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The positive sciences of the ancient Hindus

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THE
POSITIVE SCIENCES
OF THE
ANCIENT HINDUS

BY
BRAJENDRANATH SEAL, M.A., Ph.D.

LONGMANS, GREEN AND CO.
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FOREWORD

THE following pages comprise a series of monographs on the Positive Sciences of the Ancient Hindus. In the present state of Indian chronology it is not possible to assign dates to the original sources from which the materials have been drawn. Practically the main body of positive knowledge here presented may be assigned to the millennium 500 B.C.—500 A.D. Colebrooke's account of Hindu Algebra, and Hœrnle's of Hindu Osteology, have made it unnecessary for me to write separate monographs on these subjects. The former, however, requires to be brought up to date. The progress of Indian Algebra (mainly in Southern India) after Bháskara, parallel to the developments in China and Japan, is a subject that remains for future investigation.

The chapter on the "Mechanical, Physical, and Chemical Theories of the Ancient Hindus" appeared in Dr. P. C. Ray's *Hindu Chemistry* (Vol. II.), and that on the "Scientific Method of the Hindus" as an appendix to the same work.

My direct aim in the present work is to furnish the historians of the special sciences with new material which will serve to widen the scope of their survey. The Hindus no less than the Greeks have shared in the work of constructing scientific concepts and methods in the investigation of physical phenomena, as well as of building up a body of positive knowledge which has been applied to industrial technique; and Hindu

scientific ideas and methodology (*e.g.* the inductive method or methods of algebraic analysis) have deeply influenced the course of natural philosophy in Asia—in the East as well as the West—in China and Japan, as well as in the Saracen Empire. A comparative estimate of Greek and Hindu science may now be undertaken with some measure of success—and finality.

These studies in Hindu Positive Science are also intended to serve as a preliminary to my “Studies in Comparative Philosophy.” Philosophy in its rise and development is necessarily governed by the body of positive knowledge preceding or accompanying it. Hindu Philosophy *on its empirical side* was dominated by concepts derived from physiology and philology, just as Greek Philosophy was similarly dominated by geometrical concepts and methods. Comparative Philosophy, then, in its criticism and estimate of Hindu thought, must take note of the empirical basis on which the speculative superstructure was raised.

I have not written one line which is not supported by the clearest texts. The ground trodden is, for the most part, absolutely new. Fortunately, the Sanskrit, philosophico-scientific terminology, however difficult from its technical character, is exceedingly precise, consistent, and expressive. I may add that I have occasionally used (perhaps with a questionable freedom) scientific terms like isomeric, polymeric, potential, etc., in a broad sense, as convenient symbols to express ideas nearly or remotely allied.

BRAJENDRANATH SEAL.

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THE POSITIVE SCIENCES

OF THE

ANCIENT HINDUS

CHAPTER I.

THE MECHANICAL, PHYSICAL, AND CHEMICAL THEORIES OF THE ANCIENT HINDUS.

I PROPOSE in this paper to give a synoptic view of the mechanical, physical, and chemical theories of the ancient Hindus. A chronological survey, even if the materials for it were available, would be here of little account. The origins of Hindu natural philosophy in the speculations of the *Bráhmaṇas* and the *Upanishads*, or in the mythology of the *Puráṇas*, do not come within the scope of the present exposition, which relates to the results of systematic thought as directed to the phenomena and processes of Nature. I have therefore confined myself to an account of natural philosophy as expounded in the principal systems of Hindu thought. The *Sáṅkhya-Pátañjala* system accounts for the Universe on principles of cosmic evolution; the *Vaisesika-Nyáya* lays down the methodology of science, and elaborates the concepts of

B

mechanics, physics, and chemistry. The Vedánta, the Púrva-Mímámsá, and in a less degree the Bauddha, the Jaina, and the Chárváka systems, make incidental contributions on points of special interest, but their main value in this regard is critical and negative. The principal authorities followed in this account—the Vyása-Bháshya on Pátañjali's Sútras, the Samhitá of Charaka, the Bháshya of Prasastapáda, the Vártika of Udyotakara, and the *Vrihat Samhitá* of Varáhamihira—all centre round the Hindu Renaissance, the beginnings of the anti-Buddhist reaction in the fourth, fifth, and sixth centuries of the Christian era. Whenever I have made use of later authors, *e.g.* Kumáрила, Śaṅkara, Śrídghara, Váchaspati, Udayana, Bháskara, Jayanta, Varavara, Raghunátha, Vijñána-bhikshu, etc., I have taken care to see (except where the opposite is expressly mentioned) that no idea is surreptitiously introduced which is not explicitly contained in the earlier authors.

THE SÁNKHYA-PÁTAÑJALA SYSTEM.

This system possesses a unique interest in the history of thought as embodying the earliest clear and comprehensive account of the process of cosmic evolution, viewed not as a mere metaphysical speculation but as a positive principle based on the conservation, the transformation, and the dissipation of Energy.

Prakriti: the Ultimate Ground.—The manifested world is traced in the Sánkhyá to an unmanifested ground, *Prakriti*, which is conceived as formless and undifferentiated, limitless and ubiquitous, indestructible and undecaying, ungrounded and uncontrolled, without

beginning and without end. But the unity of Prakriti is a mere abstraction ; it is in reality an undifferentiated manifold, an indeterminate infinite continuum of infinitesimal Reals. These Reals, termed Gunas, may by another abstraction be classed under three heads : (1) Sattva, the Essence which manifests itself in a phenomenon, and which is characterised by this tendency to manifestation, the Essence, in other words, which serves as the medium for the reflection of Intelligence ; (2) Rajas, Energy, that which is efficient in a phenomenon, and is characterised by a tendency to do work or overcome resistance ; and (3) Tamas, Mass or Inertia, which counteracts the tendency of Rajas to do work, and of Sattva to conscious manifestation.

The ultimate factors of the Universe, then, are (1) Essence, or intelligence-stuff, (2) Energy, and (3) Matter, characterised by mass or inertia.

These Gunas are conceived to be Reals, substantive entities—not, however, as self-subsistent or independent entities (प्रधान), but as interdependent moments in every real or substantive Existence.

Even Energy is substantive in this sense. The infinitesimals of Energy do not possess inertia or gravity, and are not therefore material, but they possess quantum and extensity (परिमाण—परिच्छिन्नत्व).

