UNIT 7 SCIENCE IN COLONIAL AND MODERN INDIA

Structure

7.1 INTRODUCTION

We have seen in Unit 6 that the Industrial Revolution had led to an ever increasing demand for raw materials as well as markets for finished products. The newly industrialised countries took care of their growing demands by colonising many Asian and African countries. By the mid-nineteenth century, the British had established their colonial rule in India. The fairly long Indian tradition of science and technology and a rich cultural heritage, about which you have read in Units 2 to 5, got destroyed due to the merciless exploitation perpetrated by the colonisers. Only after Independence did we become the masters of our destiny and chose to consciously use science for the benefit of our people.

In this unit, we will outline the development of science and technology in India during the colonial and the post-Independence period. We will also try to analyse some pertinent issues relating to science and our society in the light of what we have learnt in the previous units.

Objectives

After studying this unit you should be able to :

- outline the few scientific developments in colonial India and analyse why these were so meagre,
- describe the impact of the freedom movement on the developments in science in pre-Independence India,
- describe the problems before our country after Independence and our response to solving them,
- discuss various issues related to the use of science and technology in our social context.

7.2 SCIENCE IN COLONIAL INDIA

We have seen in Units 5 and 6 that from the sixteenth century onwards, Europe began to outdistance India in scientific and material advancement. The rise of modern science in Europe strengthened European economic domination over the colonies where education, science and research were kept backward.

The advancing European trading companies of Holland, Portugal, France and Great Britain became deeply involved in political and military rivalries in India. The British East India Company emerged as the dominant trading company. This culminated in the establishment of the British supremacy over the Indian sub-continent. This was a very exciting time for the British rulers; a new empire was in the making and in the process of consolidation. The colonisers were out to collect the maximum possible information about India, its people and resources. They faithfully reported what was best in India's technological traditions, what was best in India's natural resources, and what could be the most advantageous for their employers. The rulers were also quick to realise that a thorough knowledge of the geography, geology and botany of the areas being conquered was essential. They fully recognised the role and importance of science in empire-building. Let us now see what the few scientific developments in the colonial times in India were. We will also try to analyse why there were so few developments.

An interesting feature in the early phase of this period was that colonial scientists would try their hand at several fields simultaneously and each scientist was, in fact, a botanist, geologist, geographer and educator—all rolled into one. As data-gatherers, the individual scientists were efficient. However, for analysis and drawing conclusions, they had to depend upon the scientific institutions in Britain, which received such data from many colonies. The British made investment in botanical, geological and geographical surveys from which they hoped to get direct and substantial economic and military advantages. Medical and zoological sciences did not hold such promise and, thus, they were neglected. Research in physics or chemistry was simply out of question because these subjects were related to industrial development which the British did not want to encourage. India was considered to be only a source of raw materials and a wonderful market for all sorts of articles manufactured in Britain, from needles, nibs and pencils to shoes, textiles and medicines.

However, the setting up of some scientific bodies and museums was a positive step. Pre-British India had a weak scientific base and, therefore, neither scientific institutions existed nor were there any journals to spread scientific information. William Jones, a judge of the Supreme Court of Calcutta and some other European intellectuals in the city realised this and founded the Asiatic Society in Calcutta in 1784. This society soon became the focal point of all scientific activity in India. It was followed by Agricultural-Horticultural Society of India (1817), Calcutta Medical & Physical Society (1823), Madras Literary and Scientific Society (1818), and the Bombay Branch of the Asiatic Society (1829). These societies rendered invaluable service, particularly through their journals which compared very favourably with the European ones.

When the Crown formally took over the Indian administration in 1858, activities for exploring the natural resources in the country had already passed their formative stage. The problem was more of consolidating the gains which individual efforts had made possible. For this, many institutions were set up and the government expanded the survey organisations. In 1878, the three survey branches—the trigonometrical, topographical and the revenue which had upto that time been separate departments, were amalgamated. Naturally, Revenue Survey got the upper hand. Similarly, geological explorations were patronised because of their direct economic benefit. The Geological Survey of India was created in 1851. Unlike the Geological Survey or Survey of India, an organisation for carrying out botanical explorations did not come up.

The establishment and development of various scientific departments and institutions called for a different cadre. The biggest and the oldest was the Indian Medical Service which was raised and maintained basically to serve the army. The most disorganised sector was that of agriculture. Though the maximum revenue came from agriculture, the problems of its improvement were too complex and the government left it in the hands of private agricultural societies. Much later, in 1906, an Indian Agricultural Service was organised. However, it did not grow into a well-knit and integrated scientific department because of financial and administrative constraints. A few branches which were of military or instant economic significance could manage to develop. But, on the whole, the efforts remained adhoc, sporadic and local in nature. The government wanted practical results rather than research papers. An excessive administrative control, exercised at different levels, ensured that the colonial scientists would always dance to the official tune.

