THE THEORY OF CHEMICAL COMBINATION IN ANCIENT INDIAN PHILOSOPHIES

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The atomic nature of matter, and the union and collocation of the atoms to form larger aggregates of molecules, both homogeneous and heterogeneous, constituted the basic and fundamental postulates guiding the Indian thought in their attempt to find out a rational explanation of the nature of the universe and of cosmic evolution. Science, in the strictest sense, can never be dissociated from philosophy, and is in fact a branch of the latter and known as natural philosophy. This is best expressed in Seal's[1] words: 'Philosophy in its rise and development is necessarily governed by the body of positive (scientific) knowledge preceding or accompanying it.' The present paper is an attempt to make an analysis of the views of the early Indian philosophers regarding atoms and their combination in the context of the modern scientific knowledge and in comparison with those of the contemporary Greeks.

EVOLUTION OF MATTER—ATOMS

According to the Sāṃkhya view of cosmogenesis, which is upheld by Patañjali in his philosophical system, matter in its finest possible form is made to originate at a particular stage in the process of cosmic evolution occurring in the unmanifested, ultimate ground named as *Prakṛti.*

Prakṛti is conceived as formless, limitless, ubiquitous, undifferentiated, indestructible, indeterminate, and incomprehensible infinite continuam without beginning and without end, in which and out of which the manifested and differentiated cosmic universe has been evolved through successive stages. The order of cosmic evolution based on the Sāṃkhya-Pātañjala view[2] is represented in the table following.

Prakṛti, though undifferentiated, is represented as an amalgam of three *guṇas* existing in equilibrium. Seal[1] calls these *guṇas* as 'Reals' or substantive entities. The three *guṇas* are: (1) *Sattva*—the essence or intelligence-stuff, which manifests itself in a phenomenon, (2) *rajas*—energy, which is efficient in a phenomenon, (3) *tamas*—mass-stuff or inertia, to which the phenomenon relates. These *guṇas* have been interpreted by Seal as diverse moments with diverse tendencies inherent in *Prakṛti.*

The Order of Cosmic Evolution

Prakṛti
The unmanifested, unknowable ground

Mahat
Cosmic matter of experience (stuff of consciousness)

Ahaṃkāra

Rājasik Ahaṃkāra
(subject series)

Asmitā
(Empirical ego)

Manas and Indriyas
(Mind-stuff, sensory and motor-stuff)

Tāmasik Ahaṃkāra
(object series)

Tanmātra-sūkṣma Bhūta
(Subtile material potencies or matter-stuff)

Paramāṇu-sthūla Bhūta
(Atomic and molecular constituents of gross matter)

Dravyas
(Individual substances composed of atoms and molecules—inorganic and organic)

Matter in the Sāṃkhya-Pātañjala system is evolved through three distinct stages:

(1) Evolution of *tāmasik ahaṃkāra* in the cosmic matter of experience (*mahat*) through the mediation of its subjective modification *rājasik ahaṃkāra*. This first stadium is distinguished also by the name *bhūtādi* (or literally, origin of matter), which may be regarded as supra-subtile matter.

(2) From *bhūtādi* is then evolved the infra-atomic particles *tanmātras*: five kinds of subtile matter.

(3) From the *tanmātras* are finally evolved five different classes of atoms of five elements, which are complex *tanmātrik* systems (*sthūla-bhūta paramāṇu* or atoms of gross matter).

Bhūtādi or matter in the supra-subtile state is absolutely homogeneous and inert, without any chemical or physical property excepting that of quantum or mass.

Tanmātras or infra-atomic particles of matter possess specific potential energies represented by sound, touch, colour, taste and smell. There are five different classes of *tanmātras*. Their order of genesis and structure are represented as follows:

(i) Infra-atomic particles charged with the potential of sound are known as the *śabda-tanmātras*. They possess the physical energy of vibration (*parispanda*).

