasing through the efforts of all the scientific workers of the world. A new fact may be observed or a new theory formulated by any worker, however young, and in any country where research has been established. International collaboration is, therefore, an indispensable condition for the progress of science.

3.4. Authority derived from status is irrelevant to science. Science has introduced a new concept of "scientific", or "objective validity" which has its foundation in nature itself, and which cannot be upset by any authority based on status or by supernatural powers. The transformation of all the advanced or rapidly advancing countries has been based on accepting, in an increasing measure, a scientific or rational view of life. This is the foundation of the modern age.

3.5. It is essential in every country to establish and strengthen the outlook of science, a way of thinking which becomes more and more powerful as it is more widely adopted, and which replaces dogma, superstition, and outdated customs. This scientific outlook cannot be established by force. It must depend on acceptance through proper understanding. In practical affairs, the important point is that a wise policy and programme of action should be increasingly adopted on the basis of rational argument, supported by relevant factual evidence, and should not be rejected because of emotional bias or formal dogmas or conventional rules of procedures. It is, therefore, necessary continually to encourage and promote the advancement of science in every country, large or small. Because science is indivisible, and also because science must be established in every country, it is also necessary, continually, to promote scientific collaboration between all countries of the world, large and small, and advanced or developing.

3.6. It is scarcely necessary to point out that there is no conflict between the scientific and rational view of life, on one hand, and aims and objectives based on moral or cultural values, on the other hand. On the contrary, moral and cultural values which are truly universal, and are not narrowly sectarian or nationalistic in a restricted sense, must have an objective and rational basis.

3.7. The advancement of science and the growth of the scientific outlook must be recognised as an essential condition for the modernisation of the less advanced countries. It is necessary for each country to have, as quickly as possible, a sufficient number of men

³ The phrase "uniformity of nature" must be, of course, interpreted to include chance events and random processes. Although games of chance were known and were widely prevalent in ancient times in China, India and other countries, it is important to note that the concept of probability did not arise until the 16th and the 17th centuries, that is, not until the emergence of modern science. This is easy to understand. Before the emergence of the modern scientific view of an objective world of physical reality, all chance events would have to be necessarily ascribed to the whims of gods, demons, or supernatural forces. After the emergence of the scientific view of an objective world of physical reality, it became necessary, both logically and psychologically, for the human mind to accommodate the occurrence of chance events as an integral part of the uniformity of nature. This could be accomplished only on the basis of the theory of probability, or rather, as I should prefer to put it, only through a statistical view of the world. It seems to me, therefore, that the concept of probability, or the statistical view of the world, did arise at the same time as the emergence of modern science only because it could not possibly have arisen earlier.

with a scientific outlook to influence the thinking of the nation. How to attract and hold a sufficient number of able persons to science is thus the crucial problem of national and world development. This can be achieved only through a proper and adequate social appreciation of science and scientists. The actual transformation must be brought about from within each country. Scientific aid from the advanced countries can, however, be of great help in this process.

4. Present Programmes of Technical Aid

4.1. The need of technical aid has been recognised for some considerable time. Bi-lateral or multi-lateral and international technical aid has often taken the form of either offering educational and training facilities to young workers from the less advanced countries or sending technical or scientific experts to such countries. Considerable benefit has no doubt accrued through such aid but it is necessary to recognise that much effort has also been wasted.

4.2. Scholars from the less advanced countries are usually selected on the basis of results of examinations; success in examinations not being a necessarily reliable indicator of scientific or technical ability, the very process of selection is inefficient. Some of the young scholars have difficulty in adjusting themselves to the pattern of living in the advanced countries. Some of them do not do well in their studies. Some pass the examinations successfully but have no aptitude for scientific work. Some of the more able scholars prefer to live and settle down in the advanced countries, especially in the U.S.A., because of the higher level of living or greater opportunities for scientific work. Some scholars of ability, when they return to their own countries, are unable to find suitable openings for a scientific career; and some of them go back to the country where they were trained. In applied science and technology, and especially in social sciences, many young scholars, who had often studied problems or learnt methods which are appropriate for advanced countries but totally irrelevant to their own native countries, are unable to adapt or develop methods to suit local conditions. Out of the large number of scholars who go to advanced countries for training, only a very small number of really able scientific workers ultimately become available for fruitful work in their own country. The cost of giving scientific or technological training in an advanced country is also very high. Giving training to individual scholars in advanced countries (whether the expenses are provided in the form of foreign aid or met by the scholars themselves or by the country of origin) have been, therefore, extremely wasteful in terms of both men and money.