In the educational scheme, science was never given a high priority. The charter of 1813 called for 'the introduction and promotion of knowledge of science among the inhabitants of British India'. But it remained a pious wish, at least partly because the indigenous educational system was also not sympathetic to the idea. In 1835, Macaulay succeeded in making a foreign language English the medium of instruction. Also, his personal distaste for science led to a curriculum which was purely literary. The entry of science in schools was, thus, delayed. A few medical and engineering institutions were opened but they were meant largely to supply assistants to British trained doctors and engineers. Ancient universities in India were leading centres of learning in their time and attracted scholars from other countries. So were the famous centres of Islamic learning in the medieval period in India. But these traditions did not survive. It was in 1857 that the Universities of Calcutta, Bombay and Madras were set up more or less on the pattern of London University.

However, it was only in 1870 that the Indian universities began to show some interest in science education. In 1875, Madras University decided to examine its matriculation candidates in geography and elementary physics in place of British history. Bombay was the first to grant degrees in science. Calcutta University divided its B.A. into two branches— 'A' course, i.e. literary, 'B' course, i.e. science. A fact of great significance, however, was that the entire direction of colonial education was not towards opening up the minds of students or developing a questioning attitude. Rather it encouraged passive acceptance of what was taught or written in the books. The books were in English and were mostly written and printed abroad. They depicted the British culture. Education so imparted, by and large, tended to alienate the educated people from their own culture. Further, the educational milieu ensured lack of enterprise, and readiness to take orders from above, which was indeed the intention of the rulers. Institutions and teachers looked at the British educational model as the ideal and, by and large, they tried to copy it even though they were in a very different social and economic situation.

SAQ 1

State, in the space given, whether the following statements about the scientific developments in colonial India are true or false. Write the correct answers for the false statements.

i) Botanical, geological and geographical surveys were carried out to map India's natural resources. ☐

ii) Research in physics and chemistry was encouraged to promote industrial development in India. ☐

iii) Some scientific societies came up and brought out some journals for disseminating scientific information. ☐

iv) Attention was paid to medicine only to serve the army and other British populace. ☐

v) There was a systematic and organised effort to solve problems in agriculture. ☐

vi) Several universities started offering courses in science education. ☐

vii) At school level, too, science education was given much attention. ☐

viii) The purpose of imparting education in British India was to create a spirit of free enquiry and innovative thinking. ☐

We have seen above, that the British were primarily interested in strengthening their political and economic domination over India. They exploited India's resources to the full and developed a nominal scientific infrastructure for this purpose. However, in all other areas, like physics, chemistry and agriculture, in which scientific development was not imperative, no attention was paid. In this period of colonisation, India's cultural heritage, scientific tradition and educational system got destroyed. In its place came a tradition of servility and an education that was designed to produce subservience rather than inculcate a spirit of free and creative inquiry.

The status of scientific research in colonial India was not much better. Let us see what it was.

7.2.1 Scientific Research in Colonial India

In the absence of higher scientific education, scientific research remained an exclusive governmental exercise for a long time. It was, therefore, linked to the economic policies pursued by the imperial power. A scientist serving the colonial power was supposed to not only discover new economic resources, but also to help in their exploitation. In agriculture, it was basically plantation research with emphasis on experimental farms, the introduction of new varieties, and the various problems related to cash crops. These were basically cotton, indigo, tobacco and tea, which were all to be exported to Britain. Next came surveys in geology to exploit mineral resources, again for export as raw material. Another major area of concern was health. The survival of the army, the planters and other colonisers depended on it.

In spite of difficult conditions and the government's lukewarm attitude, quite a few scientific works were carried out in this period. Ronald Ross did original work on the relation between malaria and the mosquito. Macnamara worked on cholera, Haffkine on plague and Rogers on kalazar. The famous medical scientist, Robert Koch visited Calcutta to work on cholera. Bacteriological laboratories were set up in Bombay, Madras, Coonoor, Kasauli and Mukteswar. This shift towards bacteriological research had one significant result. It led to the growth of clinical treatment, private practice and a booming drug industry. However, preventive measures like sanitary reforms, or even supply of drinking water to villages and towns remained neglected. In other fields too significant developments took place through the effort of foreign and Indian scientists working in institutions here.

