UNIT 3 IRON AGE

Structure

3.1 INTRODUCTION

In Unit 2, we briefly surveyed the ideas and techniques of the early human beings, and traced the roots of science in the primitive culture. You also read about the emergence and growth of science in the ancient world, in the historical epoch known as the Bronze Age. Now, we turn our attention to an equally important period in the history of science, known as the **Iron Age**.

From about the fifteenth century B.C., we find that civilisation was no longer limited to a few river basins but had spread to the major cultivable areas of Asia, northern Africa and Europe. The spread of civilisation was aided by the discovery and use of a new metal, iron, which led to this period being called as the Iron Age. The Iron Age did not bring about any remarkable technical advances, such as in the Bronze Age. However, the availability of a cheap and abundant metal led to widespread changes as this civilisation spread far and wide. It also affected the relations between various social classes.

We have already read that the Bronze Age river valley civilisations were decaying due to many problems of stagnating economy and culture. Their decline was hastened by the constant incursions and raids of barbarian clans. The nomadic barbarians were pastoral people who had learnt to use iron. They had great mobility as they had tamed wild horses for travel, and carried their food alongwith them. They ran through the decaying civilisations, picking up local techniques as it suited them. The devastation left in their wake was often irreparable for the people they had over-run. The barbarians spread far and wide in the world, giving rise to civilisations that were less peaceful, even less developed, but more flexible to change.

In this unit, we shall study about the developments in science and technology in the Indian and Greek civilisations of the Iron Age. In the next unit, we shall take up the study of one of the most fruitful periods of scientific developments in India, which saw tremendous advances in the areas of astronomy, mathematics and technology.

Objectives

After studying this unit you should be able to :

- describe, in an objective manner, the major developments in science and technology in India and Greece in the Iron Age,
- compare the developments in various scientific ideas and techniques in India with those in Greece,
- explain the factors that led to the decline of science in Europe.

3.2 SCIENCE IN IRON AGE INDIA

In the Indian subcontinent, nomadic Indo-Aryans came from the steppes of what is now Soviet Central Asia and Iran. They came in waves, the first one being around 1500 B.C. They moved south-east, and finally settled in the areas shown in Fig. 3.1 as postoral – agricultural communities and kingdoms. For these people, transformation from pastoral to settled agricultural communities took between 1000 to 1500 years, the period lasting until about 700-600 B.C.

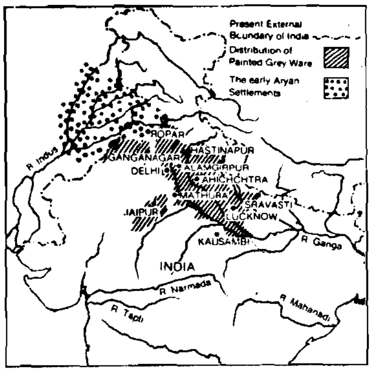

Fig. 3.1: Distribution of the Painted Grey Ware pottery in the Gangetic plain provides evidence of the Aryans' movement towards the east.

We get information about this period from the literature of Vedic times such as the Vedas, Samhitas, Upanisads, Sutras etc., and from the tools and artefacts found in excavations at various sites. Let us now try to reconstruct this history.

3.2.1 Search for Agricultural Land and Minerals

For the Aryans, the period of transition from pastoral to agricultural communities was characterised by war and strife against the local population. They were constantly in search of agricultural land, mineral deposits and ores, and they cleared dense forests for these purposes. This is called the Rigvedic period.

Rigvedic Period (1500 B.C. – 700 B.C.)

In the Rigvedic period, the Aryan groups were always on the move and in constant strife with each other or with the local non-Aryans. Therefore, they did not have enough opportunity to develop science and technology. Their technology amounted mostly to the construction of chariots, iron tools and weapons of war. The pottery of those times (1000 B.C. to 600 B.C.) found in the Gangetic plain is called the 'Painted Grey Ware' pottery. It is not as developed as the Harappan pottery. You can see this in Fig. 3.2. Similarly, there was no brick technology of any great note, especially in comparison to that achieved in the Harappan period. Craftsmen such as wood-workers, cabinet and chariot-makers, metal-workers and ship-builders, were free members of the tribe. Weaving and spinning was done only by women.

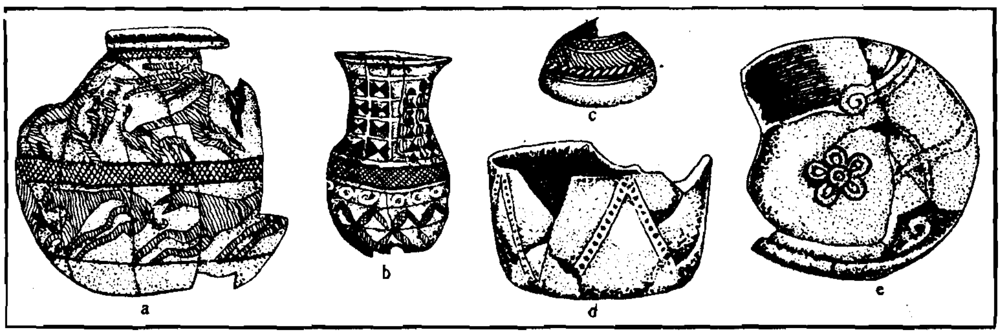

Fig. 3.2: Sketches of some pottery from the Indus Valley and Painted Grey Ware sites. Harappan pottery: a) from Daimabad dated about 2000 B.C., b) from Lothal; c) from Navadatoli, dated about 2000 B.C. Painted Grey Ware pottery; d) bowl (Panipat) and e) dish (Ahicchatra). Considerations of range, type, design, temperature of baking show that Harappan pottery is better than the Painted Grey Ware.

As for their knowledge in other areas of science, we find a reference to the division of the universe into three regions – the earth (*prithvi*), the firmament (*antariksh*) and the heaven (*dyaus*) in the Rig Veda. We now know that this is incorrect. The priests needed calendars for performing sacrificial ceremonies, which depended on the position of sun, moon and the planets. This meant tracking the motion of these heavenly bodies. The calendars they drew up gave the division of time into days, months and years and also indicated the seasons. However, these attempts did not go deep into the study of the motion of planets, of stars and constellations. We also find stray reference to different plants, their classification and structure in the hymns and verses of Rig Veda. Interest in medicine is also reflected in some of these hymns.

A Yajurvedic hymn portrays the quest of land and other resources. "May for me . . . low grade grain, food, freedom from hunger, rice, barley, sesame, kidney beans, vetches, wheat, lentils, millet... and wild rice (prosper through sacrifices): May for me stone, clay, hills...., gold, bronze, lead, tin, iron, copper, fire ..... . What grows on ploughed land and unploughed land, tame and wild cattle, prosper through the sacrifice."

Yajurvedic Period (700 B.C. – 400 B.C.)

The Rigvedic period was followed by a wave of eastward push in search of agricultural land and metallic resources. This era, called the Yajurvedic period, lasted for 300 years. Yajurveda speaks of ploughs drawn by teams of twelve oxen. Such ploughs were indispensable for driving deep furrows and turning over heavy soil which would not otherwise yield well or retain its fertility. The strong plough could be made of wood trimmed down by bronze tools, but the ploughshare for cultivating strong soil had to be of iron. Where did the iron come from? Copper may have been available in Rajasthan, but iron deposits lay much farther away in the east. India's finest deposits of iron and copper lie at the eastern end of the Gangetic plain in south-east Bihar. We also find evidence of the Aryans' movement for ores from the copper harpoons, shoulder celts and semi-human figures dated about 1000 B.C., which are found all over the Gangetic plain. The tools and artefacts lead us to surmise that these were peddled by Aryan traders. These objects imply that Aryans knew copper refining by controlled fire using good kilns (Fig. 3.3).

The mobility of the Aryans was also helped by their knowledge of sailing. We find a mention of ships with hundred oars even in the Rig Veda. Boats were used to go down the Ganges for trading and exploration, past Varanasi down to Pataliputra and the Gangetic delta.

The demand for high grade iron increased tremendously with time. As a result, Aryans explored new deposits of iron all over the country, going as far as Andhra and Mysore by about 200 to 100 B.C. Knowledge of the metallurgy of iron, copper, silver and tin continued to be developed by the Aryans till well into the Maurya period. We find that in Arthasastra, directions are given for reducing and melting of ores with distinction between various grades.

Arthasastra is the most important text that we now possess. It was written by Kautilya, minister of Chandragupta, sometime between 321 and 300 B.C.

3.2.2 Emergence of Urban Societies

The writings of this period also give us a picture of the social conditions. The social structure was undergoing radical changes at this time, from the tribal to a more structured urban society. By the time the Aryans started their eastward progress, a new sort of tribal slave, the *'dasa'* was being used for extra labour. A highly developed priesthood, specialising in sacrificial rites, combining Aryan and pre-Aryan practices, was also coming into being. Most importantly, however, commodity production was becoming established. This means that craftsmen and labourers were producing, not for direct consumption of the local society, but for trade within the far flung Aryan and non-Aryan settlements. Trade routes of Uttarapatha, and later Dakshinapatha, were established. You can see these routes in Fig. 3.4. Traders known as *Sarthavahas* (Caravaneers) and *Vaidehikas* started to ply along the routes, from Taxila to Magadha. From the coins found in the excavations, we can deduce that regular coinage had come into use by the end of the seventh century B.C.

Members of the conquered tribes, Aryan or non-Aryan, were treated as 'dasas' by the conquering tribes.