(ii) Infra-atomic particles charged with the potential of touch stimulus in addition to that of sound from the *sparśa-tanmātras*, which possess the physical energy of impact or mechanical pressure, besides that of vibration.

(iii) Infra-atomic particles charged with the potential of colour stimulus in addition to those of sound and touch give rise to the *rūpa-tanmātras*, which possess the energy of radiant heat and light, besides those of impact and vibration.

(iv) Infra-atomic particles charged with the potential of taste stimulus in addition to those of colour, touch and sound form the *rasa-tanmātras*, possessing the energy of viscous attraction together with those of heat, impact and vibration.

(v) Lastly, infra-atomic particles charged with the potential of smell stimulus in addition to those of taste, colour, touch and sound form the *gandha-tanmātras*. These possess the energy of cohesive attraction, besides those of viscous attraction, heat, impact and vibration.

The five types of *sthūla-bhūta paramāṇus* or atoms then arise from the corresponding *tanmātras* and are named respectively as *ākāśa-atom*, *vāyu-atom*, *teja-atom*, *ap-atom* and *kṣiti-atom*,[3] which are respectively mono-, di-, tri-, tetra- and penta-*tanmātrik atoms*.

In the Sāṃkhya view, the five different *bhūtas* represent five different classes of substances according to their general physical properties: namely *kṣiti* denoting solids, *ap* denoting liquids, *vāyu* denoting gases, *tejas* denoting heat and light corpuscles, and *ākāśa* denoting ether.

Different properties of different substances belonging to each *bhūta* class arise from the difference in the *tanmātrik* composition and collocation in their atoms. Thus there may be different varieties of di-*tanmātrik vāyu* atoms or of tetra-*tanmātrik ap* atoms, depending on the difference in the number of each type of *tanmātras* composing their atoms and on the difference in the collocation of these *tanmātras* in the atoms.

The Sāṃkhya view of cosmogenesis may be compared to that of the Chinese philosophers of the Chou period (Chou Empire—1027–221 B.C.). The Chinese recognized a world spirit or cosmic soul, *Tao*, responsible for the creation of the universe. *Tao*, the cosmic soul, manifested itself in the dual forces or contrary principles of *Yang* and *Yin*—*Yang* representing the male element with spiritual qualities and *Yin* representing the female element with material qualities of nature. This Chinese view of cosmogenesis was developed in the fourth or fifth century B.C., contemporaneously with that of Sāṃkhya. *Yang* and *Yin* are comparable to *puruṣa* and *prakṛti* of Sāṃkhya and *Tao* to the *puruṣottama* of Gītā. But much earlier to this (*c.* twelfth century B.C.) the Chinese postulated their five elements theory regarding the constitution of matter. These five were: fire, water, earth, wood and gold. Of these, the first three occur in common with those of Indian and Greek philosophers. The concept of five elements was also of much earlier origin in India (i.e. in the Age of Āraṇyakas and Upaniṣads).

A few words need be said here about *ākāśa*. In the Sāṃkhya view *ākāśa* functions in two different aspects: non-atomic and atomic.[4] In the non-atomic form it might be said to correspond to the hypothetical ether of the physicists, an all-pervasive, ubiquitous medium. Atomic *ākāśa* is a derivative of non-atomic *ākāśa* (*kāryākāśa* and *kāraṇākāśa*). The former is charged with vibration potential and the latter serves as a universal medium identified with space (*abakāśa*).

This two-fold aspect of *ākāśa*, non-atomic and atomic, related to each other as cause and effect, with the atomic *ākāśa* serving as the building stone of all other material atoms, may be regarded as a very significant conception of the ancient Indian philosophies. This reminds one of Dirac's hypothesis of 'anti-matter', which fills the space and from which matter is being continuously generated. Thus, the conceptions of *ākāśa*, ether and anti-matter may be viewed as the members of a remarkable triplet. Hoyle's theory of creation also bears a resemblance to the conception of non-atomic *ākāśa* as the starting-point of material creation. A similar view about the two different aspects of *ākāśa* is also found in the Vedānta philosophy where they are distinguished as *purāṇaṃ kham* and *vāyuraṃ kham*.