4.3. There has been also continuing difficulties in finding suitable individual experts for the less advanced countries. Competent scientific workers are reluctant to accept such assignments partly because of the lack of facilities for their own work in the less advanced countries and partly because their scientific or academic career is likely to be adversely affected through their absence abroad. In consequence, assignments sometimes have to be given to persons who are not fully qualified for the job, with unsatisfactory results. To create suitable conditions for scientific work in the less advanced countries is an indispensable condition for attracting competent scientists to go out to such countries.

4.4. Programmed technical aid on a group basis has been more effective. A team of young engineers from a less advanced country can receive most valuable training in an advanced country when such training is oriented to specific technological projects. Teams of experts from advanced countries have also been of very great help in establishing factories or in starting new projects in the less advanced countries. Such technical aid, especially in engineering, technology and applied sciences, should be continued and expanded. Special projects for establishing technological and research centres in the less advanced countries

have also been taken up by some of the international agencies. This type of aid can be of great value provided a sufficient number of scientific workers in the less advanced countries can be trained to work in such centres, and also provided necessary conditions are established to enable them to do their work properly.

5. Science Education and Research

5.1. It has been argued in the earlier sections that for modernisation it is necessary to establish a foundation for scientific research and the social appreciation of science in the developing and less advanced countries. Every path-finder in a new field of research must work in the first instance by himself; if he is successful, other persons gradually get interested in the subject. Such path-finders always had, and will always have to overcome much opposition, and even hostility, until the new subject becomes a recognised part of the "established" field of science. But it is only a few scientists of outstanding ability who can work in isolation. Most research workers require the stimulus of free interchange of views and ideas and of appreciation among professional colleagues.

5.2. The community of scientists has a structure of a series of widening circles similar to the structure of scientific subjects or of science as a whole. When a top scientist speaks appreciatively of some work in his special field, other scientists or lay men accept his evaluation and pass on the information to others. The social appreciation of science gradually emerges as a result of the diffusion, in widening circles, of the views of scientists, who are experts in specialised fields of research, to scientists in related and associated fields, then to scientific workers generally, and finally, through persons of position and standing who have contacts with scientists, to the general public. The speed with which such appreciation can spread increases rapidly with the increase in the number of scientific workers and improvements in the channels of communication. In the advanced countries, the awareness of the importance of science is increasing rapidly which, in its turn, is raising the social status of scientists and is promoting an increasing flow of resources for research.

5.3. The whole process is extremely slow in underdeveloped countries. The number of research scientists is very small; and channels of scientific communication are non-existent or meagre. Scientific workers usually receive lower pay and have a lower status than the administrative staff in government or in business concerns; and have to work in a rigid system of hierarchical authorities. Promotion may depend, not so much on the high quality of the scientific work done, but on success in pleasing those who are higher up in the official hierarchy. Even permission to apply for posts elsewhere is subject to the discretion of superior officers. There is a continuing tendency to bring scientists and scientific work under stricter control of the administrators, partly, perhaps, from an unconscious fear of rivalry of power. Even if the right of criticism is accepted in principle, it is restricted in practice because scientific workers are often afraid, rightly or wrongly, of giving offence to persons holding higher posts. In consequence, many scientists in underdeveloped countries suffer from a lack of self-confidence, and are afraid to take up original lines of investigation. There is little possibility of a proper evaluation or appreciation of scientific work within the country. This leads to an exaggerated dependence on the opinion of foreign scientists and gives rise to much imitative work. Also, when there is lack of appreciation or criticism from the advanced countries, there is sometimes a tendency to ascribe the unfavourable view to racial or national prejudices, and there is resistance against collaboration with foreign scientists.