At about the end of this period, professionals appeared in the fields of science, medicine and technology. Students from all along Uttarapatha started to travel to centres of learning, such as Taxila, for specialised training. The learned grammarian Panini taught in Taxila around the fourth century B.C. Atreya taught medicine around the sixth century B.C. Atreya's students and successors Jivaka, Kumarabhacha, Bhela, Parasara and others, came to have profound influence on the development of medicine and chemistry in India in the next 1000 years.

A new orderly social life came into being around 800 to 600 B.C. This was free from shortages and unending conflicts of the Vedic society. Small states or 'Janapadas', headed by kings and governed by codes and laws formulated by state powers, were being formed.

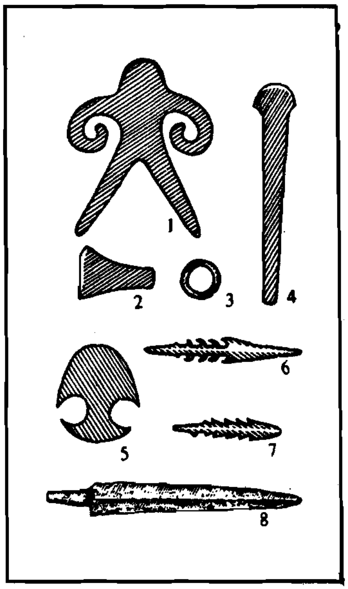

Fig. 3.3: Sketches of some copper objects found in the Gangetic plain: 1) semi-human figure; 2) axe; 3) ring; 4) bar-celt; 5) double axe; 6&7) harpoons; 8) sword.

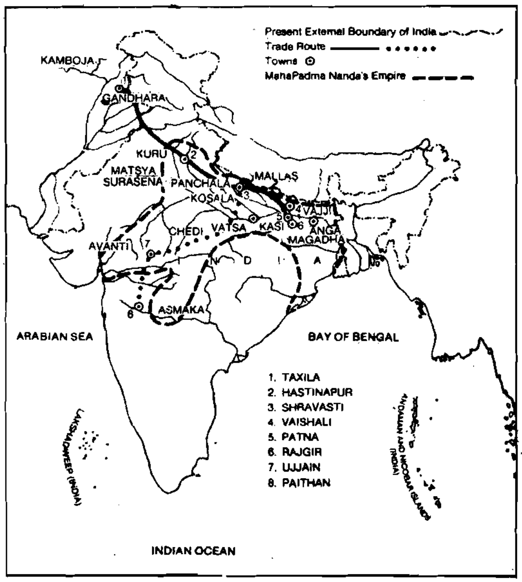

Fig. 3.4: Sixteen principal Janapadas (territories) of the seventh century B.C. Trade routes of Uttarapatha (———) and Dakshinapatha (........). Magadha empire under Mahapadma Nanda, 4th century B.C.

There were sixteen Janapadas in the seventh century B.C (see Fig. 3.4). The state income came from agriculture and trade. These societies had kings, priests, scholars, soldiers, traders, peasants, craftsmen and lowly civic labourers. For the efficient running of the state and ensuring that power remained firmly with the wealthy, the social hierarchy soon became rigid and got codified into four *'varnas'*, the *Brahmins*, the *Kshatriyas*, the *Vaisyas* and the *Sudras*. Divine sanctions were invoked to maintain this hierarchy.

SAQ 1

The following statements tell us about the various aspects of the Bronze Age and Iron Age societies in India. Put the letter B (for Bronze Age) or I (for Iron Age) against each statement to indicate the society it depicts.

i) This civilisation was spread far and wide in the Gangetic plain of India . . . .

ii) Most of the habitations of this period were located in the valley of river Indus . . . .

iii) Trade in this civilisation was essentially barter trade, i.e. goods of one kind were exchanged with other kinds of articles . . . .

iv) Commodity production had started, i.e. certain articles were produced not for local consumption, but for trade in far flung areas . . . .

v) A caste system had emerged in this society . . . .

vi) Trade was mainly done in the goods that were surplus, i.e. after the consumption needs of the society were met . . . .

vii) A large number of people were involved in innovations. . . . .

viii) Regular coinage had come into use in the trade practices. . . . .

ix) There were two main social groups: priest-kings; farmers and urban craftsmen, etc. . . . .

x) Small groups of people had started specialising in specific areas of science and technology . . . .

3.2.3 Emergence of Science

In the previous section, we gave you a glimpse of the social structure in India during the Iron Age. With the emergence of ordered urban societies, the stage was set for a tremendous development in science and technology. We will now describe, in brief, the advances in various areas of science, such as astronomy, mathematics, chemistry, botany and zoology.

Astronomy and Mathematics

We have described earlier the level of knowledge in astronomy in the Rigvedic times. Much of the later work in astronomy in this period is merely a detailed or expanded version of the astronomical knowledge already found in Rig Veda. We could, perhaps, understand this feature if we realise that the developments in astronomy in this period, stem mainly from the astrological practices of sacrificial ceremonies. As a matter of fact, astronomy degenerated into astrology in the later years of this period.

You already know about the Sulvasutras which we described in Sec. 2.3.3. They show a fairly high level of knowledge of geometry. Arithmetic was equally well developed. Numbers in multiples of 10 going up to as high powers of 10, as 10^{12} (one million million), were known and used. All the arithmetic operations on numbers were also known. Sulvasutras contain several instances of addition, subtraction, multiplication, division and squaring of fractions. Quadratic equations, indeterminate equations, permutations and combinations also appear in the Sulvasutras.

Chemistry

The level of chemical knowledge and practices in the new ordered society is reflected in the pottery, iron tools and glass objects found at various Iron Age sites. The iron tools that you see in Fig. 3.5, indicate a fairly advanced knowledge of iron smelting. By the fifth or the fourth century B.C., the Indian metalworkers had attained a high degree of perfection in the techniques of producing iron and steel.

Glass objects unearthed in over 30 sites indicate that production of glass came to be known only towards the end of this period (Fig. 3.6). Ceramic bowls, dishes, lids and carinated jars (*'handis'*) dated from about the sixth century B.C. to the second century B.C., were also found in these sites. Fermentation methods, dyeing techniques, the preparation and use of a number of chemicals and colour pigments were well known.

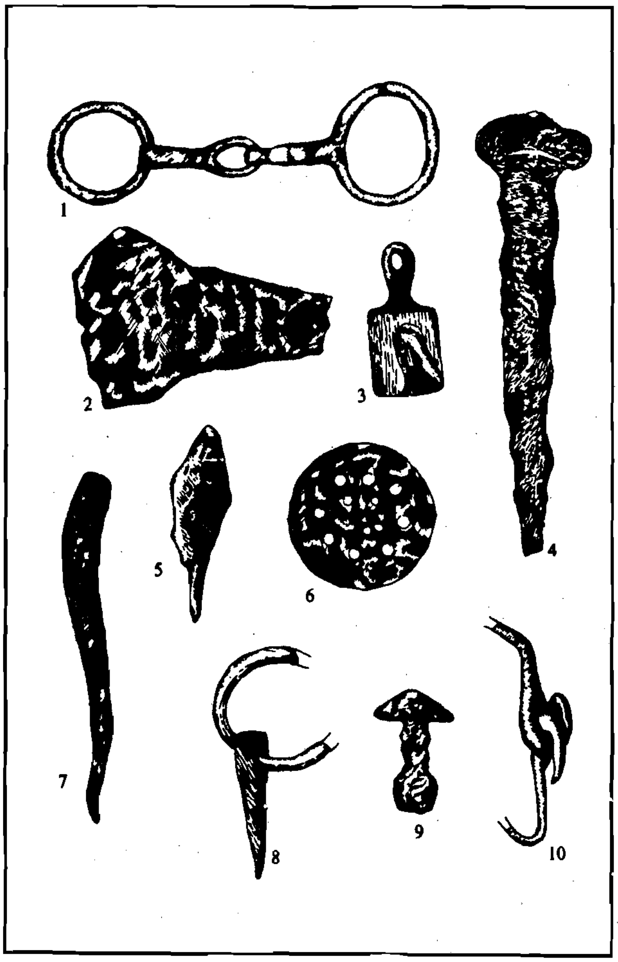

Fig. 3.5: Sketches of some ancient iron objects found at various sites such as Taxila, Hastinapur, Ujjain and Sisupalgarh: 1) ringed chain; 2) lower portion of an iron axe; 3) miniature bell; 4) staple from a looped head; 5) spearhead; 6) slightly convex iron disc with perforation; 7) spike of square section; 8) door ring; 9) circular piece of iron with a nail rivetted into it; 10) fragment of a chain.

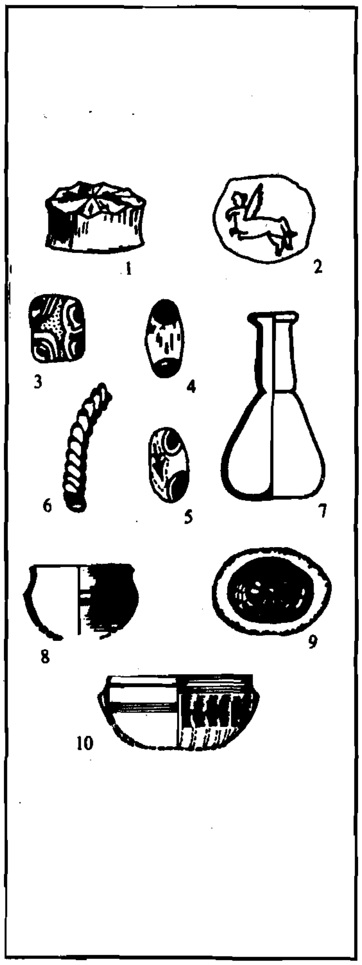

Fig. 3.6: Sketches of some ancient glass specimens from a) Taxila (6th century B.C.—1st century A.D.): 1) ear-reel; 2) seal; 3-5 beads; 6) bangle piece; 7) wine flask (the thicker line was the piece that was found); b) Arikamedu (1st century—2nd century A.D.): 8), 10) Roman glass bowls; 9) millefiori glass.