The very nature of Energy is to do work, to overcome resistance (रजसुल्लङ्घन उपादानार्थं), to produce motion. All Energy is therefore ultimately kinetic ; even potential Energy (अनुभूतवृत्तिशक्ति) is only the Energy of motion in imperceptible forms.

The Original Constituents and their Interaction.—

Every phenomenon, it has been explained, consists of a three-fold *arche*, intelligible Essence, Energy, and Mass. In intimate union these enter into things as essential constitutive factors. The essence of a thing (Sattva) is that by which it manifests itself to intelligence, and nothing exists without such manifestation in the Universe of Consciousness (समद्विबुद्धि). But the Essence is only one of three moments. It does not possess mass or gravity, it neither offers resistance nor does work. Next there is the element of Tamas, mass, inertia, matter-stuff, which offers resistance to motion as well as to conscious reflection (तमः गुरु वरसकम्).

But the intelligence-stuff and the matter-stuff cannot do any work, and are devoid of productive activity in themselves. All work comes from Rajas, the principle of Energy, which overcomes the resistance of matter, and supplies even Intelligence with the Energy which it requires for its own work of conscious regulation and adaptation. (अन्यान्याभ्याम् अहङ्काराभ्यां स्वकार्योपजनने राजसाहङ्कारः सहकारी भवति । लोकाचार्ये - तद्व्यव-
चक्षित्वाकरस्य ।)

The Gunas are always uniting, separating, uniting again. (अन्योन्यमिषुनाः सङ्घे, नैषानादिसम्प्रयोगो वियोगो वा उपलभ्यते ।) Everything in the world results from their peculiar arrangement and combination. Varying quantities of Essence, Energy, and Mass, in varied groupings, act on one another, and through their mutual interaction and interdependence evolve from the indefinite or qualitatively indeterminate to the definite or qualitatively determinate. (इते गुणाः परस्परोपररूपप्रविभागाः संयोगविभागधर्मोद्यः

इतरेतरोपाक्रमेण उपाश्रितमूर्त्तयः।—व्यासभाष्य।) But though co-operating to produce the world of effects, these divers moments with divers tendencies never coalesce. In the phenomenal product whatever Energy there is is due to the element of Rajas, and Rajas alone; all matter, resistance, stability is due to Tamas, and all conscious manifestation to Sattva. (परस्परराज्जाङ्गित्वेऽपि असंभिन्नशक्तिप्र-
विभागाः—व्यासभाष्य। अन्योन्याङ्गान्निभावेन उत्पादितेऽपि द्रव्ये प्रकाशगुणः
सहस्यैव क्रियागुणः रजसस्य स्थितिगुणस्तमसस्य—विज्ञानभिद्वु, योगवार्तिके
on व्यासभाष्य, *ibid.* नैषां शक्तयः संकीर्यन्ते—वाचस्पतिमिश्र, तत्त्ववैशारदी
on व्यासभाष्य, *ibid.*)

The nature of the interaction is peculiar. In order that there may be evolution with transformation of Energy, there must be a disturbance of equilibrium, a preponderance of either Energy or Mass-resistance or Essence over the other moments. The particular Guna which happens to be predominant in any phenomenon becomes manifest in that phenomenon, and the others become latent, though their presence is inferred by their effect. For example, in any material system at rest the Mass is patent, the Energy latent, and the conscious manifestation sub-latent. In a moving body, the Rajas, Energy, is predominant (kinetic), while the Mass, or rather the resistance it offers, is overcome. In the volitional consciousness accompanied with movement, the transformation of Energy (or work done by Rajas) goes hand in hand with the predominance of the conscious manifestation, while the matter-stuff or Mass, though latent, is to be inferred from the resistance overcome. (प्रधानबेलायाम् उपदर्शितसन्निधाना गुणत्वेषु च व्यापारमात्रेण प्रधानानर्नीतानुभितास्तिताः—व्यासभाष्य।)

The Starting-point.—The starting-point in the cosmic history is a condition of equilibrium or equipoise consisting in a uniform diffusion of the Reals. The tendencies to conscious manifestation, as well as the powers of doing work, are exactly counterbalanced by the resistances of the inertia or Mass: the process of cosmic evolution (परिचयान्) is under arrest. (सत्त्वरजस्तमसं साम्यावस्था प्रकृतिः—Pravachana, Sutra 61, Chap. I. साम्यावस्था अन्यनानतिरिक्तावस्था अन्यनाधिकभावेन असंहतावस्था अकार्थ्यावस्था इति निष्कर्षः—विज्ञानभिक्षु, *ibid.*)

Beginning of Evolution.—The transcendental (non-mechanical) influence of the Purusha (the Absolute) puts an end to this arrest, and initiates the process of creation. Evolution begins with the disturbance of the original equilibrium. How this is mechanically brought about is not very clear. A modern expounder of the Sāṅkhya supposes that the particles of Sattva, Rajas, and Tamas possess a natural affinity for other particles of their own class, and that when the transcendental influence of the Purusha ends the state of arrest, the affinity comes into play, breaks up the uniform diffusion, and leads to unequal aggregation, and therefore to the relative preponderance of one or more of the three Gunas over the others. Thus commences formative combination among the Reals, and consequent productive activity. (संहननम् आरम्भकसंयोगः न्यूनाधिकभावेन अन्योन्म संयोगविज्ञेयः—Sutra 66, Chap. I., प्रवचनभाष्य—विज्ञानभिक्षु । पृथिवीव्यक्तीनां पृथिवीत्वेनैव सस्यव्यक्तीनाम् एकजातीयतया एकता । स्वजातीयोपहम्भादिना वृद्धिहासादिकं च युक्तम् *ibid.*, Sutra 128, Chap. I.)

Formation of Wholes or Systems—Collocation of Reals.—Creative transformation accompanied with

evolution of motion (परिस्पन्द) and work done by Energy (क्रिया) cannot take place without a peculiar collocation of the Reals (Gunas). To form wholes or systems (समुदय) it is essential that one Guna should for the moment be preponderant and the others co-operant. And this cannot be without an unequal aggregation which overthrows the original equilibrium (गुणवैषम्य, न्यूनाधिकभाव)—in other words, without unequal forces or stresses coming into play in different parts of the system. (गुणविभक्ते—वाचस्पति । अरूँ सन्निर्य परिस्पन्दवत् . . . समुदयः सप्तवायः । स च गुणानां गुणप्रधानभावमन्तरेण न सम्भवति । न गुणप्रधानभावो वैषम्यं विना । न च वैषम्यमुपनर्त्तयिष्येकभावाद्गते ।—वाचस्पति, कौमुदी on Káriká 16.)