The British activities did evoke some response from the local populace, particularly the educated section, who were looking for jobs in the colonial administration and economy. A few Indians participated in the officially patronised scientific associations or institutions. However, they often searched for a distinct identity and established institutions, scholarships and facilities of their own. Ram Mohun Roy's petition to Amherst asking for a proper science education became well known. Bal Gangadhar Shastri and Hari Keshavji Pathare in Bombay, Master Ramchander in Delhi, Shubhaji Bapu and Onkar Bhatt Joshi in Central Provinces, and Aukhoy Dutt in Calcutta worked for the popularisation of modern science in Indian languages.

Geography and astronomy were the areas chosen first because, in these fields, the Pauranic myths were considered the strongest. Vyas, the author of Srimad Bhagwat, for example, had talked about oceans of milk and nectar. This is part of popular myth even now, and this was attacked by these persons. For instance, Onkar Bhatt explained that Vyas was only a poet, not a scientist, and his interest was merely to recount the glories of God, so he wrote whatever he fancied. Even Urdu poets, devoted mainly to the romances of life, took notice of the western science and technology. Hali and Ghalib, for example, talked about the achievements of western civilisation based upon steam and coal power. The next logical step from these individual efforts was to give some organisational shape to the growing yearning for modern science.

In 1864, Syed Ahmed Khan founded the Aligarh Scientific Society and called for introduction of technology in industrial and agricultural production. Four years later, Syed Imdad Ali founded the Bihar Scientific Society. These societies gradually became defunct. In 1876, M.L. Sarkar established the Indian Association for the Cultivation of Science. This was completely under Indian management and without any government aid or patronage. Sarkar's scheme was fairly ambitious. It aimed at original investigations as well as science popularisation. It gradually developed into an important centre for research in optics, acoustics, scattering of light, magnetism etc. In Bombay, Jamshedji Tata drew up a similar scheme for higher scientific education and research. This led to the establishment of the Indian Institute of Science at Bangalore in 1909. There was, thus, greater awareness about science in India by the turn of the century. This was especially so, as a movement to gain freedom from colonial rule emerged. In the next section, we will discuss the impact of the freedom movement on the scientific developments. But before studying further, why don't you work out another SAQ ?

SAQ 2

a) State, in one or two lines, what the purpose for encouraging research in colonial India in each of the following areas was:

   i) Botany

   ....

   ....

   ii) Geology, Geography

   ....

   ....

   iii) Medicine

   ....

   ....

b) Which one of the following statements describes the contributions of Indians to the scientific developments in the late nineteenth and early twentieth century? Tick mark the correct choice.

   i) There was considerable organised effort in setting up societies, research and teaching institutes.

ii) There were some attempts here and there and some institutions were set up to promote original investigations as well as science popularisation.

iii) There were almost insignificant Indian contributions to scientific development.

iv) None of the above.

7.2.2 Impact of the Freedom Movement

By the early twentieth century, the Indian society had started witnessing the first stirrings for freedom from colonial rule. While their political aspirations led to a demand for self-rule, the frustration resulting from economic stranglehold found expression in their insistence on using only goods made in India. This Swadeshi Movement provided further impetus for :

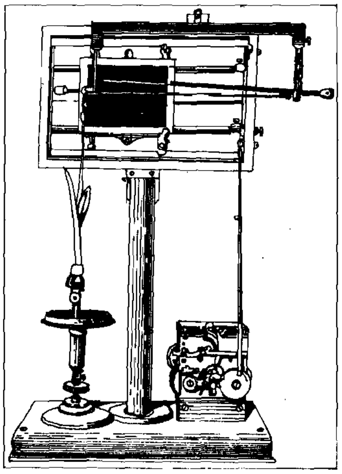
i) promotion of education along national lines and under national control with special reference to science and technology,

ii) industrialisation of the country.

In 1904, an Association for the Advancement of Scientific and Industrial Education of Indians was formed. The object was to send qualified students to Europe, America and Japan for studying science-based industries.

As mentioned earlier, in colonial India the environment was not conducive to higher studies, much less to research. Indians were allowed only subordinate posts and even those who had distinguished themselves abroad were given less salary than the Europeans of the same grade and rank. This 'apartheid' in science made the Indians react strongly. J.C. Bose, the first noted Indian physicist, refused to accept this reduced salary for three years. Not only this, till the Royal Society recognised Bose, the college authorities refused him any research facility and considered his work as purely private. J.C. Bose was unorthodox in one more sense. He was one of the first among the modern scientists to take to interdisciplinary research. He started as a physicist but his interest in electrical responses took him to plant physiology. To fight for a place and recognition in the scientific circles in Britain was no less difficult than fighting against the administrative absurdities of a colonial government. Bose persisted and won.