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A wide divergence of views regarding the genesis and structure of matter, however, prevailed among the ancient thinkers. Mention may be made here of some typical views like those of Viṣṇu Purāṇa, Parāśara, Patañjali and Vedāntists, which differ in many details from the Sāṃkhya view and from one another. But as our major interest in this paper relates to the theory of atoms and chemical combination, we shall now proceed to give an account of the latter, as conceived by the early Indians.

Atomic Theory of Kaṇāda

Atoms and their properties have been elaborately discussed in the Nyāya-Vaiśeṣika system of Indian philosophy. Kaṇāda, the founder of the Vaiśeṣika system, primarily occupied himself with the idea of atoms and molecules and their characteristic properties. The atomic hypothesis, as propounded by Kaṇāda, has many points in common with that of the Greek philosopher Democritus (470–360 B.C.). The Nyāya system of Hindu philosophy also echoes the identical view.

Kaṇāda's view about the atoms differs somewhat from the Sāṃkhya view, reported before. Kaṇāda recognized only four kinds of atoms: namely *kṣiti, āpo, tejas* and *vāyu* atoms. According to Kaṇāda, *ākāśa* has got no atomic structure, serving merely as an inert and ubiquitous substratum of sound, which is supposed to travel in the form of waves in the manifesting medium of *vāyu*. Sāṃkhya, too, as stated before, conceived of *ākāśa* in its non-atomic aspect to behave as a universal all-pervading medium in which air, light and heat corpuscles and other atoms move and float about. Kaṇāda's view about the propagation of sound, though a mere speculation, is surprisingly similar to that of our modern science. Another remarkable statement made by Kaṇāda relates to the nature of light and heat, which, according to him, are only the different forms of one and the same essential entity *tejas*.

Atoms, according to Kaṇāda, are eternal, ultimate, indivisible and infinitesimal. Atoms possess certain characteristic properties, such as mass, numerical unit, weight, fluidity or its opposite, viscosity or its opposite, velocity or quantity of impressed motion. They also possess characteristic potentials of sense stimuli like colour, taste, smell, or touch, not produced by the chemical operation of heat. The qualities of *kṣiti* are colour, taste, smell and touch; the distinguishing quality is, however, smell. *Ap* has the qualities of *kṣiti* excepting smell and with the addition of viscidity; its distinguishing quality is coolness. *Tejas* has the qualities of *kṣiti* excepting smell, taste and weight; its distinguishing quality is colour and hotness. *Vāyu* has the qualities of *kṣiti*, with the exception of smell, taste and colour; its distinguishing quality is touch.

Combination of atoms.—One atom combines with another atom under an inherent impulse to form a binary molecular or a compound of two atoms (*dvyāṇuka*). The atoms possess an intrinsic vibratory or rotatory motion (*parispanda*). Atoms of the same *bhūta* class uniting in pairs give rise to molecules, with homogeneous qualities corresponding to the original quality of the atoms, provided that no chemical change under the action of heat corpuscles takes place. The binary molecules then combine among themselves by groups of three, four, five, etc., to produce larger aggregates as determined by physical causes and in obedience to the moral law underlying the creation (*adṛṣta*). But another view in the Vaiśeṣika maintains that some atoms may unite in pairs, some in triads, others in tetrads, etc., either directly or by successive addition of one atom to each preceding aggregate. It may thus lead to the formation of binary (*dvyāṇuka*), ternary (*tryāṇuka*), quaternary (*caturāṇuka*) molecules, etc. The variety of substances of the same *bhūta* class, say of the earth substances, is the consequence of the difference in their molecular composition and configuration (*avayava sannibeśa*) with the development of different specific qualities.