The Formula of Evolution—Differentiation in Integration.—Evolution (परिणाम) in its formal aspect is defined as differentiation in the integrated (संसृष्टविषेक). In other words, the process of Evolution consists in the development of the differentiated (वैषम्य) within the undifferentiated (साम्यावस्था), of the determinate (विज्ञेय) within the indeterminate (अविज्ञेय), of the coherent (युतसिद्ध) within the incoherent (अयुतसिद्ध). The evolutionary series is subject to a definite law which it cannot overstep (परिणामनियम). The order of succession is not from the whole to parts, nor from parts to the whole, but ever from a relatively less differentiated, less determinate, less coherent whole to a relatively more differentiated, more determinate, more coherent whole. That the process of differentiation evolves out of homogeneity separate or unrelated parts, which are then integrated into a whole, and that this whole again breaks up by fresh differentiation into isolated factors

for a subsequent reintegration, and so on *ad infinitum*, is a fundamental misconception of *the course of material evolution*. That the antithesis stands over against the thesis, and that the synthesis supervenes and imposes unity *ab extra* on these two independent and mutually hostile moments, is the same radical misconception as regards *the dialectical form* of cosmic development. On the Sāṅkhya view, increasing differentiation proceeds *pari passu* with increasing integration within the evolving whole, so that by this two-fold process what was an incoherent indeterminate homogeneous whole evolves into a coherent determinate heterogeneous whole.

The different stadia in the order of cosmic evolution are characterised as follows :—

- (1) The inconceivable, the unknowable, the formless, of which no character can be predicated (अलिङ्ग), including Prakṛiti, or the Reals in a state of equilibrium.
- (2) The knowable, the empirical universe, cosmic matter of experience, things as matter or stuff of consciousness (लिङ्ग), comprising Mahat, the intelligible Essence of the cosmos, evolved by differentiation and integration within the formless, characterless, inconceivable Prakṛiti.
- (3) Individual but still indeterminate stuff bifurcating into two series—Subject-experience and Object-experience, comprising on the one hand the indeterminate unity of apperception, or the empirical Ego, as the co-ordinating principle of the Subject-series (अस्मिता), and on the other hand

(though through the mediation of this subjective modification, अस्मिता or Ahāṅkāra) the indeterminate material potencies, the subtile vehicles of potential Energy (तन्मात्र, सूक्ष्मभूत), the ultimate subtile constituents of the Object-series (the material world). The previous stadium, the cosmic matter of Experience (लिङ्ग, महत्), evolves within itself, by differentiation and integration, an individuated but still indeterminate stuff in two co-ordinated series, Subject and Object, though the latter is mediated through the former.

- (4) Determinate stuff (विशेष) evolved within the indeterminate by further differentiation and integration, viz., in the series of Subject-experience, sensory and motor stuff; and in the Object-series, a corresponding atomic matter-stuff actualising the material potencies in the form of specific sensible Energies. The latter includes the different classes of Paramānus, the different kinds of atomic constituents of different kinds of gross matter (स्थूलभूत).
- (5) Coherent and integrated matter-stuff, individual substances, characterised by generic and specific properties, which however are not rigidly fixed, but fluent, being subject to a three-fold change and constantly evolving. (अयुतसिद्धावयवभेदानुगतः समूहः द्रव्यमिति पतञ्जलिः—व्यासभाष्य, Sutra 44, Chap. III. सामान्यविशेषसमुदायो द्रव्यं—व्यासभाष्य, *ibid.* सामान्यविशेषात्मा अन्वयी धर्मो, *ibid.* धर्मिणां धर्मैल्लक्षणावस्थापरिचयः)

(6) And so the cosmic series moves on in ascending stages of unstable equilibrium (विसङ्गस्यपरिचयान्) until the reverse course of equilibration and dissipation of Energy (सङ्गस्यपरिचयान् and साम्यावस्था), which even now constantly accompanies the evolution and transformation of Energy, completes the disintegration of the Universe into its original unmanifested ground, the unknowable Prakriti.

The order of Cosmic Evolution according to the आसभाष्य (Sutra 19, Pada II.) is shown below in a tabular form :—

Prakriti, the unmanifested unknowable ground

(गूढमव्यक्तमलिङ्गं)

Cosmic matter of experience (महत्, लिङ्गं)

SUBJECT SERIES (अविज्ञेय). → OBJECT SERIES (अविज्ञेय) :

evolved in the cosmic matter of experience but through the mediation of the individuated mind-stuff अस्मिता (Ahañkāra).

Individuated indeterminate mind-stuff (unity of apperception, empirical Ego (अस्मिता).

Individuated but indeterminate matter - stuff (subtile material potencies (तन्मात्र).

Determinate mind - stuff (विज्ञेय), sensory and motor psychoses, etc. (ज्ञानेन्द्रिय, कर्मेन्द्रिय and मनः).

Determinate matter-stuff (विज्ञेय), atomic and molecular constituents of gross matter (परमाणु—स्थूलभूत).

Coherent and integrated matter-stuff (अयुतसिद्धावयवः समूहः सङ्घातः द्रव्यं).

Individual substances, with generic and specific characters subject to constant change or evolution, e.g. inorganic objects composed of atoms or molecules (परमाणु), vegetable organisms (वृक्ष), animal organisms (शरीर). (अयुतसिद्धावयवः सङ्घातः शरीरं वृक्षः परमाणुरिति—व्यासभाष्य, Sutra 44, Pada III.)

तत्र तत् संसृष्टं विविच्यते क्रमानतिवृत्तेः, तथा बहुविज्ञेयाः लिङ्गमात्रे संसृष्टा विविच्यन्ते, परित्यागक्रमनियमात्, तथा तेषु अविज्ञेयेषु भूतेन्द्रियाणि संसृष्टानि विविच्यन्ते, न विज्ञेयेभ्यः परं तस्मान्नरमस्ति तेषाम् धर्मलक्षणव्याख्यापरित्यागात् व्याख्याविच्यन्ते । (व्यासभाष्य, Sutra 19, Pada II.)