(a)



(b)

Fig. 7.1: (a) J.C. Bose; (b) the crescrograph, one of the many instruments invented by J.C. Bose, could record plant growth magnifying a small movement as much as 10,000,000 times.

Another noted Indian scientist, P.C. Ray had also suffered similarly. On his return from England in 1888 with a doct ꞁte in chemistry, he had to hang around for a year and was finally offered a temporary assistant professorship. All through he had to remain in Provincial Service. P.N. Bose, preferred to resign, when in 1903 he was superseded for the directorship of the Geological Survey by T. Holland who was 10 years junior to him.

Fig. 7.2: Acharya P.C. Ray.

These problems were reflected on the political platform of the country. In its third session (1887), the Indian National Congress took up the question of technical education and has since then passed resolutions on it every year. K.T. Telang and B.N. Seal pointed out how, in the name of technical education, the government was merely imparting lower forms of practical training. The Indian Medical Service was also severely criticised. In 1893, the Congress passed a resolution asking the government "to raise a scientific medical profession in India by throwing open fields for medical and scientific work to the best talent available and indigenous talent in particular." Whether it be education, agriculture or mining, the Congress touched several problems under its wide sweep.

We find that the activities of this era had two important features. One was that almost all the exponents of Swadeshi looked to Japan as a major source of inspiration. Japan's emergence as a viable Asian industrial power and its subsequent military victory over Russia in 1904-05 caught the imagination of Indians. Another characteristic was that quite often they showed revivalist tendencies. This may have been because the distant past comes in handy for the recovery of a lost self or reassertion of one's identity. This search for moorings made P.N. Bose, a geologist, mention about whom has been made above, write *'A History of Hindu Civilisation'* in three volumes. J.C. Bose gave Sanskrit names to the instruments he had fabricated, like ***Kunchanagraph*** and ***Shoshangraph***. Many science popularisers had a tendency to show that whatever was good in western science existed in ancient India also. For example, Ramendrasundar Trivedi's discussion on Darwin ends with comparing his theory with what is written in Gita. Later, B.K. Sarkar wrote on the Hindu Achievements in Exact Science.

Kunchanagraph is an instrument to show how plant body reacts to stimulus, by undergoing contractions. Shoshangraph is an instrument for studying absorption of water or any liquid by plants.

All these scientists were for the industrial application of modern science but failed to overcome certain cultural constraints, which was necessary for this effort. All they tried to do was to demonstrate that the Indian ethos and the values of modern science were congruent and not poles apart. In such a situation, it was not easy to evolve a correct understanding of our intellectual and cultural heritage. This was all the more difficult because of the total colonial domination both in education and in social life.

Fig. 7.3: Nobel Laureate C.V. Raman.

These efforts had, nonetheless, a galvanising effect. Taking advantage of the University Act of 1904, which allowed the existing Indian universities to organise teaching and research instead of merely affiliating colleges, Sir Asutosh Mookherjee took the initiative of establishing a University College of Science in Calcutta. Eminent scientists such as P.C. Ray, C.V. Raman, S.N. Bose and K.S. Krishnan taught there. This very college, although starved financially all through, produced a group of physicists and chemists who received international recognition. By contrast, the contributions of many government scientific organisations staffed by highly paid Europeans were rather poor.

Those who put India on the scientific map of the world were many. J.C. Bose showed that animal and plant tissues display electric responses under different kind of stimuli, like pricking, heat etc. We have referred to his work earlier also. S. Ramanujan, an intuitive mathematical genius contributed a lot to number theory. P.C. Ray analysed a number of rare Indian minerals and started the Bengal Chemical and Pharmaceutical Works, a pioneering and pace-setting organisation in the field of indigenous chemical and pharmaceutical industry. C.V. Raman's research on the scattering of light later won him the Nobel Prize in 1930. K.S. Krishnan did theoretical work on the electric resistance of metals. S.N. Bose's collaboration with Einstein on the study of elementary particles led to what is known as the Bose-Einstein Statistics. D.N. Wadia worked in the field of geology, Birbal Sahni in palaeobotany, P.C. Mahalanobis in statistics, and S.S. Bhatnagar in chemistry. Apart from the individual contributions of these scientists, their greatest contribution was in the field of teaching and guiding research. Many institutes were set up. For example, the Bose Institute (1917), Sheila Dhar Institute of Soil Science (1936), Birbal Sahni Institute of Palaeobotany etc. This gave further impetus to scientific activity in India.

Fig. 7.4: S. Ramanujan.