Botany

In the Bronze and the Iron Ages, agriculture became the principal mode of production of man in all lands. It is, thus, not surprising that in India, botany and elementary plant physiology developed with the advances made in agriculture. The developments in medicine also helped these sciences. For example, in Rigvedic hymns, Atharvaveda, Taittiriya Samhita etc., scattered references are made to the following:

i) different parts of the plant such as *mula* (root), *tula* (shoot), *kanda* (stem), *valsa* (twigs) etc.

ii) classification of plants such as *osadhi* (medicinal), *valli* (climber), *guccha* (bushy) etc., according to their morphology and use, and

iii) physiology of plants in terms of what nourishes a plant through addition to the soil, such as cowdung etc.

A systematic study of botany, 'Vrksayurveda' by Parasara, however, came into being by only about the first century B.C. The treatise formalised a lot of the earlier botanical and medicinal knowledge. We will not go into its details.

Zoology

The domestication of animals like horses and elephants and their use in warfare necessitated the study of their anatomy and physiology. A survey of Vedic literature has revealed that more than 260 animals were known at that time. Classification of animals and study of their dietary value had been attempted. Human physiology had also been studied. Post-Vedic literature also contains the names of animals and a vast storehouse of observations on their natural history. These observations may have stimulated the later thoughts and concepts about classification, heredity, embryology etc.

However, none of the developments in astronomy, mathematics, chemistry, botany and zoology that we have described so far, compare with the tremendous advances made in medicine in that period. We will tell you about these advances in the next section.

SAQ 2

State whether the following statements about the level of scientific and technical developments in the Iron Age India are true or false :

a) The development of astronomy, which arose from astrological practices and sacrificial ceremonies, resulted in a study of the motion of sun, moon, planets and stars and many new models, laws and theories were given ....

b) The need to make sacrificial altars gave rise to a fairly high level of knowledge in geometry ....

c) Indians knew how to make steel in the Iron Age ....

d) Plant and animal classification, anatomy and physiology were known in an elementary form ....

e) The developments in modern science were all known in the Vedic times and we are just rediscovering that knowledge ....

3.2.4 Developments in Medicine

During the early Vedic period, healing was thought to be the duty of the priests. Diseases were seen as the results of God's wrath for sins committed, or of being possessed by demons. Interwoven with these ideas, we find speculations about the origin of disease, use of healing drugs, beneficial treatment and surgery in the Vedic texts. The Ayurvedic concept of 'medical knowledge as a science' developed only later.

The Ayurvedic System of Medicine

Punarvasu Atreya (about 6th century B.C.) taught medicine at Taxila. Each of his disciples such as Bhela, Jatukarna, Harita, Ksarapani, Parasara wrote treatises on medicine. Atreya himself, Patanjali (about 2nd century B.C.) and later many others wrote commentaries on what is considered to be the main Indian treatise on medicine, the *Caraka-Samhita*. Very little of the original samhita survives today. Most of what we know of this treatise, comes from some of these commentaries. The origin of *Caraka-Samhita*, and the surgical text *Susruta-Samhita*, is generally estimated to be around 600 B.C. There is difference of opinion as to who wrote these samhitas. While some ascribe them to individuals, others describe the authors to be practising doctors and surgeons belonging to a group of tribes. The main body of the work is a meticulous classification and documentation of symptoms of various ailments, corresponding healing systems, their properties, methods of application and their dosages. The treatises are so important, because

'Caraka' is to be pronounced as Charaka i.e. चरक and Susruta as Sushruta i.e. सुश्रुत

i) they are scrupulously scientific in their approach and method,

ii) they have influence on the development of other branches of science such as chemistry and botany, and

iii) they are transmitted through the ages in a form of practice known as Ayurveda.

Approach and Method

Their approach and method had the following significant features:

In the words of the original "Medical discussion is to allow no proposition which is irrelevant, unauthoritative, uninvestigated, without any practical significance, confused and without any general applicability. Every proposition must be substantiated by reason. Only those propositions that are substantiated by reason and are untainted by any other consideration prove useful for therapeutic purposes."

i) The physician was interested only in one thing and that was the cure of the patient. Towards this, he was allowed to take any steps including subterfuge and lies. For example, if it was essential for the patient to eat some flesh, the physician had to work out some tactics to overcome the patient's religious or aesthetic revulsion.

ii) The physician was to direct his attention towards curing the patient. Hence, he was not supposed to cause any injury to the patient even though his own life may be at stake. The physician was to treat the patient as his own son.

iii) Medical knowledge was to be acquired from previous practitioners as well as through medical discussions.

iv) Empirical data constituted the first and absolute minimum for science. It was said that of all types of evidences, the most dependable ones were those that were directly observed by the eyes. A knowledgeable physician was never to try to examine, on grounds of pure logic, the efficacy of a medicine which was known by direct observation to have a specific medical action.

Diagnosis and Prognosis

The diagnosis and prognosis of disease were done directly by seeing, hearing, smelling and touching all external human organs and human waste and often indirectly by pulse examination. These observations, singly or in combination, were correlated in specific diseases. Thus, in an abscess, the physician heard the bustling sound of air with frothy blood. Similarly, the sounds in entrails, the crack of a joint, changes in voice etc., gave other indications. His diagnosis was based not only on direct observation but on knowledge of the patient's home, caste, mode of living, diet and other aspects of medical history. Prognosis was based on the dictum that a clever physician should not treat an incurable patient. Accordingly, detailed examination of *'arista'* or bad omens (classified according to the nature of disease) which led to death, was made.

Curing methods

The most important curing methods were classified under five heads, namely, inducing vomiting, giving purgative, enema, oily enema and nasal therapy. Specific applications of these were made according to the disease. Possible accidents during their application were also listed. There was also extensive classification of diseases.

In the *Caraka-Samhita*, purgatives are prescribed in fever, poisoning, cholera hemorrhoids, leprosy, wind, diabetes, jaundice, colic, cataract or glaucoma, abscess, fistula of the anus etc.

Healing substances were classified into preventive and curative medicines. According to *Caraka-Samhita*, these were animal, vegetable and mineral substances. This classification was crossed by another consideration, that of grouping according to the effect of medicine, as emetic, purgative etc. These groupings were further subdivided into fifty groups of decoctions according to the relief they provided.

Among the animal substances, the *Caraka-Samhita* mentions honey, milk, excreta, urine, sperm, horns, flesh etc. Minerals include gold, silver, copper, zinc, antimony etc. *Carakas* mention 700 plants according to the diseases for which these were to be applied.

Surgery

Susruta-Samhita, a major treatise on surgery, was derived not only from exhaustive observation of symptoms of diseases and their possible treatments but also a fairly detailed knowledge of human physiology, anatomy, and especially the internal organs. For example, in treating ulcers or wounds, it is directed that the instruments should be introduced with the precaution of avoiding dangerous places, such as veins, bones and the like, until the pus is visible. In the Samhita there is also detailed description of different types of iron instruments, made by local smiths for extraction, cutting etc., in terms of sharpness, shape and size (see Figs. 3.7 and 3.8). Two interesting features of this treatise are:

i) Scrupulous attention to pre and post-surgical cleaning of the wound, implying some empirical knowledge of infection, and

ii) use of anaesthetics. While instructions are given to bind the patient strongly so that he could not move during the operation, it is also mentioned that he should be given wine to drink before the operation so that he might not faint and might not feel the knife.

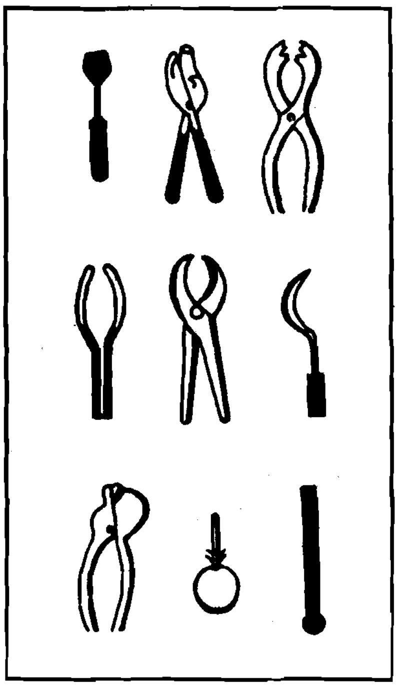

Fig. 3.7: Artist's reconstruction of Susruta's surgical tools as described in Susruta-Samhita.