N.B.—The usual order given in the Sāṅkhya-Pātañjala compendiums is as follows :—Prakṛiti, Mahat, Ahankāra—and then the bifurcation, viz. 11 organs (sensory, motor and common sensori-motor) from Rājasic Ahankāra, and Tanmātras from Tāmasic Ahankāra—and

finally the *Paramānus* of the *Sthūla Bhūtas*. This is literally correct, but misses the significance of the doctrine of "differentiation within the integrated," according to which the *Tanmātras* are all evolved, through the medium of *Ahaṅkāra*, in the cosmic matter of Experience (*Mahat*).

The Conservation of Energy (and of Mass)—the Transformation of Energy.—The *Gunas* (*Reals*), though assuming an infinite diversity of forms and powers, can neither be created nor destroyed. The totality of the *Mass* (*Tamas*), as well as of *Energy* (*Rajas*), remains constant, if we take account both of the manifested and the unmanifested, the actual and the potential. But the individual products of the evolutionary process—the concrete phenomenal modes resulting from the combined action of the original *Mass*, *Energy*, and *Essence*—are subject to addition and subtraction, growth and decay, which are only due to changes of collocation, and consequent changes of state from the potential to the actual (in other words, from the future to the present and from the present to the past, in a time series)—changes which are illusorily ascribed to the *Reals* themselves. The different collocations of *Mass* and *Energy* give birth to the divers powers of things, the various forms of *Energy* which may be classed as like and unlike; indeed, the course of *Evolution* from the *Reals* conforms to a fixed law, not only as regards the order of succession, but also as regards the appearance (and mutual relations) of like and unlike *Energies*. And this transformation is constantly going on—the course of *Evolution* is not arrested for a moment.

गुणास्तु सर्वधर्म्मोनुपातिनः न प्रत्यस्तमयन्ते नोपजायन्ते व्यक्त्तिभिरेव
 अतीताऽनागतव्ययागमवतीभिः गुणान्वयिनीभिः उपजनापायधर्म्मेका इव
 प्रत्यवभासन्ते (व्यासभाष्य, Sutra 19, Pada II.) परिग्रामिनित्यता
 गुणानाम्। सर्व्वेभिर्दं गुणानां सत्त्विशेषशेषमात्रम्। (*ibid.*, Sutra 13,
 Pada IV.) एते गुणाः तुल्यजातीयानुत्पजातीयशक्तिभेदानुपातिनः (*ibid.*,
 Sutra 19, Pada II.) परिग्रामक्रमनियमात् (व्यासभाष्य, Sutra 19,
 Pada II.) क्रमान्वयत्वे परिग्रामान्वयत्वे हेतुः (Patañjali, Sutra 15,
 Pada III.) प्रकृतिः परिग्रामनशीला अग्रमप्यपरिग्रम्य नावतिष्ठते।

The Doctrine of Causation, a corollary from the conservation and transformation of Energy—the Principle of Collocation—the Storing-up and the Liberation of Energy :—

The Sāṅkhya view of causation follows at once as a corollary from this doctrine of the conservation and transformation of Energy. As the total Energy remains the same while the world is constantly evolving, cause and effect are only more or less evolved forms of the same ultimate Energy. The sum of effects exists in the sum of causes in a potential (or unevolved) form. The grouping or collocation alone changes, and this brings on the manifestation of the latent powers of the Gunas, but without creation of anything new. What is called the (material) cause or sum of material causes is only the power which is efficient in the production, or rather the vehicle, of the power. This power is the unmanifested (or potential) form of the Energy set free (उद्भूतवृत्ति) in the effect. But the concomitant conditions are necessary to call forth the so-called material cause into activity. When the favourable combination or co-operation of concomitants is wanting, there is no manifestation of the

effect. The question is—what is the aid which the concomitant conditions render to the determination (and production) of the effect existing in potency in its material cause? First there is the merely mechanical view as illustrated by some commonplace examples, *e.g.*, the manifestation of the figure of the statue in the marble block by the causal efficiency of the sculptor's art, or of the oil in the sesamum-seed by pressing, or of the grain of rice out of the paddy by the process of husking. In these cases the manifestation of an effect is only its passage from potentiality to actuality, a stadium in the process of evolution from possible (future) existence to actual (present) existence; and the concomitant condition (सहकारिभक्ति) or efficient cause (निमित्तकारण), the sculptor's chiselling, the pressing, the husking, is a sort of mechanical or instrumental help to this passage or transition. कार्यभक्तिरन्वये उपादान-कारणत्वम् । सा भक्तिः कार्यस्य अनागतावस्था एव । स एव विज्ञेयः (उत्पन्नेः प्राक् कारणे विज्ञेयः) अस्माभिः कार्यस्य अनागतावस्था इत्युच्यते । (विज्ञानभिक्षु-प्रवचनभाष्य, Sutra 115, Chap. I.) अभिव्यक्तिः वर्तमानावस्था । कारणव्यापारेणैव कार्यस्य वर्तमानलक्षणापरिणाममेव जनयति । यथा शिलास्यप्रतिमायाः लैङ्गिकव्यापारेण अभिव्यक्तिर्नात्र तिलस्यतैलस्य च निष्पीडनेन धान्यस्यतद्गुलस्य च अचघातेन । (विज्ञानभिक्षु-प्रवचनभाष्य, Sutra 129, Chap. I.)

These mechanical examples of the Kapila-Sāṅkhya have the merit of simplicity, but the Patañjali-Sāṅkhya brushes them aside, and explains causation on the basis of the conservation and transformation of Energy advancing it as the liberation of potential Energy existing stored up in a *Guṇa* collocation (the sum of material causes), the liberation following on the action

of the proximate efficient cause, or concomitant condition (निमित्तकारण).

The causal operation of concomitant conditions (efficient causes) lies only in this, that they supply a physical stimulus which liberates the potential Energy stored up in a given collocation. Everything in the phenomenal world is but a special collocation of the ultimate Reals (Energy, Mass, and Essence). The sum of (material) causes potentially contains the Energy manifested in the sum of effects; and in the passage from potency to actualisation, the effectuating condition (the concomitant cause), when it is itself accomplished, is only a step in the evolutionary series, which adds a specific stimulus, and renders determinate that which was previously indeterminate. When the effectuating condition is added to the sum of material conditions in a given collocation, all that happens is that a stimulus is imparted which removes the arrest, disturbs the relatively stable equilibrium, and brings on a liberation of Energy (उद्गतवृत्तिशक्ति) together with a fresh collocation (गुणसन्निवेशविशेष). सञ्ज्ञेभिर्दं गुणानां सन्निवेशविशेषमात्रम् इति परमार्षतो गुणात्मानः (आसभाष्य, Sutra 13, Pada IV.) सतश्च फलस्य निमित्तं वक्ष्यमानोकारणे समर्थं न अपूर्वोपजनने । सिद्धं निमित्तं नैमित्तिकस्य विशेषानुग्रहं कुरुते । नापूर्वमुत्पादयति । (आसभाष्य, Sutra 12, Pada IV.).