The need for an annual scientific meeting had been felt all along, so that different scientific workers throughout the country might be brought into touch with one another more closely. So far it had been possible only in the purely official and irregular conferences such as the Sanitary Conference or the Agricultural Conference. Thus, was born the Indian Science Congress Association (ISCA) in 1914 with the following objectives :

- to give a stronger impulse and a more systematic direction to scientific enquiry,
- to promote the interaction of societies and individuals interested in science in different parts of the country,
- to obtain a more general attention to the cause of pure and applied sciences.

The objectives have not changed much since then and the ISCA has now grown into the largest organisation of Indian scientists and technologists representing all disciplines of science and technology.

In the wake of the first World War (1914-18), the Government realised that India must become more self-reliant scientifically and industrially. It appointed an Indian Industrial Commission in 1916 to examine steps that might be taken to lessen India's scientific and industrial dependence on Britain. The scope of the resulting recommendations was broad, covering many aspects of industrial development. But few of the Commission's recommendations were actually implemented. Similar was the fate of numerous other Conferences and Committees. Whenever requests were made by Indians for starting new institutions or expanding existing ones, the government pleaded insufficiency of funds or inadequacy of demand. The interests of the colonial administration and those of the nationalists in most instances often clashed.

If we look at the events during the first quarter of the twentieth century, we find that this period was characterised by debate about further development. When Gandhiji started his campaign for cottage industries, varying notes were heard at the annual session of the Indian Science Congress. P.C. Ray, for example, held that general progress through elementary education and traditional industries, is a necessary pre-condition for scientific progress. But many differed with him. M.N. Saha and his *Science & Culture* group opposed the Gandhian path of economic development and supported setting up of big industries. The socialist experiments in Russia had unveiled the immense potentialities of science for man in terms of economy and material progress. The national leadership was veering towards heavy industrialisation and socialism, both of which stood on the foundations of modern science and technology. On Saha's persuasion, the then Congress President Subhas Chandra Bose agreed to accept national planning and industrialisation as the top item on the Congress agenda.

Fig. 7.5: S.N. Bose.

The result was the formation of the National Planning Committee in 1938 under the chairmanship of Jawaharlal Nehru. This Committee appointed 29 sub-committees, many of which dealt with such technical subjects as irrigation, industries, public health and education. The sub-committee on Technical Education worked under the Chairmanship of M.N. Saha. Other members were Birbal Sahni, J.C. Ghose, J.N. Mukherjee, N.R. Dhar, Nazir Ahmed, S.S. Bhatnagar and A.H. Pandya. The sub-committee reviewed the activities of the existing institutions to find out how far the infrastructure of men and apparatus was sufficient in turning out technical personnel.

The outbreak of the Second World War (1939-45) and the interruption of the direct sea route between India and England made it necessary for the colonial government to allow greater industrial capability to develop in India. It was, therefore, felt necessary to establish a Central Research Organisation and this was eventually followed by the establishment of the Council of Scientific and Industrial Research in 1942. As part of the post-war reconstruction plan, the government invited A.V. Hill, President of the Royal Society. In 1944, he prepared a report that identified various problems confronting research in India. These developments offered greater opportunities to Indian scientists in policy-making and management of scientific affairs. In fact, the origins of the science policy of free India and of the whole national reconstruction can be traced to these activities.

Fig. 7.6: Birbal Sahni.

Before you study further about the scientific developments in post-Independence India, you may like to attempt an SAQ to consolidate these ideas.

SAQ 3

Fill up the blanks in the following statements that summarise the impact of freedom movement on scientific developments in pre-Independence India :

i) An impetus for promoting science education and industrialisation according to national needs came from the .... movement.

ii) There were several notable contributions by individual .... However, the overall atmosphere did not encourage the growth of .... and .... in colonial India.

iii) The leaders of the freedom movement realised this and put forth a demand for raising the standards whether in education, ... mining or ....

iv) As the freedom movement intensified and scientific activity grew, there was a debate about further development. Eventually, the path of .... and national .... was chosen.

v) Committees were set up to review the activities of existing infrastructure, to identify the problems and to suggest ways of solving them. All these efforts formed the basis of the .... of free India and also of national reconstruction.

Fig. 7.7: M.N. Saha.

The foregoing analysis of British India illustrates that it was futile to expect the emergence of science here under an alien administration obsessed with one-sided commercial preferences. In such a situation, field sciences were developed to exploit natural resources and grow commercial crops; but a balanced development of research did not take place. When industry was not allowed to develop, many related sciences could not grow properly. As we have seen in Unit 6, an atmosphere of vitality and exuberance in the social and economic life was necessary to bring forth innovative ideas and to encourage scientific progress. Individual scientists, however, did shine in adverse circumstances. It was all the more so under the influence of a larger social movement and struggle, which promised to liberate and transform society. Thus, the situation changed when India became independent in 1947. Let us now discuss, in brief, the developments in science and technology in post-Independence India.