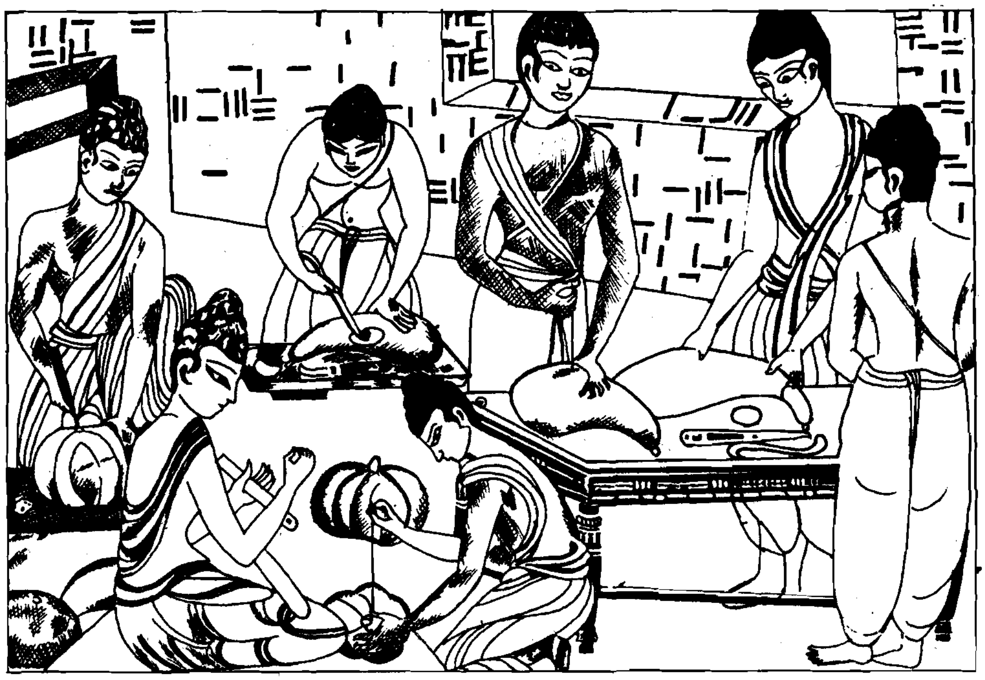

Fig. 3.8: An artist's sketch of Susruta's students practising surgery on vegetables, like gourd (*puspaphala*), bottle-gourd (*alavu*) or cucumber (*ervaruka*). The students were given thorough practical training on vegetables, water bags, dead animals and full-sized stuffed dolls before performing surgery on human beings.

These dictums are from Aitareya Upanisad and Brhadaranyaka Upanisad.

Note also that pancabhuta is pronounced as panchabhuta, i.e. पंचभूत

Thus, we find that in Iron Age India, a scientific approach and method was adopted in the practice of medicine. It is not surprising that the scientific practices of *Carakas* and *Susrutas* earned the wrath and displeasure of the priests. This was, possibly, because their practices often contradicted the prevailing ideas of priests who earned their living by reciting dictums such as "the gods are fond of the obscure" or "the gods are fond of the obscure, they detest direct observation." In the practice of medicine, the Indian physicians did not distinguish between the upper and the lower castes in terms of their medical attention. This was another reason why they were not too popular with the priests.

This is not to say that the practice of medicine was entirely free from the influence of the ideas prevalent in society. Cosmogonic speculations, that is, philosophical ideas about the origin of universe, earth and living beings, find a reflection in Ayurveda. For instance, the practice of ascribing the causes of illness to humours or *'dosas'*, such as wind (*'vayu'*), bile (*'pitta'*) and phlegm (*'kapha'*), reflects this influence. So does the practice of relating the qualities of curative substances to the five elements (*'pancabhutas'*)—earth (*'prithvi'*), fire (*'jyoti'*, *'agni'*), water (*'apas'*, *'jala'*), air (*'vayu'*) and empty space (*'akasa'*). According to Ayurveda, the *'tridosas'*, *'vayu'*, *'pitta'* and *'kapha'*, are supposed to be present in all living creatures. Diseases are said to be caused by their imbalances, paucity or excess in the body. However, the prevalent philosophical and religious dogmas did not influence the physicians while prescribing what they thought was good for the patient.

SAQ 3

Which one among the following features is an exception to the scientific approach and method adopted in the practice of medicine by the *Carakas* and *Susrutas*? Tick the appropriate answer.

a) Medical knowledge was based on the observation of previous practitioners and was obtained through discussions.

b) New therapies were investigated thoroughly and substantiated by reason before being accepted.

c) Observation and experiment played a great role in determining the medicines or curing methods that were to be used for various diseases.

d) It was thought that diseases were caused by the three humours, wind, bile and phlegm; and the curative substances got their healing properties from the five elements—earth, water, fire, air, empty space.

e) Classification of medicines and diseases was carried out.

It is, indeed, a great tragedy that the medical science which had such a sound beginning in meticulous empirical observation never got beyond the stage of classification of such observations. It never came to acquire a rigorous scientific theoretical basis. No general laws or theories could be deduced on the basis of this wealth of information. After the third or the fourth century A.D., it relied less and less on fresh innovatory observation and more and more on mystical 'causes'. The reasons for this stagnation are many. One of these is, possibly, the opposition from orthodox religious ideas.

We also find that the nature of the developments in various areas of science, in this era, was very different from what had happened in the previous era. In the Bronze Age, human beings innovated and evolved techniques of tool making, metallurgy, ship-building or medicine as they confronted problems in their struggle for survival or in making a better living. It was a universal phenomenon, in the sense that a large number of people involved in production were also innovators.

However, in the Iron Age, scientific pursuits, such as making innovations, deducing general laws from observations, curing people or transmitting knowledge to future generations, were limited to a small group of individuals patronised by the state. This had positive as well as negative aspects. On the positive side, this made it possible to observe and experiment, or to systematically learn about a complex phenomenon in great depth, or to simply contemplate, without being burdened by the daily struggle for existence. On the other hand, this led to the isolation of people with knowledge from those who practised and used techniques. This made interaction of theory and practice difficult, thus, creating the danger of abstract knowledge or blind practice. This was true for both Indian science and the Greek science.

We will now describe the developments in science in the Iron Age Greece.

3.3 SCIENCE IN IRON AGE GREECE

One of the most remarkable features of world history of the Iron Age is the similarity of developments of culture in India and in Greece (Fig. 3.9). We know that there was trade between the two areas. The spread of knowledge may have taken place through West Asia and finally through direct contact established at the time of Alexander's incursion into north west India in 327 B.C. It is, therefore, easy to see that Indian and Greek cosmogonic speculation, medicine and surgery came to influence each other through these contacts.

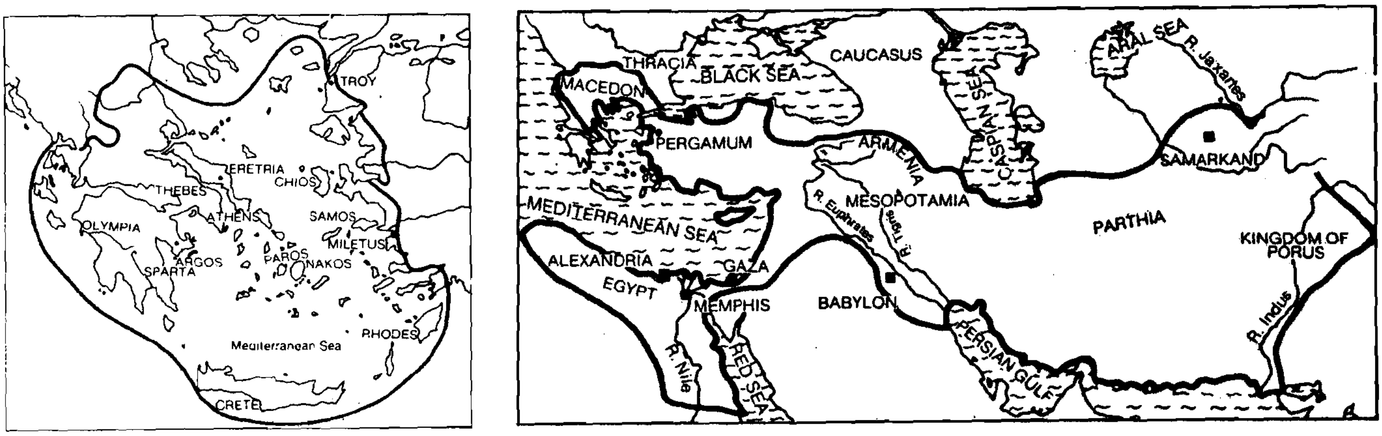

Fig. 3.9: a) Greek city states. b) Alexander's empire.

One of the similarities between the Indian and the Greek civilisations was growth of the same kind of stratified social structure, at about the same period. While in India, the caste structure was relegating all practical and manual work to the lower castes, manual work was being associated with slaves in Greece. The craftsmen and manual-workers were considered to be definitely inferior beings to brain-workers or contemplative thinkers. Although much craft work was done by free men, they were degraded by competition with slaves, so that their work was also called base and servile. This, as we have observed earlier, led to the separation of contemplative science from technique, both in Greece and in India. It reduced the influence of thinkers on practical work, and of practice on thinking.

The patronisation by the rulers, of a group of people, whose profession was to contemplate and to teach, led to the peculiar development of science during that period. Initially, it led to the flowering of Greek sciences such as geometry, mechanics, medicine and cosmogonic system. But, finally, it made Greek science far too speculative and abstract. The abstractions were totally removed from life. However, as they were formulated by leading authorities and philosophers of those times, these abstract ideas, generally, came to be accepted as "laws of nature". Not much attention was paid to people who challenged such ideas, on the basis of observation. As such, these abstractions became a major stumbling block to the growth of science, for the next 2000 years.

In India, abstractions certainly grew in physics and cosmogonic systems, but medicine, chemistry, botany and agricultural science retained strong links with practice. Medicine, in addition, required the use of proscribed flesh and other substances for healing. The general approach of the medical practitioners to healing and saving of life disregarded *Karma* and other orthodox tenets. This led to their condemnation by the spiritual and legal authorities, resulting in the stagnation of medical science in India, by about the third to the fourth century A.D.