Describing the production of bodies ("organic vehicles") for individual souls out of matter of Prakriti, under the influence of their merit and demerit, as concomitant conditions, Patañjali points out that non-material concomitants like merit and demerit do not supply any moving force or Energy to the sum of

material conditions, but only remove the arrest (the state of relatively stable equilibrium) in a given collocation, even as the owner of a field removes the barrier in flooding his field from a reservoir of water. This description is intended to represent the super-physical influence of non-material concomitants (or causes) like volition, merit and demerit, etc., but the causal operation of a material concomitant condition is essentially the same; there is the same reservoir of stored-up Energy in a given collocation, the same condition of arrest or relatively stable equilibrium, the same liberation of the stored-up potential Energy which flows along the line of least resistance; the only difference being that in the case of material concomitants the stimulus which removes the arrest is physical, instead of being transcendental as in the case of non-material causes like will, merit and demerit, etc.

The Vyása-Bháshtya helps us to a clear mental representation of the details of this process:—As the owner of many fields can irrigate, from a field which is already flooded, others of the same or a lower level, without forcing the waters thereto with his hands, and merely by making an opening in the barrier or dyke, on which the waters rush in by their own force; or, further, as the same person cannot force these waters, or the earthy matters held in solution therein, into the roots of the rice plants, but only removes the obstructive grasses and weeds, on which the fluids of their own power enter the roots;—such is the action of an effectuating condition (निमित्त) added to a sum of material causes or conditions.

निमित्तम् अग्रयोजकं प्रवृत्तीनां वरणभेदस्तु ततः क्षेत्रिकवत् । (Patañjali, Sutra 3, Pada IV.) न हि धर्मादि निमित्तं यथा क्षेत्रिकः केदारात् अर्पां पूरयात् केदारं पिप्पलावयिषुः समं निम्बं वा निम्बतरं वा नापः पाणिनाप-
करोति चावरणं तु आसां भिनक्ति तस्मिन् भिक्षे स्वयमेवापः केदारान्तरं
आप्सावयन्ति ।

Chain of Causation—Fixed Order.—The order of Evolution with the transformation of the Energies follows a definite law. The unalterable chain of causes and effects in the phenomenal world illustrates this fixed order. But though the cosmic order is one and fixed, it comprehends divers series arising from different combinations of the original Gunas, which constitute subordinate or particular laws of cause and effect (क्रमान्वयं परिणामान्वये हेतुः, Patañjali, Sutra 15, Pada III.).

What we call the qualities of things are only modes of Energy acting in those collocations. योग्यतावच्छिन्ना धर्मिण्यः शक्तिरेव धर्मः—स च फलप्रसवभेदानुमितसद्भावः । (आसभाष्य, Sutra 14, Pada III.) ते सत्वनी धर्मा वर्तमाना व्यक्तात्मानः, अतीताऽनागताः सुक्ष्मात्मानः सर्व्वमिदं गुणानां सत्त्वैशमात्रमिति परमार्थतो गुणात्मानः । (आसभाष्य, Sutra 3, Pada IV.). And these various Energies are sometimes actual (kinetic), sometimes potential, rising to actuality, and sometimes sub-latent, subsiding from actuality into sub-latency. In fact, the original Energy is one and ubiquitous, and everything therefore exists in everything else, *potentialiter* (सर्व्वं सर्व्वोत्पत्तिमिति), without prejudice to the generic and specific differences of things (जात्यनुच्छेदेन सर्व्वं सर्व्वोत्पत्तिः). Inorganic matter, vegetable organisms, and animal organisms are essentially and ultimately one (जलभूम्योः पारिणामिकं रसादिवैश्वरुष्यं स्यावरेषु दृष्टं तथा स्यावराणां जङ्गलेषु जङ्गमानां स्यावरेषु) so far as Mass and Energy are

concerned, but the varied forms of Energy and the generic and specific qualities (or properties) of things, which are but modes of Energy, follow a definite unalterable law in the order of their appearance and succession, under conditions of space, time, mode, and causality, and hence all effects do not manifest themselves at once. देशकालाकारनिमित्तापवन्धात् न खलु समानकालम् चाल्मनामभिष्यक्तिः (*ibid.*, Sutra 14, Pada III.) यो यस्य धर्मेस्य समनन्तरो धर्मेः स तस्य क्रमः । पितृः प्रथ्यवते षट् उपजायते इति धर्मेपरिष्कारक्रमः । लघ्वद्यापरिष्कारक्रमः षट्स्य अनागतभावात् वर्तमानभावक्रमः, तथा पितृस्य वर्तमानभावात् अतीतभावक्रमः । (व्यासभाष्य, Sutra 15, Pada III.).

Time, Space, and the Causal Series.—A Tanmātra (infra-atomic particle of subtile matter) is conceived by our understanding to stand in three relations—(1) position in Space (देशावच्छिन्न), (2) position in the Time-series (कालावच्छिन्न), and (3) position in the Causal-series (निमित्तावच्छिन्न).

These three relations are the work of the intuitive stage of knowledge (निश्चिकित्सप्रज्ञा) as opposed to the conceptual (सविकित्सप्रज्ञा). But this is not the pure relationless intuition of Reality (निश्चिन्तारा निश्चिकित्सप्रज्ञा), which may be termed intellectual intuition, but the intuition that imposes its forms on the Real substrate (सविचारा निश्चिकित्सप्रज्ञा) or in other words empirical intuition.

तत्र भूतसूक्ष्मेषु अभिव्यक्तधर्मेकेषु देशकालनिमित्तानुभाववच्छिन्नेषु या समापक्तिः सा सविचारा इत्युच्यते । तथापि एकबुद्धिनिर्गोक्षमेव उदितधर्मेविशिष्टं भूतसूक्ष्मनालम्बनीभूतं समाधिप्रज्ञायानुपतिष्ठते । (व्यासभाष्य, Sutra 44, Pada I.).