7.3 SCIENCE IN POST-INDEPENDENCE INDIA

When the Second World War ended in 1945, Germany, Italy and Japan had been defeated and France had been badly shaken. Even Britain had suffered tremendous losses and its economy was almost ruined. Thus, the colonial powers which had ruled the world and spread poverty, hunger and disease everywhere, were in no position to suppress people anywhere any more. The constant struggle for freedom in the colonial countries had also reached a high pitch. The result was that, one after another, more than a hundred countries of Asia, Africa and South America became free. The war had shattered the old system, and a new world had been born, with an entirely different set of opportunities and problems.

The countries which had become newly independent had the tremendous problem of reconstructing their economy so that tolerable conditions of living could first be created for all their people. The old ruling countries, on the other hand, had to think of ways and means of continuing to drain the wealth of their erstwhile colonies. This was necessary to enable their business enterprises to continue making high profits so that they could maintain relatively high standards of living to which their own people had become accustomed.

Science and technology had to be deliberately employed by both sets of countries. The only difference was that the developing countries had to make a start from scratch—with hardly any institutions or people who could engage in competitive science and technology, whereas the advanced or developed countries now had a stronger base of science and technology than ever before. During the war great sums of money had been spent on developing nuclear science and the atomic bomb, on electronics as applied to radar and communication, and on advanced designs of aircrafts, submarines and other means of waging war. All other sciences were also in a much better position than before. This base of science and technology was to be used to the advantage of developed countries to regain the old glory and power. In other words, our struggle for "development" and their struggle for supremacy are two sides of the same coin. Science and technology play a pivotal role in this international competition.

The Indian freedom movement had been conscious that political independence was only a stepping stone to economic independence. Our leaders had realised that our decisions about industry and trade would have to be taken by us alone without compulsion of foreign governments or their business counterparts. And that our economic development would have to serve the people and meet the minimum needs of their food, health, shelter, education, culture etc. For this, we could not leave economic development to chance, or to the purely profit motive on which private industry and trade operate, their natural tendency being to produce what can sell, rather than what is needed in our social context. Therefore, an essential part of our approach to development was to plan our economy to bring about maximum human satisfaction combined with growth.

The role of science and technology was crucial for this endeavour and this was clearly expressed in the "Scientific Policy Resolution" adopted by the Parliament in 1958. This resolution was drafted and piloted through the Parliament by our first Prime Minister, Jawaharlal Nehru. In the words of this Resolution :

"The key to national prosperity, apart from the spirit of the people, lies, in the modern age, in the effective combination of three factors, technology, raw materials and capital, of which the first is, perhaps, the most important, since the creation and adoption of new scientific techniques can, in fact, make up for a deficiency in natural resources, and reduce the demands on capital. But technology can only grow out of the study of science and its applications."

Since Independence, and particularly after the passage of the Resolution, a great expansion of science and technology in both education and research has taken place. The situation today is far different from what it was in 1947. We have now about 200 universities including 6 Indian Institutes of Technology, over 800 engineering colleges and 110 medical colleges, a few hundred scientific research laboratories under the Central and State governments, as also R & D units in private industry. Research is being done in almost all areas of modern science. The conspicuous success of our scientists in atomic energy, space research and agriculture is well known.

The funds allocated to research have also vastly increased over what they used to be 40 years ago. But in the modern world, it is not enough to be in the forefront of creative science or innovative technology. Out of the total world expenditure on research, excluding the socialist countries, 98% is spent by the developed countries, the old imperial powers. Only 2% is spent by all the developing countries taken together. In this, India's share may be half a per cent. Moreover, since the developed countries have better facilities, better opportunities for scientific world and higher standards of living, a fairly high proportion of our talented young people migrate to those countries. They are, thus, unable to contribute towards national development by solving our problems through science and technology. New discoveries and new inventions, therefore, still come from the advanced or developed countries. This position does not seem likely to change in the near future.