5.4. In underdeveloped countries there are very few, sometimes only one or two, individuals of outstanding ability in scientific research or in any other scientific field. As leadership can be supplied only by individuals of high ability, and as such persons are few in number, it is much more difficult in underdeveloped countries to utilise the services of individuals of average ability and qualifications. The advanced and advancing countries have a double advantage. They have a large number of persons with qualities of leadership

and can, therefore, utilise in a fruitful way larger numbers of persons of average ability. This is why many scientific workers from underdeveloped countries, who are unable to do much useful work in their own native country, can often do very good work in the environment of a higher state of organisation of research in an advanced country.

5.5. The aim of scientific aid must be to create in every underdeveloped country, as quickly as possible, a sufficient number of research scientists to form a community of professional workers which would be sufficiently large to facilitate an independent evaluation of scientific work through free criticism and frank exchange of views. It is, therefore, necessary to focus attention on identifying and giving support to persons who have the ability to undertake research work of high quality, and to try to increase their number as quickly as possible, and at the same time to offer opportunities for training to persons of average ability whose services would be equally essential in supplying a wide base for the pyramid of scientific work.

5.6. There is urgent need of fostering the spirit of objective scientific criticism through free expression and exchange of views and opinions. One effective way of promoting this would be to make it easy for scientific workers to migrate from one post to another and give an absolute guarantee of such freedom to migrate. Any scientific worker who feels, rightly or wrongly, that he has not enough opportunities for fruitful work in one institution would be free to migrate to some other institution. Such migrations or the possibility of such migrations would have an indirect but most important selective effect on scientists at all levels.

5.7. It is necessary to recognise that the social value of an individual scientist of high ability is far greater in a developing country because of the leadership he may be able to supply. It is only scientists engaged in fundamental research who can function as the eyes and ears of the nation in making the nation appreciate and identify urgent needs of applied research. The emergence of even one or two outstanding research scientists can enhance the prestige of the nation in a most significant way at the international level and promote the growth of self respect and self confidence of the nation. This is why it is particularly important in developing countries to identify such individuals, at first very few in number, and give them all possible facilities and encouragement to continue their work in their own country.

5.8. In the highly developed countries science advanced both from progress at the highest levels of research, at the top, and from the wide diffusion of education, at the bottom. The same strategy may be adopted with advantage in the less advanced countries. What is urgently needed is 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 develop advanced studies of science and technology and research at the highest level. The school system must fit into the economic life of the general mass of the people and have its grass roots in the villages. It must offer facilities for training technicians and technical personnel for science and technology and also supply candidates of outstanding merit for admission to higher scientific and technological institutions.

6. Need of Direct Aid for Science

6.1. I shall offer, briefly, a few suggestions for giving direct aid for the development of science in the less advanced countries. I have stressed the need of building up a system of school education with a definite orientation to science. It would be, however, a fatal mistake to establish an expensive system of education on the model of the advanced countries which would have little relevance to local needs and would be beyond the means of the national economy. It is necessary to evolve a system, through experimentation and trial and success, which would be within the means of the national economy. The approach must be therefore to use teaching aids which are easily available or can be made available on a large scale and at a low cost. As most of the pupils will be living in villages, it

would be of great advantage if agriculture and some of the rural industries can be adopted as a base for the teaching of science. The programme may consist largely of nature studies, observations, and experiments which can be done with the help of simple articles, specimens, etc., likely to be locally available or which can be constructed with local materials.

6.2. There would be still some need of supplying teaching aids and materials from outside which would have to be specially designed to reduce costs. It is essential also to prepare books of instructions and text books to suit a fairly wide range of needs. These are difficult tasks which would call for extended study and research by scientists of high calibre with a serious interest in problems of science education. As basic conditions in underdeveloped countries are likely to be similar to a large extent, it may be possible to evolve broad general methods for science education which would be capable of being adapted without much difficulty to suit differing local conditions.