An elementary substance thus produced by primary combination may, however, undergo qualitative transformation under the influence of heat corpuscles. This may lead to the decomposition of the molecules into the original homogeneous atoms, then a transformation of the character of the atoms, and finally a reunion of the transformed atoms into different groups or arrangements with different characteristic properties.

Combination may also occur either between two or more substances belonging to the same *bhūta* class or those of different *bhūta* classes. A classification on this basis gives the following order of compounds:

(1) *Mono-bhautik compounds.*—Compounds formed by the union of homogeneous atoms of different substances of the same *bhūta* class.

(2) *Hetero-bhautik compounds.*—Bi- or poly-*bhautik* compounds formed by the union of heterogeneous atoms of substances belonging to the different *bhūta* class. Vaiśeṣika gives complicated details of their formation.

In the Nyāya-Vaiśeṣika view the atoms, though eternal in themselves, are, however, non-eternal as aggregates, which may be organic and inorganic. Atoms are also conceived of as spherical in shape. A conception of the arrangement of atoms in space constitutes an essential part of Kaṇāda's theory of chemical combination under the influence of heat corpuscles.

The Nyāya-Vaiśeṣika theory of chemical combination has been expounded and elaborated by several commentators; prominent among which are Praśastapada (*c.* second century A.D.), Śrīdhara (*Nyāya-Kandalī*, *c.* tenth century A.D.) and Udayana (*Kiraṇāvalī*, *c.* eleventh century A.D.).

The cause of chemical combination between atoms, according to Nyāya-Vaiśeṣika, is an inherent impulse of the atoms themselves, which is also expressed as an obedience to the moral law in creation (*adṛṣta* or unseen force). This is equivalent to the natural or characteristic property of the atoms in our modern terminology. It should be noted that Kaṇāda does not speak of any divine or supernatural intervention, but of inherent impulse, unknown power, or moral law.

Summing up, chemical combination in Kaṇāda's view may be defined as the union of atoms or bodies under an inherent impulse leading to the formation of other bodies having properties generally different from those of the atoms or bodies combined.

In the light of our modern ideas, this definition is more or less unexceptionable and is comparable to the well-known and brilliant definition of chemical combination found in the record of Aristotle's teaching at the

Lyceum., which, according to Farrington,[5] represents the 'logical perfection of Greek Science' of the time. He rendered it into English as follows:

'Chemical combination is a union of several bodies capable of such combination, involving a transformation of the properties of the bodies combined.'

It may likewise be stated that both Kaṇāda and Democritus anticipated Dalton by several centuries in the formulation of atomic theory.

But while the atomism of Kaṇāda and of Democritus failed to make any tangible contribution to the growth of science in India or Greece, as the case may be, the atomic theory of Dalton, as is well known, served as the key to unlock the flood-gates of knowledge that led to the growth of the modern science of chemistry and physics. The reason for this is not far to seek. The atomic theory of Dalton was enunciated as the result of an attempt to find a ready explanation for the *experimentally* determined laws of chemical combination, whereas the atomism of Kaṇāda or Democritus was by and large a brilliant speculation based on rational, systematic and logical thought on the nature of matter and the structure of the universe, as also on the observation of some natural and technical processes by unaided senses. There are very little experimental findings to support the ancient atomism, nor were the techniques sufficiently developed at the time to test its validity. There was thus little scope for its application which alone could help in the progress of science in India or Greece in those early days. The atomism of Democritus or Kaṇāda, therefore, played no part in the formulation of Dalton's atomic theory, a fact which is ignored by many writers who are inclined to attach significance of tested and developed views of a later age to the speculative ideas of the earlier ones.

It is pertinent to point out here that our knowledge of the views of the ancient Indian philosophers is derived in most cases from the interpretation of their commentators, who often flourished at an age varying from 500 to 1,000 years later than that of the original authors. There is thus every likelihood on the part of these commentators reading into the words of the earlier authors the meaning of a later age. This necessarily stands in the way of arriving at a correct assessment of the significance of the views of the ancient authors. It is a danger, which is indeed difficult to avoid.