Infinite Time is a non-entity objectively considered, being only a construction of the understanding

(बुद्धिनिर्माक) based on the relation of antecedence and sequence, in which the members of the phenomenal series are intuited to stand to one another. These phenomenal changes as intuited by us in the empirical consciousness fall into a series, which the understanding conceives as order in Time. The Time-series, then, is a *schema* of the understanding for representing the course of Evolution. The *schema* of the understanding supervenes on the phenomenal world as order in Time, and hence in the empirical consciousness the Time-series appears to have an objective reality, and to form a continuum. As there is an ultimate and irreducible unit of extensive quantity (परिमाणक) in the Gunas or infinitesimal Reals of Prakriti, which are without constituent parts, so the moment may be conceived as the ultimate and irreducible unit of this Time-continuum as represented in the empirical consciousness. A moment therefore cannot be thought of as containing any parts standing in the relation of antecedence and sequence. If change is represented by the Time-series, a moment as the unit of time may be supposed to represent the unit of change. Now all physical change may be reduced to the motion of atoms in space, and we may therefore define the moment as representing the ultimate unit of such change—viz. the (instantaneous) transit of an atom (or rather a Tanmátra) from one point in space to the next succeeding point. Even an atom has constituent parts (the Tanmátras), and hence an atom must take more than one moment to change its position. The motion of that which is absolutely simple and without parts from

one point in space to the next must be instantaneous, and conceived as the absolute unit of change (and therefore of time, क्षण). If this is held to be an irreducible absolute unit, it will follow that what we represent as the Time-continuum is really discrete. Time is of one dimension. Two moments cannot co-exist; neither does any series of moments exist in reality. Order in Time is nothing but the relation of antecedence and sequence, between the moment that is and the moment that went just before. But only one moment, the present, exists. The future and the past have no meaning apart from potential and sub-latent phenomena. One kind of transformation to which a thing is subject is that it changes from the potential to the actual, and from the actual to the sub-latent. This may be called the change of mark (लक्षणापरिणाम) as opposed to change of quality (धर्मपरिणाम) and the change due to duration or lapse of time (अवस्थापरिणाम). The present is the mark of actuality, the future the mark of potentiality, and the past of sub-latency, in a phenomenon. Only one single moment is actual, and the whole Universe evolves in that one single moment. The rest is but potential or sub-latent.

अणतत्क्रमयोर्नास्ति वस्तुसमाहार इति बुद्धिसमाहारः मुहूर्त्ताहोरात्रादयः । स सत्यं कालः वस्तुशून्यो बुद्धिनिष्क्रियः शब्दज्ञानानुपाती लौकिकानां अल्पित-दशैर्नानां वस्तुस्वरूप इव अवभासते । अणस्तु वस्तुपतितक्रमावलम्बी । क्रमश्च अणानन्तर्गतात्मा । तं कालविदः काल इति आचक्षते योगिनः । न च द्वौ अणौ सह भवतः, क्रमश्च न द्वयोः सहभुवोरसम्भवात् पूर्वोत्तराभ्यां यदानन्तर्यं अणस्य स क्रमः । तस्मात् वर्तमान एवैकः अणः न पूर्वोत्तराभ्याः सन्तीति तस्मादास्ति तत्समाहारः । ये तु भूतभाविनः अणाः ते परिणामान्विता व्याख्येयाः । तेनैकेन अणेन कृत्वो लोकः परिणाममनुभवति, तत्क्षणाद्गदाः

सत्त्वमी भर्त्माः । यथाऽपकर्षपर्यन्तं द्रव्यं परमाणुः एवं परमाणुपकर्षपर्यन्तः कालः क्षणः । यावता वा समयेन चलितः परमाणुः पूर्वदेशं जहात् उत्तरदेशम् उपसम्पद्यते स कालः क्षणः, तत्रवाहापिच्छेदस्तु क्रमः । (व्यासभाष्य, Sutra 52, Pada III.).

Vijñāna-bhikshu points out that this does not amount to a denial of Time. It means that Time has no real (or objective) existence apart from the "moment." But the latter is real, being identical with the unit of change in phenomena (गुणपरिणामस्य क्षणत्ववचनान्). But even this is real only for our empirical (relative) consciousness (सुप्तियतदर्शन), which intuits the relation of antecedence and sequence into the evolving Reals (Gunas), in the stage of "empirical intuition" (सविचारानिश्चिक्त्यप्रज्ञा). The "intellectual intuition" (निश्चिचारानिश्चिक्त्यप्रज्ञा), on the other hand, apprehends the Reals as they are, without the imported empirical relations of Space, Time, and Causality.

Space as Extension and Space as Position.—Space must be distinguished as *Desa* (locus, or rather extension) and *Dik* (relative position). Space (*Dik*) as the totality of position, or as an order of co-existent points, is wholly relative to the understanding, like order in Time, being constructed on the basis of relations of position intuited by our empirical (or relative) consciousness. But there is this difference between Space-order and Time-order: there is no unit of Space as position (*Dik*), though we may conceive a unit of Time, viz. the moment (क्षण), regarded as the unit of change in the phenomenal or causal series (परमाणुक्रिया—गुणपरिणामस्य क्षणत्ववचनान्—योगवासिष्ठिक, Sutra 51, Pada III.). Spatial position (*Dik*) results only from

the different relations in which the all-pervasive *Ākāśa* stands to the various finite (or bounded) objects. On the other hand, Space as extension or locus of a finite body, *Desa* (देशः स्थिताधारः), has an ultimate unit, being analysable into the infinitesimal extensive quantity inherent in the Reals (*Gunās*) of *Prakṛiti*. (गुणप्रकृते-
रगुपरिचयः—योगवार्तिक । एतेन निम्ना दिग्धि अग्रामाधिकी व्याख्याता,
सामान्यतो दिग्ध्व्यवहारभावात् । पूर्वोदिग्ध्व्यवहारस्य दिग्गुपाधिभिरेव सम्भवात् ।
सामान्यतः कालदिग्ध्व्यवहारसञ्ज्ञेऽपि आकाशादेव तदुपपत्तेः । कालाच्च
दिश्यते विश्लेषः यत् कालः क्षयरूप इत्यते, दिक् तु सर्वथैव नेष्यते ।)

The Causal-Series.—The relation of Cause and Effect has been already explained. It only remains to add that the category of causality is mediated through the *schema* of order in Time. The empirical intuition first superimposes relations of antecedence and sequence on changing phenomena (the evolving *Gunās* or Reals), and the understanding out of these relations creates order in Time. The empirical intuition then intuits the phenomenal series of transformations of Energy in this Time-order, and in so doing imports the relation of cause and effect into the course of Nature. (कार्यकारणभावादीनां
क्षयवदितत्वात्—योगवार्तिक, Sutra 51, Pada III.)