It is interesting to note a basic difference between Indian and Greek science in terms of the influence of existing ideological and religious systems on science. Indian scientific treatises of this age always started with obeisance to divinity. But, the actual text, except for those on cosmogony and, to some extent, those on medicine (containing ideas of five elements and three *dosas*), were free from philosophical interlacing and inspirations. Greek science of this period was, however, deeply influenced by the prevailing social philosophy and ideologies, with some exceptions, such as the works of Democritus and Hippocrates.

In Greek science, this was the age of questioning. The philosopher-scientists continuously looked for reasons and causes of things. But, in the absence of experimental tools, and more importantly, being influenced by the social philosophy of slave society, they sought answers in parallels with the existing order of society.

The early Greek philosophers of the sixth century B.C., such as Thales, Empedocles and Pythagoras were exceptions, in the sense that they speculated on what the world was and how it came to be without the intervention of gods. The theory of four elements—earth, water, air and fire is attributed to these Ionian philosophers. We will talk more about their work in the sections that follow..

Aristotle (4th century B.C.), who was one of the leading Greek philosophers came to occupy a central place in the history of science. He broke away from the Ionian school by refusing to consider how the world had been made. In his view, the world always had been as it was then, and would always be the same, because that was the reasonable way for it to be. Aristotle built his physical world in the image of an ideal social world, in which subordination was the natural state. In this world, everything, whether fish in the lower strata of evolutionary tree or slaves in a Greek city state, knew their place, and for the most part, kept to it. In this order, inanimate objects moved only when they were out of place and wanted to return to their original place in the pre-ordained order. For example, a stone when thrown up in air always returned to its native earth. Or sparks flew upwards, to join the heavenly fires. Animate objects moved because it was in their nature to do so. Thus, it was in the nature of a bird to fly in the air, of a fish to swim in water. In this way, he tried to explain all motion in nature by ascribing it to a predetermined reason or a final cause.

Aristotle never told anyone anything they did not already believe. He explained that the world as they knew it, was just the world as they knew it. As long as the world remained the same, Aristotle's ideas would hold. However, as we shall see, the world did not remain the same and Aristotle's ideas were challenged, although it took a long period of about 2000 years for this to happen.

Fig.. 3.10: Aristotle's best personal scientific work lay in biology. He made some careful studies of marine creatures and of bees and their diseases.

3.3.1 Developments in Some Areas of Science

We shall now describe, in brief, some of the major developments in some areas of Greek science.

Geometry and Astronomy

The need to portray an ideal world of perfect forms and proportions led to the development of geometry by Pythagoras (582-500 B.C.) and Hippocrates of Chios (about 450 B.C.) (Fig. 3.11). The latter occupied himself with the solution of problems which were unanswered for a long time, such as squaring the circle and doubling the cube. He failed in both, but opened the way to study the geometry of curves. Eudoxus (408-355 B.C.) was probably the greatest Greek mathematician and he was able to explain the motion of sun, moon and planets by means of sets of concentric spheres, each rotating about an axis fixed in the one outside it (Fig. 3.12). The model was crude, and too simple to explain observed facts, even as known at that time. But the sets of actual metal spheres based on this mode provided the basis for most of the astronomical instruments for a long time.

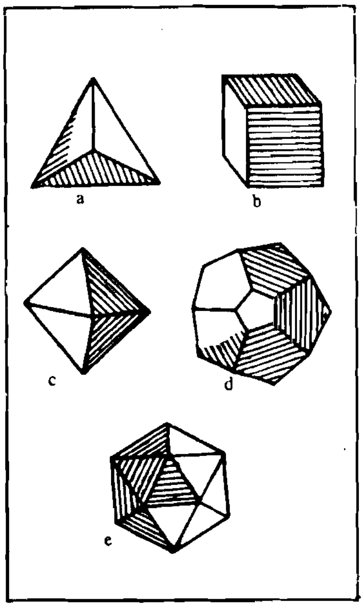

Fig. 3.11: Five regular geometrical solids much studied by the Greeks: a) tetrahedron; b) cube; c) octahedron; d) icosahedron and e) dodecahedron. In all these solids, the faces are equal in area and in shape. Pythagoras, the Greek mathematician and philosopher, is credited with their discovery.

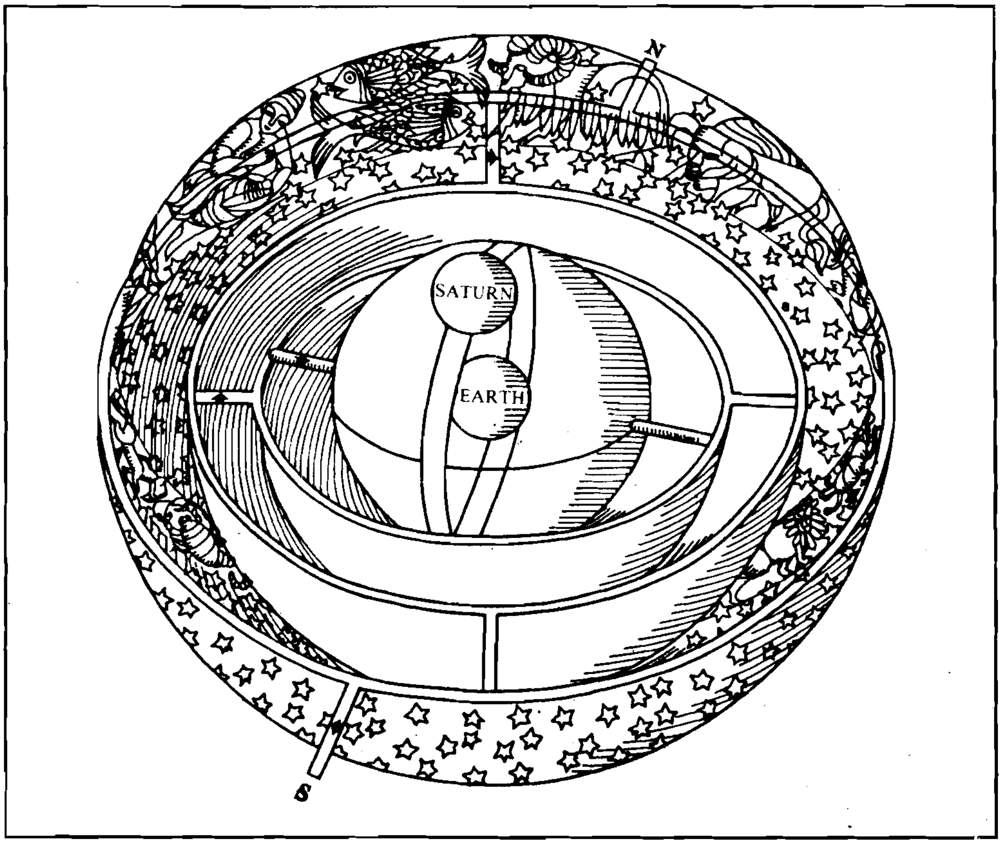

Fig. 3.12: Part of Eudoxus' model of spheres within spheres, to explain the motion of the planets. Believing that planets orbited the earth in perfect circles, Eudoxus drew 27 concentric spheres around the earth. Each sphere, with its planet attached, rotated on a different axis. Arrows in the figure show the rotation of spheres.

The Museum of Alexandria was the first state-supported research institute in the West which led to developments in astronomy, optics, mechanics and mathematics. These were not much improved upon in the next 2000 years.

Around 300-200 B.C., the tradition of geometry which grew up in the scholarly atmosphere of academies, schools and lyceums of Athens shifted to the Museum of Alexandria. The geometry of Eudoxus was elaborated by Apollonius of Perga (about 220 B.C.), who worked out the details of conic sections-ellipse, parabola and hyperbola (Fig. 3.13). A large part of the previous mathematical knowledge was built together into a single body of knowledge based on deduction from axioms, by Euclid (about 300 B.C.). This is the geometry which is still studied in schools today.

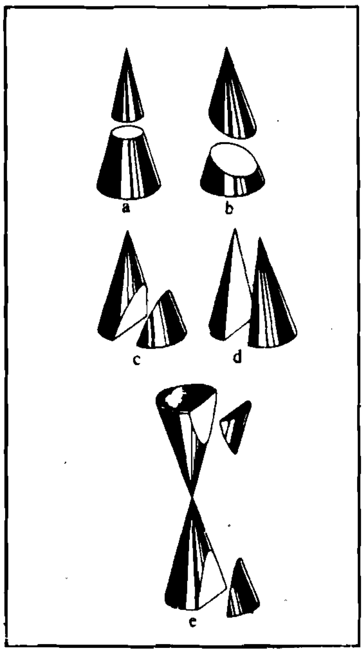

Fig. 3.13: Conic cuts of Apollonius: a) a cut parallel to the cone's base made a circle; b) an oblique cut an ellipse; c) a slice parallel to a straight line on the cone made a parabola; d) a cut down through the top point produced two intersecting lines; e) cutting through the cone and its mirror image on top resulted in a hyperbola or double curve.

The study of astronomy lay between the theoretical and the practical. According to Plato, a noted Greek philosopher and Aristotle's teacher, it was the study of an ideal world in the sky, and the deviations that were observed could be ignored. On the other hand, it was also important to know the accurate position of stars and planets. As a result, Greek astronomers tried to invent complicated models to fit the observations without violating the image of an ideal, simple and beautiful world. The mathematical basis of astronomy were the spheres of Eudoxus as shown in Fig. 3.12. But for actually working out the planetary motion Hipparchus (190-120 B.C.) adopted a flat model, that of 'wheels within the wheels'. He also invented most of the astronomical instruments used for the next 2000 years.