The Vedāntic View

Chemical change, according to the Vedāntic view, can occur spontaneously in a substance without the influence of any external force and in the absence of a second substance. Formation of curd from milk and ice from water are cited as examples. The latter is not a chemical but a physical change only. It shows that the ancient Indian philosophers were incapable of making any distinction between the physical and the chemical changes. Āchārya

Seal in his *Positive Sciences of the Ancient Hindus*[6] has wrongly interpreted the above described changes as comparable to the 'isomeric change' of modern chemistry. The Vedāntists, however, include this type of change in the category of natural changes (*svāvāvik pariṇām*).

Another type of change recognized by the Vedāntists is described as change resulting from combination between different substances (*dravyāntara saṃyoga*). This is the proper chemical change in our modern sense. Such combination, according to the Vedāntists, may produce (*a*) a substance having the same qualities as the constituents (*samāna jātīyotpatti*) or (*b*) a substance or substances with new qualities (*vijātīyotpatti*). Translated into our modern chemical terminology the former corresponds to the addition or molecular compounds (e.g. double salts) and the latter to the true chemical compounds, simple or complex. As an example, the product of fermentation from rice and molasses is cited.

It might be pointed out here that the Vedānta does not recognize the atomic structure of matter. According to the Vedāntic doctrine the *sūkṣma-bhūtas* are homogeneous and continuous matter, while the *mahā-bhūtas* are composite and continuous. The Vedānta speaks of *aṇu* (*paramāṇu*) only as the smallest conceivable quantum or measure of matter.

Atomic Theory of the Buddhists

Four essentials of matter are recognized by the Buddhists. These are: extension (with hardness), cohesion (with fluidity), heat and pressure (with motion) and four sensibles (subtile matter) of colour, taste, smell and touch.

The four types of elements formed by aggregation from their corresponding atoms are *vāyu*, *tejas*, *ap* and *kṣiti*.

Vāyu atoms are touch-sensibles, having impact or pressure as their characteristic property.

Tejas atoms are colour and touch-sensibles, having heat for their characteristic property.

Ap atoms are taste-, colour- and touch-sensibles, having viscosity as the characteristic property.

Kṣiti (earth) atoms are smell-, taste-, colour- and touch-sensibles, having dryness or roughness as the characteristic property.

The four elements (*bhūtas*) thus originated combine to form aggregates, giving rise to inorganic and organic substances and the sense organs (*vide* Dhammasangani, Atthasalini, etc.).

Atomic Theory of the Jainas

Matter is called *pudgala* in the Jaina philosophy, which acts as the vehicle of energy in the form of motion. Everything in the material world is either an entity (*dravya*) or a change of state in an entity (*paryāya*). *Pudgala* (matter) and changes therein, whether of the nature of subtile motion (*parispanda*) or of evolution (*pariṇāma*), must furnish the physical as opposed to the metaphysical basis of all our explanations of Nature.

Pudgala (matter) can exist in two forms: as *aṇu* (atom) and *skandha* (aggregate). The latter are formed from the former. An *aṇu* is an infinitesimal, eternal and ultimate particle of matter; it has no parts, no beginning, middle, or end. A *skandha* may vary from a binary (*dvyāṇuka*) aggregate to an infinitum (*anantāṇuka*), formed by the successive addition of an *aṇu* (atom) to the previous *skandha* (aggregate or molecule). A *skandha* may therefore be made up of a definitely large number of *aṇus* that may be counted (*saṃkhyaya*), of an indefinitely large number of *aṇus* (*asaṃkhyaya*), of *aṇus* of an infinitely large number of the first order (*ananta*), of *aṇus* of an infinitely large number of the second order (*anantāṇua*), and so on.

The *pudgala* in its original state corresponds to *bhūtādi* of the Sāṃkhya-Patañjali and is homogeneous and indeterminate, from which determinate and discrete particles (*aṇus*) arise as the result of evolution.