The Dissipation of Energy (and of Mass)—their Dissolution into the Formless Prakṛiti.—Cosmic Evolution (परिचयः) is a two-fold process, creative as well as destructive, dissimilative as well as assimilative, katabolic as well as anabolic (अनुलोमसर्गे and विलोमसर्गे, विसदृशपरिचयः and सदृशपरिचयः). In one aspect there is the aggregation (unequal aggregation) of Mass and Energy, with consequent transformation of Energy, resulting in the creation of inorganic as well as organic

matter, and the genesis of worlds. The successive steps of this process may be described as (1) unequal aggregation with storing-up of Energy in a certain collocation, under a state of arrest (*i.e.* in a state of relatively stable equilibrium), (2) a stimulus removing the arrest and disturbing the equilibrium, and (3) liberation of the Energy, moving on to a fresh collocation, fresh aggregation, arrest, and equilibrium. The process of the world thus moves on from equilibrium to equilibrium, and the result of that process is the development of a coherent determinate heterogeneous whole (लिङ्ग, अविशेष, विशेष, अयुतसिद्धावयवसमूह, युतसिद्धावयवसमूह) in what is essentially an incoherent indeterminate homogeneous whole (अलिङ्ग).

But there is a second aspect of this evolutionary process. Unequal aggregations are unstable; there is a constant tendency in things to go back to the original stable equilibrium, the state of uniform equal diffusion of Reals. This process is called the resolution of like to like (सदृशपरिचय), consisting in assimilation and dissipation, and being the exact opposite of the process of "differentiation in the integrated" which has evolved the Cosmos. The collocations of Mass, Energy, and Essence are always breaking up, and the Energy, as well as the Mass, however slowly, however imperceptibly, are being dissipated, *i.e.* dissolved into the original formless Prakriti, a state of permanent equilibrium and arrest, from which there is, and can be, no return, except under the transcendental influence of the Absolute at the commencement of a new creative cycle. Not that there is a destruction of the Mass or Energy,

but a dissipation or dissolution into a condition of equal uniform diffusion from which there is no return. This is not the phenomenon of kinetic Energy disappearing and becoming potential or sub-latent, for in such cases there is restitution or reconversion by natural means. When this reverse current of assimilation (and dissipation) prevails over the current of dissimilation (and integration), the Universe will disintegrate more and more, until it disappears in the formless Prakriti, its unknowable source and ground. (*Vide* तन्मात्र and कौमुदी.)

The Evolution of Matter (तन्मात्रिक सृष्टि). — The ultimate constitution of Matter is a question of the profoundest interest in the Sāṅkhya-Pātañjala system. Three stages clearly stand out in the genesis of Matter:—(1) the original infinitesimal units of Mass or inertia, absolutely homogeneous and ubiquitous, on which Energy does work, when the original equilibrium comes to an end (भूतादि—तानसाहकार); (2) the infra-atomic unit-potentials, charged with different kinds of Energy, which result from the action of Energy on the original units of Mass (तन्मात्र); and (3) the five different classes of atoms, the minutest divisions of which gross matter is capable, but which are themselves complex Tanmātric systems (स्थूलभूतपरमाणु).

The first stadium, Bhūtādi, is absolutely homogeneous and absolutely inert, being devoid of all physical and chemical characters (रूपादिभिरसंयुत) except quantum or mass (परिच्छिन्नत्व, परिमाण); and this admits neither of addition nor of subtraction, can neither be created nor destroyed. The second stadium, Tanmātra, represents subtile matter, vibratory, impingent, radiant, etc.,

instinct with potential energy. These "potentials" arise from the unequal aggregation of the original Mass-units in different proportions and collocations with an unequal distribution of the original Energy (Rajas). (तन्मात्र-रूपादेः किं कारणम् इति चेत् स्वकारणद्रव्याणां न्यूनाधिकभावेन अन्योन्यं प्रति संयोगविशेष एव—स्वाजातीयोपहन्नादिना वृद्धिहासादिकं च युक्तं ।) The Tanmátras possess something more than quantum of Mass and Energy; they possess physical characters, some of them penetrability (अवकाशदान), others powers of impact or pressure, others radiant heat, others again capability of viscous and cohesive attraction. In intimate relation to these physical characters they also possess the potentials of the energies represented by sound, touch, colour, taste, and smell; but being subtile matter, they are devoid of the peculiar forms (विशेष) which these "potentials" assume in particles of gross matter like the atoms and their aggregates. In other words, the potentials lodged in subtile matter must undergo peculiar transformations by new groupings or collocations to be classed among sensory stimuli—gross matter being supposed to be matter endued with properties of the class of sensory stimuli, though in the minutest particles thereof the sensory stimuli may be infra-sensible (अतीन्द्रिय but not अनुभूत). (तस्मिंस्तस्मिंस्तुतन्मात्राः ते च अविशेषविधयः । ते च पदार्थाः ज्ञानधोरमूढास्थैः स्थूलगतशब्दादिविशेषैः शून्या एकरूपत्वात् । तथाच ज्ञानादिविशेषशून्यशब्दादिमत्समेव भूतानां शब्दादितन्मात्रत्वम् ।)

The Tanmátras, then, are infra-atomic particles charged with specific potential energies. First, the "potential" of the sound-stimulus is lodged in one class of particles, Tanmátras which possess the physical

energy of vibration (परिस्पन्द), and serve to form the radicle of the ether-atom (आकाशपरमाणु); then the potential of the tactile stimulus is lodged in another class of Tanmātras, particles which possess the physical energy of impact or mechanical pressure in addition to that of vibration, and serve to form the radicle of the air-atom (Vāyu Paramānu); next, the potential of the colour-stimulus is lodged in a third class of Tanmātras, particles which are charged with the energy of radiant heat-and-light, in addition to those of impact and vibration, and serve to form the nucleus of the light-and-heat corpuscle; then the potential of the taste-stimulus is lodged in other Tanmātras, particles which possess the energy of viscous attraction, in addition to those of heat, impact, and vibration, and which afterwards develop into the atom of water; and, lastly, the potential of the smell-stimulus is lodged in a further class of Tanmātras, particles which are charged with the energy of cohesive attraction, in addition to those of viscous attraction, heat, impact, and vibration, and which serve to form the radicle of the earth-atom.