About two hundred years later, Ptolemy (90-168 A.D.) adopted this model in which the earth was at the centre and the rest of the planets, the sun and the stars revolved around it (Fig. 3.14). This was to be standard astronomy in Europe till the fifteenth century.

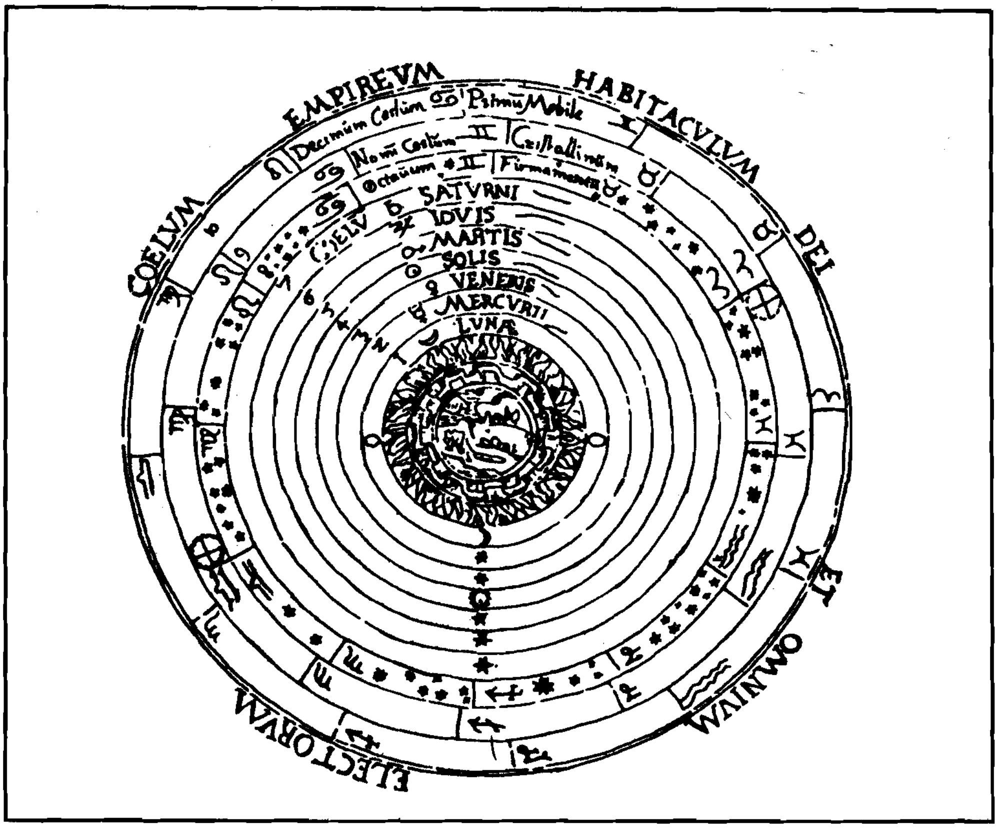

Fig. 3.14: Ptolemy's model of the earth-centred universe. The earth is shown in the centre, with the four elements, earth, air, fire and water. Above these elements are the heavenly bodies, the Moon, Mercury, Venus, the Sun, Mars, Jupiter and Saturn. Then comes the sphere of fixed stars; beyond that the ninth and the tenth spheres driven by divinity from which all other spheres derive their motion. Beyond this lay heaven, where 'God and the Elect' lived.

An alternative version, that of the sun at the centre and the earth and other planets moving around it, was also presented by Aristarchus of Samos (310-230 B.C.) and others. But it was not accepted because it was thought to be philosophically absurd, and violated everyday experience. It was, however, transmitted by Arabs, revived by Copernicus (1473-1543) and finally justified by Galileo (1564-1642), Kepler (1571-1630) and Newton (1642-1727). You will read more about this in Units 6, 9 and 10.

Mechanics

Another branch of science which is, perhaps, the greatest contribution of Greek civilisation is mechanics. Mechanics developed out of the necessities of irrigation, moving of heavy bodies, ship-building and making military equipment with known tools and methods. As the invading armies of Alexander came in contact with the craftsmen of the middle-eastern countries, a number of inventions such as the pulley, windlass and screw came into use and were improved upon (Fig. 3.15). Archimedes (287-212 B.C.) aided this process of building machines by his ideas of forces having to balance each other to keep a body static (at rest). And his contribution to the study of floating bodies and hydrostatics is useful even today.

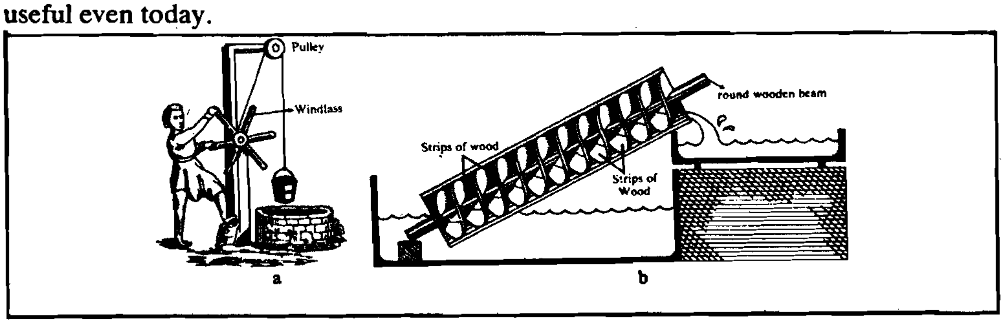

Fig. 3.15: Some mechanical devices used in Greece: a) windlass and pulley for drawing water from a well; b) cross-section of a water-raising screw designed by Archimedes, widely used for irrigation. Strips of wood were wrapped in a spiral on the edge of a round wooden beam. This was then encased in boards. When placed in water and spun, it caused the water to climb the spiral and gush out.

Medicine

The other area, in which the Greek developments had a parallel in India, was medicine, although encouragement for this development in the two cases came from diametrically different sources. The *Carakas* and *Susrutas* in India were roaming physicians who went about healing ordinary rural folk and fostered democratic thinking and world views. Greek medicine, on the other hand, could continue its older traditions because of the support it received from the aristocracy. In the era when Greek society was declining from the highest point of its achievement, wealthy citizens could not do without doctors as they led an increasingly unhealthy life of pleasure and abundance. We find that the Museum of Alexandria encouraged much research in anatomy and physiology.

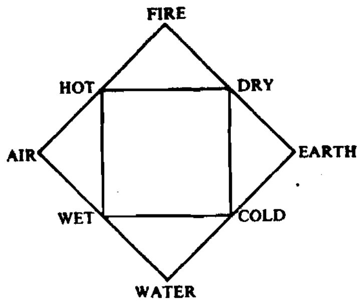

Fig. 3.16: The four 'elements' of the Greek thinker, Empedocles. According to Empedocles, the 'primary matter' could change into different substances, depending upon which primary qualities were affecting it. For example, the primary matter could become earth with the pair of primary qualities, cold and dry; water, with cold and wet; fire, with hot and dry; and air, with hot and wet.

Hippocrates of Cos is a legendary figure in Greek medicine. His works, probably written sometime between 450 to 350 B.C., contain a clinical account of many diseases based on careful observations. Magical or religious causes or cures for diseases are not mentioned. However, the practice of medicine of the original Hippocratic school was superseded by the doctrine of four humours, firstly put forward by Empedocles, an Ionian philosopher (see Fig. 3.16). His ideas proved very damaging to the practice and theory of medicine.

A great doctor of those times, Herophilus (about 300 B.C.) based his work on observation and experiment. He was the first to understand the working of the nerves, distinguish between sensory and motor nerves, and make clinical use of the pulse. Erasistratics (about 280 B.C.) went further and noted the significance of the peculiar structure of the human brain. Unfortunately, most of the fine work of this period has been lost in its original form. But the essence of these findings was picked up and further developed by Galen (130-200 A.D.) who was born in Asia Minor but practised in Rome. Galen became a great founder of Arabic and medieval medicine with authority as great as that of Aristotle. He dissected animals and gained much anatomical knowledge. Galenical physiology described the ebbing and flowing of spirits, and blood in arteries and nerves, with the heart as the origin of heat, and the lungs as cooling fans. It provided a comprehensive, though rather unreal, view of human body. In terms of providing explanation of the phenomena, even Galen could not break out of the old doctrine of three spirits and souls, a doctrine which blocked any substantial advance in man's knowledge of his own body for another 1500 years.

SAQ 4

The developments in Greek science show that at all times, these were influenced by two streams of thought, one trying to understand the actual observations, the other trying to work out theories and models fitting their views of an ideal world. In the table given below, we have listed some developments of Greek science in column 2. Identify, to which of the two kinds of development listed in column 1, do they belong.

1	2
	i) Study of floating bodies, invention of pulley, water lifting screw, etc.
	ii) Model of the universe with the earth at its centre.
a) Developments based upon the Aristotelian views of an ideal, symmetric and beautiful world.	iii) Study of regular symmetric solids and geometrical curves.
	iv) Clinical accounts of diseases, study of working of nerves, dissection of animals, etc.
	v) The theory of four humours of the body corresponding to the four elements in nature.
b) Developments based upon actual observations of the changing world.	vi) The inability to see any other shapes in nature except for the perfect circle or sphere. This led to the model of concentric spheres to explain planetary motion.
	vii) Studies of marine creatures and bees, and their diseases.
	viii) Ideas like 'the world was always as it is now and will always remain so'.