A new feature of the world since the Second World War is the armaments race. It started with the Americans dropping the radically different weapon, the atom bomb, on Hiroshima and Nagasaki in Japan. Since then, modern bombs, each equivalent to a million tons of the old explosive, were developed both by the U.S., the then Soviet Union and other nuclear powers. Nuclear powers have missiles which can carry the bombs to targets half way round the globe. Each offensive weapon has led to a new defensive system. There has also been a race to obtain bases in other countries. A dangerous aspect about nuclear weapons is that these could be triggered off even by mistake, and could destroy all civilisation. Thus, we can see that the security of neither of these countries has improved. In fact, many other countries are drawn into the race because weapons of one country have to be matched by another. It is calculated that the world is spending more than 1,00,000 crore rupees per year on armament and the developing countries are spending about 20% of this amount, much of which goes to buy weapons from firms in the developed countries.

Imagine such a lot of money, representing human labour, being wasted year after year. Naturally resources for development are diverted to "security". On the other hand, people in underdeveloped countries are still largely illiterate and deficiently served in basic requirements of life, such as food, drinking water, medicine etc. Interestingly, it is said that the arms race has led to huge profits being made by a small number of firms, and it is designed to suck away the resources of developing countries so that their dependence on foreign loans, technologies and strategic policies is increased. The more sophisticated the weapons are, the more is our dependence on the advanced countries.

Surely, this is neither a happy situation nor a stable one. The power of science has reached such a pitch that international relations have to be readjusted, and national effort has to be recast so as to bring the benefits of science to the lives of common people.

We now end this discussion with an SAQ for you!

SAQ 4

Tick mark the three statements that reflect the efforts of our country in solving our problems with the help of science and technology.

i) Adopting a carefully formulated science policy. ☐

ii) Allowing young scientists to migrate to developed countries. ☐

iii) Expansion of science and technology in both education and research. ☐

iv) Increased research funding. ☐

v) Diverting resources, for buying weapons.. ☐

7.4 WHAT WE HAVE LEARNT

What we have discussed so far in Blocks 1 and 2 leads us to underline the following points about the use of science and technology in our social context.

i) Knowledge is one, and its various components such as physics, chemistry, biology, medicine, technology, economics etc. are profoundly inter-related. However, we have become accustomed to separating the study of science from that of social sciences and humanities. This may be explained by historic circumstances as we have mentioned in Sec. 5.2.1 and Sec. 6.4.1, but it is an undesirable feature of the present educational and research system. It does not allow a person to have a unified view of how the components interact, or more particularly, how science plays a role in changing the socio-economic system and how the socio-economic plans and policies affect science.

   For many years, scientists believed that science is good in itself. This continued until the sociologists pointed out how science can be destructively used, how diseases can be spread rather than controlled by science, how aeroplanes and even the modern space science can be misused to wage wars for subjugating people or even killing them on a massive scale. For science to be good, it must be designed to help in serving the purpose of uplifting and improving the human condition.

ii) We have seen in Unit 6 that much of the modern scientific and technological development has taken place in the context of, and according to, the demands of the West European society, and, later, the American society. We should carefully examine if all the ideas developed there suit our Indian society. For example, practically all mechanisation was to increase productivity of labour, or, in practical terms, to have more production from fewer people. This is a labour saving outlook,,fit for a country where labour was in short supply—as in the European countries. What would be the effect of mechanisation on the employment situation in a populous country like ours? Mechanisation as an exact copy of what happened in the western world may not be in our best interest, unless employment and the related buying power of the people is ensured.

   Mechanisation and modernisation may reduce the labour cost of production and hence profits may increase, but the social costs may become unbearable in a country in which the majority of population is poor. Obviously, a careful and cautious policy is needed. A concrete example is in agriculture: non-mechanical agriculture typically produces 5 to 10% surplus so that the population in the towns can be fed. Mechanisation does not increase the yield from soil. What happens is that only fewer people, say 5%, can produce the entire needed surplus. But then what would the rest of the rural population do? If they are unemployed and made poorer still, they may not be able to buy the food which is produced. The answer is to open up other avenues of employment. It means that careful and many-sided planning is necessary to take real advantage of mechanisation in agriculture or in industry.

iii) Another disputable idea is that of "efficiency" of an enterprise, say, a factory. As we have seen in Unit 6, historically, maximising profit was the only concern of the factory owner. Therefore, he made an analysis of the inputs to the production system and the outputs. Social concerns did not figure in his scheme of things. For instance, some factories set up on the basis of 'high efficiency' have led to terrible pollution of the environment, with smoke and soot and all kinds of dirty stinking or acidic water coming out of the factories and stagnating around them. We see such a situation in India even now when we have not reached as high a degree of industrialisation as in the West. In Europe or America, where industrialisation was even more intense, whole cities like Birmingham in U.K. or Chicago and Detroit in USA had become black, often covered with smoky fog. Similarly, scarce resources from the earth were mined and sold for a handsome profit without caring either for degradation of the soil or depletion of the resources in the long run. Thus, with the so called 'efficiency' related only to the profit that one could make, social problems were often made more acute. We cannot afford to further complicate our problems by uncritically using an idea, approach or a definition from the developed countries.