Every atom possesses an infra-sensible or potential taste, smell and colour, and two infra-sensible tactile qualities (roughness or smoothness, dryness or moistness, hardness or softness, heaviness or lightness, heat or cold). A *skandha* or aggregate, however, possesses in addition the following physical characteristics: sound, atomic linking, dimension, shape and configuration, divisibility, opacity, radiant heat and light.

A very significant feature of the atomic theory of the Jainas relates to the mechanism of chemical combination and atomic linking. Mere juxtaposition of two atoms is not sufficient for chemical combination; they must be unlike in character, being endowed with opposite qualities for the combination to occur. The opposite qualities are roughness (*rukṣatva*) and smoothness (*snigdhatva*) or dryness and moistness. Then, again, the linking will not occur, or will be very weak, if these opposite qualities be very feeble. The particles of like character or similar qualities will not generally unite, if the qualities be of equal intensity. If, however, the strength or intensity of the qualities, though alike in character, of two atoms differ widely, then even atoms of similar qualities will be attracted towards each other to enter into chemical combination. The properties of the atoms suffer a change as the result of their linking or chemical combination.

A detailed presentation of the atomic theory and the theory of chemical combination of the Jainas is found in the *Tattvārthadhigama* of Umasvati (Chap. V), which dates back to the first or second century A.D. It may remind one of Empedocles's idea of four elements uniting with, or separating from, each other, under the impulse of love and hate even before the concept of atom was formulated by Democritus in the fifth century B.C. It is further intriguing to note that the theory of chemical combination of the Jainas bears some crude resemblance to the *dualistic hypothesis* of Berzelius, propounded some 1,800 years later in the early part of the nineteenth century. Atoms were believed by Berzelius to be charged with an excess of positive or negative electricity and the chemical combination was believed by him to occur between two unlike atoms (one positive and one negative) with consequent neutralization of their charges.

Chemical Action and Heat

In many ancient Indian philosophical works, particularly of the Nyāya-Vaiśeṣika system, a close association of chemical change with heat has been recognized.

According to Vātsyāyana (first century A.D.) chemical changes may occur either by the application of external heat or it may result from the operation of internal heat.[7] When the fuel undergoes change by combustion, the heat evolved was believed to exist in a latent form in the fuel before. Udayana in his *Kiraṇāvalī*[7a] considers the solar heat as the ultimate source of all heat required for chemical changes occurring on this earth. This invisible solar heat was also believed to be responsible for the change of colour in the grass, for the ripening of mangoes, in which their colour, smell and taste change, for the rusting of metals (combustion due to solar heat—*sūryapāka*), and for the conversion of food into blood. All these cases are instances of chemical transformation (cf. *Nyāyabodhinī* on Annam Bhatta's *Tarkasaṃgraha* of *c.* eighth century A.D.)

Heat and light rays were assumed by many early philosophers to consist of infinitely small particles radiating in straight lines in all directions with inconceivably high velocity and with a sort of conical dispersion. These on striking the atoms may break up their grouping, transform their physio-chemical character and bring about chemical changes (cf. Jayanta, *Nyāya-mañjarī*, eleventh century A.D.).

Arrangement of Atoms in Space (Molecular Configuration)

In the Nyāya system atoms are conceived to possess a spherical shape (*parimaṇḍalya*). The original physical arrangement of atoms is also given by Vācaspati (*c.* A.D. 850), in which each (spherical) atom is surrounded by six others. Variation of this arrangement in the collocation of atoms and molecules gives rise to the variety of mono- and poly-*bhautik* compounds.[8]

The Indian and the Greek Atomism: Question of Priority

It has been shown that there is much in common between the atomic theory of Kaṇāda and that of his contemporary, the Greek philosopher, Democritus. The reason for their failure to promote the progress of science in either country has also been discussed. It now remains to consider the question of their priority, or of the indebtedness of one to the other, in this respect. There has been much controversy over this matter, which has given rise to two opposite schools of thought. Without indulging in polemics about the question of priority or exchange of ideas between the two countries, it is easier to demonstrate that both in ancient India and in ancient Greece philosophical and scientific concepts were developed independently on parallel lines with characteristic and distinctive features of their own. A consideration of the following points will make it clear.