So far, we have described the developments in Greek science in areas like geometry, astronomy, mechanics and medicine. Another aspect which fascinated the philosophers was the nature of matter. Philosophical speculations about the nature of matter in the universe gave rise to parallel theories, in India and in Greece. We will now describe some of these theories. These ideas may appear somewhat strange to you. We also know that these are not valid any more. However, they do reveal our ancestors' curiosity about the world around them and their attempts to understand it.

3.4 ATOMIC THEORY IN ANTIQUITY

The oldest of Indian philosophical systems was *Samkhya*. The system envisaged that everything except consciousness evolved out of primaeval matter. According to this philosophy, consciousness, inert mass and energy were three forms of interdependent and inter-related existence. In the process of evolution, matter could be neither created nor destroyed and the sum total of all the three, mass, energy and consciousness, remained the same. The redistribution of mass and energy gave rise to all the diversity of the material world, the plants and the animals. Matter was recognisable through its five qualities—smell, taste, touch, colour and sound, corresponding to the five senses. There were five forms of matter—earth, water, fire, air and empty space.

A parallel to this theory, but possibly of a much later origin (about 600 B.C.), was the materialistic cosmogony of Thales and others in Greece. Thales formulated the idea that everything originally came from water, and then earth, air and living things separated out. To earth and air, mist and fire were added to be called elements from which other substances were made, like words are made from letters. These elements, as in the case of *Samkhya,* had to fulfil two incompatible functions. On the one hand, they stood for actual observed phenomenon, such as wind, flood, storm etc., while on the other hand they stood for qualities such as hot, cold, wet, dry, light, heavy etc.

The distinct contribution of *Samkhya* as well as the Greek school of thought was that they had set up a picture of how the universe had come into being and how things happened, without the intervention of gods and a predetermined design. The weakness of these ideas lay in their vagueness and their purely descriptive character. By themselves, these ideas could lead nowhere, nothing concrete could be done with them and there was no practical application. However, with all their shortcomings, these thoughts represent man's first stirrings to search for his origins and that of the universe.

A very different way to understand the nature of matter was to stipulate the existence of atoms. Atoms were thought of as the fundamental building blocks of observed substances. A particular combination of atoms imparted properties and qualities to substances.

The Indian *Vaisesika* system, the well known proponent of which was Kanada (about 600 B.C.), considered the smallest particles as dimensionless mathematical points. These points possessed potential quality of the four elements, earth, water, fire and air, on the basis of which, they were divided into four categories. At least six atoms of the same category joined together, with the space in between filled by empty space, to form a complex atom which is analogous to a chemical element.

The problem of different, heterogeneous atoms joining together was overcome by the Jainas. Jainas said that when two heterogeneous atoms joined together, the combination gave rise to a new body. The mechanism of joining was by mutual attraction, one positive, the other negative. All changes in qualities of compounds were explained by the nature of their mutual attraction.

While the above shows a high level of intellectual activity, the limitations lay in the abstraction. The philosophers had no hesitation at all in putting together obviously contradictory ideas in their abstractions. For example, in their cosmogonic system they included things they observed in the material world alongwith things they did not observe, or things they learned from religious texts, or things which had no material basis. Thus, the Jainas brought in *karma* and soul within their otherwise materialistic system; and the *Vaisesikas* formulated that atoms were set in motion by *adrista,* i.e. performance in the previous life.

The Greek atomists were, curiously enough, free from these distortions such as ideas of soul, *adrista* or *karma* propounded by Indian atomists. Democritus (about 420 B.C.) imagined the universe to be made out of small innumerable indivisible particles moving in the void of empty space. The atoms were unalterable. They were supposed to be of various geometrical forms to explain their capacity for combining to form all the different things in the world. Their movement accounted for all visible change.

This atomic theory avoided appeal to pre-ordained harmonies, i.e., it did not say that the universe was static, where things worked according to a predetermined design. Instead, it presented a dynamic universe where things were not static, but were changing. In this sense, it remained a heresy, as it challenged the established ideas of Plato and Aristotle.

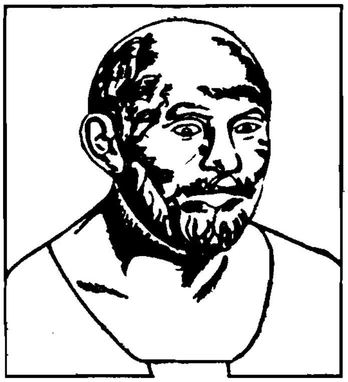

Fig. 3.17: Democritus

We cannot consider the Greek or Indian atomism as a part of scientific ideas, in spite of its brilliance. No conclusions could be drawn from it which could be practically verified. However, we cannot deny that Greek atomism, with its inherent materialism and reasonableness did influence the atomism of Gassendi (1592-1655), Newton (1642-1727) and through them that of Dalton (1766-1844), 2000 years later.

SAQ 5

In the table given below, on one side, we list some features of Greek science and society, and on the other side, the corresponding features of Indian science and society in the Iron Age. We have left out some blank space on both sides which you have to fill. We have worked out the first part as an example.

	Greek Science	Indian Science
a)	The Greek society was stratified into nobles, peasants, craftsmen, merchants and slaves.	*The Varna system came into being into India. There were four Varnas, the Brahmins, Kshatriyas, Vaisyas and Sudras.*
b)	....	Most of the developments in science were free from the influence of the prevailing philosophy and ideas in India, even though almost all the works started with a reference to divinity. They retained their links with practice and observation, depending less on mere speculation.
c)	The Greek medicine flourished mainly because of the support it received from the aristocracy.	....
d)	The Greek cosmogonic system was made of four elements, air, fire, mist and earth.	....
e)	....	The Indian atomists brought in the notions of soul, *karma* or *adrista* in their theories of matter and the notion of atom.

3.5 DECLINE OF EUROPEAN SCIENCE

By the middle of the second century B.C., the Greek empires were collapsing in anarchy and under the weight of the more vigorous power of Rome. Italy, in the third century B.C., was a farming country with a good climate and a growing healthy population. By the first century B.C., the Romans had organised themselves into a powerful military dictatorship, with popular support. The army went on to conquer the countries of eastern and western Mediterranean as well as Britain, western Germany and Austria (Fig. 3.18). While the army became all powerful, the land was ruled by slave owners and wealthy merchants. The cementing force of the empire was the army, as it was used by the emperor to collect enough taxes to keep the soldiers from mutinying and choosing another emperor. The best land was cultivated by the slave gangs from the villas of the wealthy, while the poorer areas were left to the pagan natives or to newly settled free slaves from the villas.

Thus, the mainstay of the economy was loot from the empire by military coercion, and agriculture by slaves. In such a situation, it is, perhaps, not surprising that there was very little demand to increase production and to improve the economy through the applications of new techniques. There was, therefore, a very limited contribution to culture in the form of science and arts during the period of the Roman Empire which continued until the second century A.D.

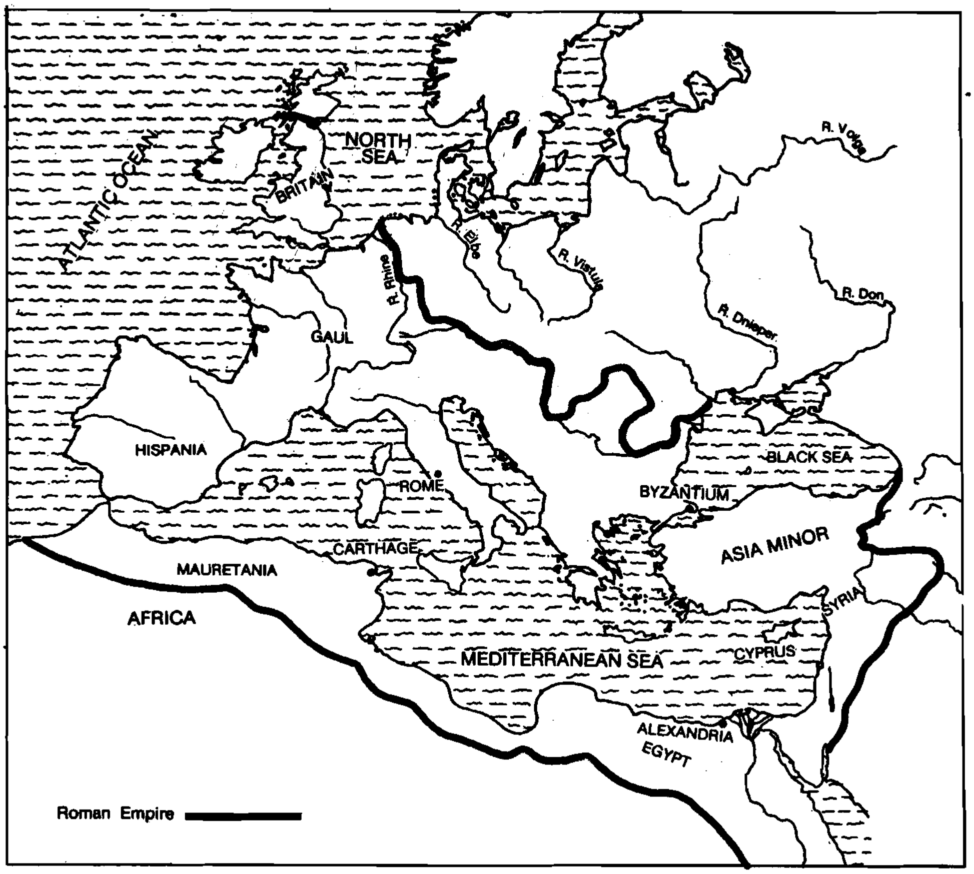

Fig. 3.18: Roman Empire in second century A.D.