6.3. A great deal of pioneering research would be necessary for this purpose for which the help of advanced countries is indispensable. A good deal of experimental studies will have to be undertaken under conditions actually prevailing in underdeveloped regions. In the beginning, the studies would have to be organised on a small scale with the help and support of the local authorities and of such teachers and scientists as may be available to cooperate in the venture in the underdeveloped country itself. The project can be gradually extended, in the light of experience, to cover different subject fields at different educational levels, and also from one underdeveloped country to another. Fortunately, even one or two scientists can start the work in one single country. The important point is to make a beginning at the earliest opportunity.

6.4. I may now mention a second type of programme. Certain facilities for scientific research are already available in India and other developing countries. In most of these countries, scientific work is being hampered for lack of small replacement parts, additional accessories and instruments, and supply of essential consumable stores which have to be imported from the advanced countries. It is often difficult to secure import licences on account of shortage of foreign currency. This difficulty can be overcome through a simple plan of gifts in kind of replacement parts, instruments and equipment, stores, books and journals and reprints or microfilms of scientific papers etc., to be arranged through non-governmental committees of scientists. Such committees, which can be set up in the advanced countries through or in cooperation with appropriate scientific organizations or societies, would try to secure suitable grants from Government and other sources. In developing countries where scientific research has already started, the counterpart committees of scientists would also be set up, preferably, at a non-governmental level and with a majority of members from universities and non-governmental scientific institutions. All arrangements would be made with the concurrence of the government of the less advanced country concerned, but decisions relating to gifts for scientific work must be made by direct consultations between the scientific committees themselves. A scheme of this type can be usefully started, on an experimental basis, for a few selected countries, at a low cost, with gifts to the total value of perhaps one or two hundred thousand dollars per year. The amount can be increased if the experiment proves successful.

6.5. Another important form of scientific aid would be to arrange for competent research scientists from the advanced countries to work for a year or two in existing research units in the less advanced countries or to help in establishing high level research units in such countries. The less advanced countries can offer challenging problems and opportunities for research in many fields of science, which cannot be duplicated in the advanced countries, for example, in geology, meteorology and geography; biology, botany, and zoology; agriculture; medical science and public health; economics of development; linguistics, archaeology; and historical and cultural studies of various kinds. In some of the developing countries there

would be also increasing opportunities for active participation in research in mathematics and statistics, and physico-chemical and technological sciences. In establishing research units in underdeveloped countries it would be desirable to keep one broad aim in view, namely, to encourage joint studies by active collaboration between different research units. This would help in developing a community of research cells or units which, in its turn, would foster the growth of the spirit of scientific criticism and appraisal among wider circles of scientific workers.

6.6. To attract competent visiting scientists it is necessary to offer them facilities to pursue or start fruitful research in the less advanced countries; sometimes special equipment may have to be provided for this purpose. Secondly, the assignment in a less advanced country, would have to be treated as deputation in the same way as participation in scientific expeditions, and which would be recognised as a part of normal duties and also as a possible qualification for promotion. The visiting scientist must receive sufficient compensation in his home currency to meet his continuing home commitments during his absence abroad. Living and other local expenses should be normally met by the institution or by the government of the country in which he would work. Such sharing of costs would promote effective cooperation in the less advanced country, and would also reduce the total cost appreciably.

6.7. An important part of the responsibilities of a visiting scientist would be to give training to the scientific workers of the underdeveloped countries. When necessary, the visiting scientists would be able to select, for further training in an advanced country, the right type of persons who can be depended upon to go back to their own country after the completion of the training abroad. It would be also possible to give aid in the form of equipment and instruments in an effective way on the basis of objective appraisals of needs and possibilities by the visiting scientists.