The conception of *ākāśa* is a distinctive feature of the Indian philosophical thought. It has already been stated that in the Sāṃkhya and the Vedāntic views *ākāśa* has two forms in two successive stages of evolution: non-atomic and atomic, or original and derivative. The former represents the motionless, ubiquitous, undifferentiated, primordial matter-stuff or matter-rudiment, which must not be confounded with vacuum or void of Democritus—a merely negative concept. The other form of *ākāśa*, i.e. the atomic *ākāśa*, represents a subtile proto-atomic (*tanmātrik*) integration residing in the ubiquitous non-atomic *ākāśa* according to Sāṃkhya. In Kaṇāda's view *ākāśa* has no atomic structure and takes no part in the material evolution, being absolutely inert. It has been postulated only to serve as the substratum of sound which, according to our modern knowledge, is obviously wrong.

In the Sāṃkhya-Pātañjala atoms are not indivisible in the strict sense of the word, as they are made up of *tanmātras* in different proportions for each type of element.

We find an elaborate account of the operation of heat implied in chemical combination in the philosophical views of the Nyāya-Vaiśeṣika system, particularly in the commentaries of the later age.

For reasons already stated both the Indian and Greek atomisms sooner or later receded to the background.

The history of the Indian thought about the nature of matter and the structure of the universe like that of the contemporaneous Greeks followed a double tradition; a naturalistic, or materialistic, or agnostic, or atheistic tradition, and a religious tradition. Both these traditions, materialistic and religious, were not infrequently blended together, particularly in the case of the Indians. While among the Greeks we can recognize many purely naturalistic or materialistic philosophers like Empedocles, Anaxagoras, Democritus and the Hippocratic doctors of the pre-Socratic period, as well as Strato, Archimedes, Epicurus, Lucretius, Pliny and Galen among others of the period after Aristotle and of the Graeco-Roman Age, it is difficult to find any such among their Indian contemporaries. Barring the Cārvākas or Lokayatikas, whose writings are all lost or destroyed, and whose existence at any period of history is doubted by many, the views of practically all the ancient Indian philosophers are not free from religious tradition in some form or other. Even the agnostic Buddhist and Jaina philosophies are dominated by faith in the rebirth and transmigration of souls. This is possibly one of the reasons why it might be stated in the words of Farrington[9] that 'with the science of Alexandria and of Rome we are in very truth on the threshold of the modern world. When modern science began in the sixteenth century it took up where the Greeks left off'. This cannot, however, be asserted with a like emphasis for the contemporary Indian scientific knowledge, at least so far as experimental sciences are concerned.

Decline of the Scientific Spirit in India

Writing about the achievement of science of the Graeco-Roman Age, Farrington, as stated above, observed that it was on the threshold of modern world. But at the same time he enquired about the failure of the Greeks and Romans 'to push open the door' and discussed about the rapid decline of the Greek science by the end of the second century A.D. The decline of Greek science, as Farrington[10] has rightly observed, was the inevitable consequence of the prevailing conditions of the society, which was split into a majority of slave-labourers and a privileged minority of slave-owners or free men with contempt for all manual labour, because of the social stigma they attached to it. In the words of Farrington: 'Graeco-Roman science was a good seed, but it could not grow on the stony ground of ancient slave society.

'There was a mischievous separation of the logic from the practice of science. Science had ceased to be a real force in the life of society. Instead there had arisen a conception of science as a cycle of liberal studies for a privileged minority. Science had become a relaxation, an adornment, a subject of contemplation. It had ceased to be a means of transforming the conditions of life.'