While there was no improvement in techniques and no growth of science in the Roman era, the existing knowledge was applied to construct buildings for civil and military administration. Burnt bricks and concrete made from volcanic ash and lime were used to construct roads, harbours, aqueducts, baths and theatres (Fig. 3.19).

Accumulation of power and wealth in the hands of a few rich men, and general brutalisation and consequent impoverishment of a population of slaves, lowered the demand for commodities. This depressed the conditions of merchants and craftsmen still further. With

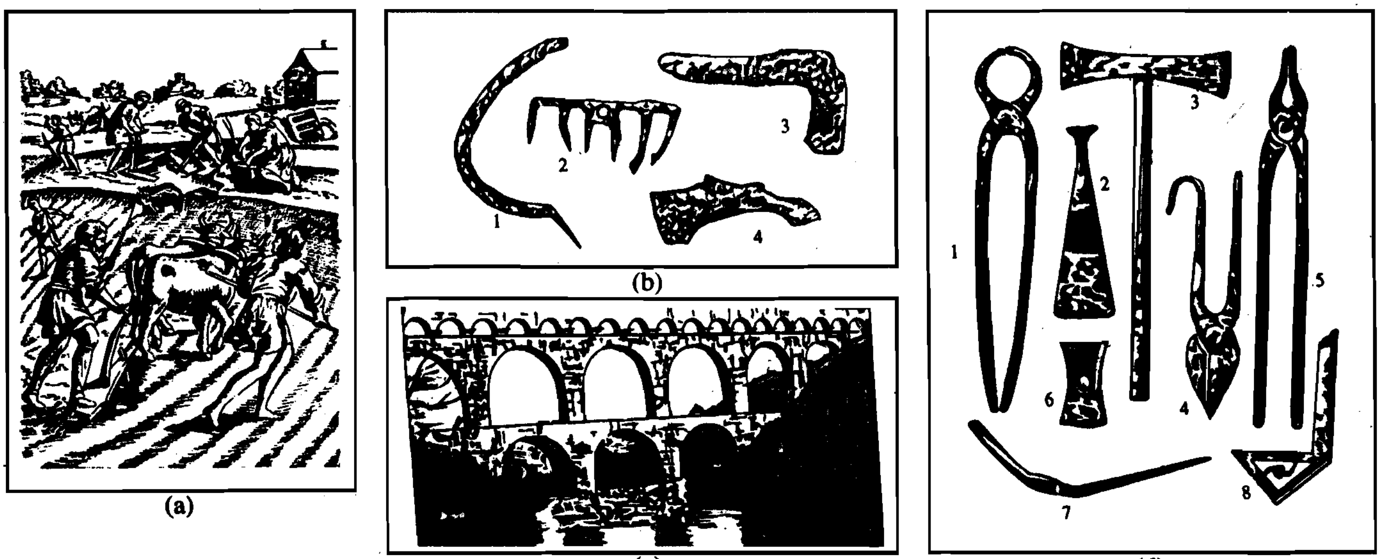

Fig. 3.19: a) Roman agriculture. Notice the ploughing and other activities like sawing wood, making plough, basket weaving. Note also a harrow in the background; b) agricultural implements: 1) sickle; 2) rake; 3) garden knife; 4) axe-hoe; c) the aqueducts built of burnt brick and of concrete made from lime and volcanic ash were used to carry water across hundreds of kilometres in the Roman Empire. Water pipes passed over the bridge; d) tools for constructing Roman buildings: 1, 5) tongs; 2) trowel for spreading mortar; 3, 6) hammer and a hammer head; 4, 7) cutting tools; 8) a mason's square.

no incentive for science to develop new techniques, science lost its essential quality of inquiring into nature. As the Roman Empire was followed by the serf-owning feudal economy of Europe, this state of cultured stagnation continued till the fifteenth century. Europe was engulfed by the Dark Ages and the centre of learning and enlightenment shifted to the East. You will study more about the developments in Europe and in the East in Units 5 and 6.

You may enjoy reading the following piece from J.D. Bernal's famous book "Science in History" (page 231), illustrating how social decline leads to the decline of science.

"Classical civilisation was already intrinsically doomed by the third century B.C., if not earlier. The tragedy for science was that it took so long to die, because in that period most of what had been gained, was lost. Knowledge that is not being used for winning of further knowledge does not even remain—it decays and disappears. At first the volumes (books-Ed.) moulder on the shelves because very few need or want to read them; soon no one can understand them, they decay unread, and in the end, as was the legendary fate of the Great Library of Alexandria, the remainder are burnt to heat the public-bath water, or disappear in a hundred obscure ways."

3.6 SUMMARY

In this unit, we have studied the development of science and technology in the Indian and Greek civilisations of the Iron Age, in the period 1500 B.C., to about 400 B.C. We have seen that a stratified social structure had emerged in this period, both in India and in Greece, which affected the nature and growth of science in these societies. We now summarise some important aspects:

- In India, the search for agricultural land and minerals led to the spread of civilisation all over the Gangetic plain. It took almost a thousand years for the pastoral Aryan tribes to settle down as agricultural communities. The society changed from a tribal to a more urban and structured form which was relatively free from conflicts. Trade within the urban settlements grew and commodity production started. These changes were accompanied by the emergence of a caste system which became rigid as time passed. Around the same time, a slave society had evolved in Greece.
- Initially the period witnessed significant advances in many areas of science like astronomy, geometry, mechanics, chemistry, botany, zoology and medicine in both the civilisations.
- However, in the rigid stratified social structure, those who worked with their hands got isolated from the thinkers. The separation of theory and practice had serious implications for the growth of science. In Greece, it led to an idealist philosophy about the universe and the world as reflected in Aristotle's ideas. Aristotelian ideas dominated not only Greek science but also the world science for the next 2000 years.
- In India, the scientific practice of medicine adopted by *Susrutas* and *Carakas* was an exception. These travelling mendicants went about healing the rich and poor, regardless of their caste or creed. Medicine, therefore, suffered much less except for some aberrations like the theories of three humours and five elements.
- The middle of the second century B.C. saw the collapse of Greek empire and the rise of Roman empire. Roman economy was based on loot by military coercion and agriculture by slaves. There was no incentive to absorb new ideas and improve techniques to increase production. Therefore, the Roman era made very little contribution to the growth of science and culture. This state of cultural stagnation continued in Europe until about the fifteenth century A.D.

3.7 TERMINAL QUESTIONS

1) In the Roman phase in the Iron Age, existing knowledge was applied to build roads, aqueducts, theatres etc. There were no improvements in techniques and no new ideas were developed. Gradually, science lost its spirit of enquiry. What features of social life led to this stagnation of science?

....

....

....

....

2) Certain concepts and ideas that you studied in the Unit 1, are illustrated by some instances described in this unit. In the space provided below, write the instances from this unit that illustrate each one of the following statements.

   a) The separation of theory from practice becomes an impediment in the growth of science.

   ....

   ....

   ....

   ....

   b) The theories of science are influenced by the general intellectual atmosphere and ideas prevailing in the society.

   ....

   ....

   ....

   ....

   c) New theories or practices which contradict the prevailing social ideas or philosophy come into conflict with them. They may slowly be wiped out and be revived only later in a different society.

   ....

   ....

   ....

   ....

   d) Stability leads to social stagnation and eventually to stagnation in science.

   ....

   ....

   ....

   ....

3.8 ANSWERS

Self Assessment Questions

1) (i) I (ii) B (iii) B (iv) I (v) I (vi) B (vii) B (viii) I (ix) B (x) I.

2) a) F b) T c) T d) T e) F.

3) d).

4) a) (ii), (iii), (v), (vi), (viii).

   b) (i), (iv), (vii).

5) b) The developments in Greek science were greatly influenced by prevailing social philosophy and ideologies, with only a few exceptions.

   c) In India, the physicians healed ordinary rural folk as well as the rich and treated them on the same footing.

   d) The Indian cosmogonic system had five elements—earth, fire, water, air and empty space.

   e) The Greek atomists were free from the ideas of soul, *adrista* or *karma*. Their atomic theory presented the picture of a world that was changing.

Terminal Questions

1) a) The Roman economy was based on loot by army and agriculture by slaves.

b) Power and wealth accumulated in the hands of a few, while the majority of the people were poor.

Thus, science had no incentive to improve or to develop new techniques to improve production.

2) a) The practical and manual work was done by lower caste peasants and craftsmen in India and by slaves in Greece. There was no contact between them and the small group of thinkers who pursued science and had state patronage. This separation of practice from theory became an impediment in the growth of science.

b) In India, the Ayurvedic system of medicine adopted the ideas of the *'tridosas'* and *'pancabhutas'* under the influence of the cosmogonic speculations. Also in the atomic theory, the elements of soul, *'karma'*, *'adrista'* were introduced. In Greece, the Aristotelian views of an ideal world influenced many areas of science as you have seen in SAQ 4.

c) The scientific practices of *Carakas* and *Susrutas* contradicted the ideas of the priests in Indian society. By the third or the fourth century A.D., due to the opposition from orthodox religious ideas and other factors, the Ayurvedic system of medicine began to rely more on mystical 'causes' than on observations. It is only now that attempts are being made to give it a scientific basis again.

Similarly, in Greece, Aristarchus of Samos presented a heliocentric (sun-centred) theory of planetary motion, which was not accepted because it contradicted the prevailing philosophical ideas. It was revived by Copernicus.

d) The decline of science in the Roman empire is an illustration of this concept.