6.8. A fourth programme could be to send from advanced countries young scholars, who have just finished their education in universities or higher educational institutions or have already done some research, to start or continue suitable lines of research for about two years or so in existing institutions or in research units to be established for this purpose in underdeveloped countries. The common participation in research projects of young scholars from the advanced and the underdeveloped countries would be of great help in establishing scientific traditions and an atmosphere of scientific criticism. It would promote self-confidence among the scientific workers of the underdeveloped country, especially, if the visiting scholars from advanced countries take higher degrees from institutions in the less advanced countries.

6.9. All the above forms of scientific aid can be started, if desired, on a small scale and at low cost, and, if successful, can be expanded in the light of experience. Also, these forms of scientific aid would not in any way overlap or hamper bigger programmes for gifts of expensive equipment or large projects for the setting up of national or regional centres and institutes for scientific research in the less advanced countries. On the contrary, the modest programme described in this note would prepare the ground for bigger projects.

7. Conclusion

7.1. In conclusion I may refer, very briefly, to some recent developments. After the second world war the movement for terminating colonial rule gained rapidly in strength; and one country after another in Asia and Africa has won political independence. It is being increasingly realised, however, that independence is not enough for economic development. The need of economic and technical aid is also being increasingly appreciated. Both the "western" and the "eastern" powers have started helping in the economic development of the less advanced countries in Asia, Africa and Latin America, but still without an adequate impact. The time has come to recognise that economic aid is essential but is also not sufficient.

7.2. Revolutions to capture political power have been occurring throughout human history and are even now occurring in many of the politically independent countries in Latin America or in most of the newly independent countries in Asia and Africa. Such revolutions do not automatically promote rapid economic development, because purely political revolutions do not lead to any fundamental transformation of the old society based on the principle of authority associated with levels of status. It is becoming increasingly clear that rapid economic development cannot be achieved without developing a structure of society in which decisions would tend to be made more and more on grounds of reason, that is, in accordance with the principle of objective validity instead of authority. It is relevant to note that the French Revolution was preceded by the age of reason; the American War of Independence had the support of influential leaders inspired by the spirit of science; and the socialist government, which was established after the October Revolution in 1917 in Russia, made great efforts to build up a countrywide system of science-oriented education and to promote scientific research and, in this way, succeeded in modernising the whole society leading to rapid economic development.

7.3. One thing is clear. In the absence of rapid economic development, political conditions in the less advanced countries would remain unstable. In many or most countries there would be one revolution after another tending to get the two power groups involved directly or indirectly in the struggle. The world must get out of this vicious circle. There are only two possibilities. One is for a violent type of revolution to occur which would suddenly change the whole structure of society to make it fit for rapid development of science and economic progress. The other alternative is deliberately to build up the foundation of science-oriented education and research to promote the modernisation of society in a peaceful way, and make conditions favourable for economic development.

7.4. Aid for scientific and economic development from either the western or the eastern countries, even when given in a spirit of competition, would be cooperative in effect. In any event, competition in constructive tasks of building up scientific foundations in developing countries is less dangerous and is likely to be far more useful than competition in the methodologies of warfare. Also, collaboration in promoting education and research in pure science can be pursued without any threat to national security or national interests, and would be of great help in promoting a rapid advance of the underdeveloped countries and in fostering better understanding among the nations of the world. The advanced countries have a great opportunity for peaceful cooperation in giving aid for science.

This pamphlet has not yet been published in any journal and is being printed for private circulation. Certain aspects of these problems were discussed by me in articles and addresses between 1955 and 1959 which were reprinted in *Talks on Planning* (1961), and in other articles such as *A Note on Problems of Scientific Personnel* (1959), *Recent Developments in the Organisation of Science in India* (1959), and a lecture at Sofia University in December 1961. Some of the ideas given in the present pamphlet were presented by me before a Conference on International Cooperation in Salzburg-Vienna in July 1962.

Professor P. M. S. Blackett in his presidential address to the British Association for the Advancement of Science in 1957 and in other articles in *Nature*, (3 February, 1962; May 1962 etc.) has considered various problems from the point of view of the advanced countries. Professor Stevan Dodijer made a penetrating analysis in an article in *Nature* (6 August, 1960) and in another article published recently in Stockholm, *TVF*, 33, (1962).

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