Science cannot grow *in vacuo* and it never or nowhere did so, isolated from its relation to the society. It progresses with the social progresses of man, as it helps in the progress of the society. There is need for the harmonious blend of the two essential elements for the growth of science: an element of observation and an element of thought, which fertilize each other. Observation involves experiment and technique. With our unaided senses observation cannot but be limited. The power of our senses are increased for increased observation with the help of increased experimental technique, which involves manual work. Operation of thought comes in for making inference out of the experimental results. Hence, science can grow only through a co-operation between theory and application. It originated in techniques, in arts and crafts, in manifold activities of man for the preservation of his life and the improvement of his living conditions. But logical and rational thought is required to build up a body of abstract scientific truth which helps in the development of improved technique. In a social structure where rational thought or exercise of the head is isolated from observational technique or exercise of the hand, science is bound to become paralysed or remain stagnant. This was what happened in the case of the slave-ridden Graeco-Roman society by the end of the second century A.D.

It may be shown that the causes for the decline of scientific spirit in India were not otherwise than what operated in the case of the Greek science. This is most eloquently expressed by P. C. Rây[11] in his *History of Hindu Chemistry*, from which the following is quoted:

'In the Vedic age the *ṛṣis* or priests did not form any exclusive caste of their own . . . But all this was changed when the Brahmins reasserted their supremacy on the decline or the expulsion of Buddhism.

'The caste system was established *de novo* in a more rigid form. The drift of Manu and the later Purāṇas is in the direction of glorifying the priestly class, which set up most arrogant and outrageous pretensions. According to Suśruta, the dissection of dead bodies is a *sine qua non* to the student of surgery, and this high authority lays particular stress on knowledge gained from experiment and observations. But the very touch of a corpse, according to Manu, is enough to bring contamination to the sacred person of a Brahmin . . . It was considered equally undignified to sweat away at the forge like a Cyclops.

'The arts thus being relegated to the low castes, and the professions made hereditary, and the intellectual portion of the community being thus withdrawn from active participation in the arts, the *how* and *why* of phenomenon—the co-ordination of cause and effect—were lost sight of. The spirit of enquiry, gradually died out among a nation, naturally prove to speculation and metaphysical subtleties, and India for once bade adieu to experimental and inductive science.'

We thus find that in India, too, the decline of the scientific spirit was the result of the cleavage of the society into a privileged higher caste minority and a degraded lower caste majority. For, this led to a separation of the theory from the practice or application of science. This reminds one of Bacon's words, 'If you make a vestal virgin of science you must not expect her to bear fruit.' In other words, science must be wedded to technology if she is expected to deliver the real good for the society.

References

1 Seal, B. N., *Positive Sciences of the Ancient Hindus*. Longmans, 1925.
2 *Vyās Bhāṣya*, Sūtra 19, Pada II.
3 ——— Sūtra 19, Pada II; Sūtra 14, Pada IV; *Pravacana Bhāṣya*, Sūtra 62, Chap. I.
4 Vigñānabhikṣu, *Jogabartikā*, Sūtra 40, Pada III.
5 Farrington, B., *Greek Science*, p. 186.
6 Seal, B. N., *Positive Sciences of the Ancient Hindus*. Longmans, 1925, p. 89.
7 *Vātsyāyanabhāsya*, Chap. IV, Āhnika 1, Sūtra 47.

[7a] Udayana, *Kiraṇāvalī*—commentary on *Praśastapadavāṣya* of Nyāya-Sūtra.

[8] Vācaspati, *Tātparyyaṭīkā*, Chap. IV, Āhnika 2, Sūtra 25.

[9] Farrington, B., *Greek Science*, p. 301.

[10] ——— *Greek Science*, p. 302, et. seq.

[11] See *History of Chemistry in Ancient and Medieval India*, incorporating the *History of Hindu Chemistry* by P. C. Rây. Edited by P. Ray. Indian Chemical Society, Calcutta, 1956, p. 240.