iv) There are many other ideas which would need to be scrutinised and modified before being accepted for our conditions. One is "economy of scale", which means you can make more profit if you produce goods on a large scale, since the overhead costs do not increase proportionately. This idea was good in the past when markets, particularly in the colonies, and export markets were more freely available to the industrialised countries. Today, the social needs, howsoever limited, will have to be taken into account. For instance, in our context, men and machines should be producing what is urgently needed by our own people. Gearing production to an export market, even if one were available, at the cost of our own needs, is not an unmixed blessing.

v) Another misconception that people have is that science and technology are freely available to all who care to use them. Unfortunately, technology and the most advanced ideas in science are used to produce goods which are sold either at exorbitant prices or to bargain for concessions of another kind. You may have read in the newspapers about defence equipment, "super computers", and other sophisticated technology being offered to developing countries under all kinds of conditions. Technological secrets are the most jealously guarded secrets in the present world. Even scientific advances made by laboratories in the developed countries are withheld for as long as circumstances would allow.

Thus, we can see that even after the colonies have gained their independence, the colonial yoke has not completely gone. Science and technology are being used as tools to make developing countries behave more or less according to the interests of the developed countries. We will resume this discussion in the last block of this course and explore how we can use science and technology for the national good.

7.5 SUMMARY

In this unit, we have dealt with the developments in science in colonial and post-Independence India. The newly industrialised countries had in their search for raw materials and markets for finished products, colonised many Asian and African countries. India came under the British colonial yoke. This influenced the subsequent scientific developments in India. Let us now summarise the main features of this unit :

- The colonisers were interested only in exploiting India's natural resources. Thus, developments took place in a few areas like botany, geology, geography etc. However, the long standing Indian tradition of science was destroyed. All creative thought was sought to be stifled by the colonial masters to keep the Indians backward.
- The local populace responded by setting up institutions of their own that worked for the popularisation of science. The freedom movement gave further impetus to this cause. Several Indian scientists received international recognition for their work. But, above all, there emerged a conscious thinking about using science and technology for the benefit of all our people.
- This was reflected in the policies adopted by our country after gaining independence. Several steps were taken to effectively use science. Yet, there are still several aspects which need careful attention. Notable among these is applying western ideas and approaches to our problems regardless of our social milieu. We have also to fight against the tactics of the developed countries to dominate us by withholding scientific or technological information, embroiling us in the arms race etc. We have yet to go a long way in attaining the standards of the developed countries.

7.6 TERMINAL QUESTIONS

1) State, in four or five lines, why there were such few developments in science in British India.

....

....

....

....

2) List two aspects of the role of developed countries, which impede our development in science and technology.

....

....

....

....

....

....

3) Which three options from among the following would you expect our country to exercise for using science and technology in our social context? Tick your choices.

i) Increasing the funding of education and research. ☐

ii) Preventing brain-drain, i.e. the migration of young scientists to developed countries by creating favourable conditions. ☐

iii) Leaving economic and scientific development entirely to private enterprise. ☐

iv) Encouraging an all-round education in the various components of knowledge. ☐

v) Adopting uncritically, the ideas or practices of the developed countries. ☐

7.7 ANSWERS

Self Assessment Questions

1) i) T ii) F iii) T iv) T v) F vi) T vii) F viii) F.
ii), v), vii), viii): It was just the opposite for each case as you can see from the text.

2) a) i) To solve the problems of introducing new varieties of cash crops like cotton, tea, indigo for export to UK.
ii) To exploit mineral and natural resources.
iii) To provide healthcare for the colonisers.

b) ii)

3) i) Swadeshi
ii) Scientists, science, technology
iii) agriculture, medicine
iv) Industrialisation, planning
v) science policy

4) i) ✓ ii) × iii) ✓ iv) ✓ v) ×

Terminal Questions

1) The primary aim of the colonisers was to maximally exploit India's natural resources for supplying raw materials to Britain and sell finished products in the Indian market. They were just not concerned with preserving India's scientific and cultural tradition or encouraging any development, scientific, educational or material in India.

2) i) Use of science and technology to assert their domination over underdeveloped countries and to make them behave.
ii) Encouraging the arms race so as to make huge profits and increase the dependence of poor countries on loans, technologies and strategic policies.

3) i) ✓ ii) ✓ iii) × iv) ✓ v) ×