षड्विंशोऽध्यायः तद्व्यायं शब्दतन्मात्रं स्पृशतन्मात्रं रूपतन्मात्रं रसतन्मात्रं गन्ध-
तन्मात्रञ्च इत्येकद्विविधतुस्यचलक्षणाः शब्दादयः पञ्चाविंशोऽध्यायः । (व्यासभाष्य,
Sutra 19, Pada II.) अहङ्कारात् शब्दतन्मात्रं ततश्चाहङ्कारसहकृतात्
शब्दतन्मात्रात् शब्दस्पृशगुणं स्पृशतन्मात्रम् । एवंक्रमेण एकैकगुणपृष्ठा तन्मात्राणि
उत्पद्यन्ते । (प्रवचनभाष्य, Sutra 62, Chap. I.)

शब्दादीनां मूर्तिसमानजातीयानाम् एकः परिग्रामः पृथिवीपरमाणुः तन्मात्रा-
वयवः । भूतान्तरेषु अपि जेहीष्यप्रणामित्वाञ्चकाशदानानि उपादाय सामान्यम्
एकविकारारम्भः समाधेयः । (व्यासभाष्य, Sutra 14, Pada IV.) तद्व्यायं ।
गन्धतन्मात्रं वर्ञ्चयित्वा चतुस्तन्मात्राणां जेहजातीयानाम् एकः परिग्रामः जल-
परमाणुः तेषां च महाजलादिः । एवं गन्धरसौ वर्ञ्चयित्वा जीष्यजातीयानां

चित्तमात्राणां तेजोऽणुः तेभ्यः महातेजसादिः । एवं गन्धरसरूपाणां चञ्चनान्
 द्वाभ्यां वाय्वणुः तेभ्यः महावाय्वादिः । एवं शब्दतन्मात्रादहङ्कारांशसहकृतात्
 आकाशाणुः तेभ्यः महाकाशादिः ।

विज्ञानभिक्षु remarks : अत्र दर्शने अयं सिद्धान्तः शब्दादितन्मात्रपञ्चके
 काठिन्यकोहादिव्यङ्ग्याः पृथिवीत्वादिजातयः सन्ति । (योगवासिक, Sutra 14,
 Pada IV.).

Before explaining the genesis of atoms it is necessary to say something about *Ákása*, which is the link between the infra-atomic particles (*Tanmátras*) and atoms (*Paramánus*). *Ákása* corresponds in some respects to the ether of the physicists, and in others to what may be called proto-atom (protyle). In one aspect *Ákása* is all-pervasive (विष्णु), and devoid of the property of impenetrability which characterises even the infra-atomic potential units (*Tanmátras*). In another aspect *Ákása* is described as having originated out of the mass, or inertia, in *Prakṛiti* (*Bhútádi*) when the latter became charged with the first potential (the sound-potential). *Vijñána-bhikshu*, in the *Yoga-Vártika*, boldly tackles the difficulty. *Ákása*, he explains, has two forms—original and derivative, non-atomic and atomic. The original *Ákása* is the undifferentiated formless *Tamas* (mass in *Prakṛiti*, matter-rudiment—*Bhútádi*), which is devoid of all potentials, and is merely the all-pervasive seat or vehicle of the ubiquitous original Energy (*Rajas*). This *Ákása* must not be confounded with vacuum, which is merely negative (आवरणाभाव—un-occupiedness), though it must be conceived as all-pervasive, occupying the same space as the various forms of gross matter (समानदेशकम्—अवकाशरूपम् आकाशं—योगवासिक), and therefore devoid of

the property of impenetrability (मूर्धानरासमानदेशान्—योगवास्तिक) which characterises atomic matter. But when the original equilibrium (साम्यावस्था) comes to an end, unequal aggregations form collocations in different groups and proportions of the three Gunas (मूनाधिकभावेन अन्योऽन्यं संयोगविशेषः संहननं—विज्ञानभिद्यु, प्रवचनभाष्य and योगवास्तिक). The transformation of Energy now begins—working on a collocation of mass (with Essence) (गुणान्तरापसमृद्धं सद्दशतः—विज्ञानभिद्यु, योगवास्तिक); it first gives rise to the sound-potential (शब्दजननयोग्यार्थरूपेण परिणमति—विज्ञानभिद्यु), and the atomic *Ákása* (proto-atom, protyle) is but an integration of the original unit of mass charged with this vibration-potential. This vibratory (or rather rotary) ether-atom (आकाशाणु) is integrated, limited (परिच्छिन्न), and as such cannot occupy the same space with other (subsequently integrated) atoms. But this proto-atomic integration of *Ákása* (कार्याकाश) is formed everywhere, and, itself residing in the ubiquitous non-atomic *Ákása* (कारणाकाश—अवकाशरूपमाकाशं), forms the universal medium in which air or gas atoms, light-and-heat corpuscles, and other atoms move and float about.

वायोरावरणं । यदि हि अवकाशरूपम् आकाशं न स्यात् तदा मूर्तेद्रव्येषु स्यात्वादिषु अन्नस्तेजसादिप्रवेशो न स्यात् (विज्ञानभिद्यु, योगवास्तिक, Sutra 40, Pada III.) आकाशं हि कार्यकारणरूपेण द्विविधम् । तत्र कारणाकाशं तनोगुणविशेषतयैव व्यभिच्यते । तदानीम् आकाशाताव्यञ्जकशब्दादिगुणविशेषाभावात् । तच्च कारणाकाशं गुणान्तरापसमृद्धं सद्दशतः आदी शब्दजननयोग्यार्थरूपेण परिणमते । ततश्च अणुसङ्घातेन पृथिवीवदेव महाभूताकाशम् अहङ्कारापेक्षया परिच्छिन्नं वायोरावरणम् उत्पद्यते (विज्ञानभिद्यु, योगवास्तिक, Sutra 40, Pada III.).

The Genesis of the Infra-Atomic Unit-Potentials (Tanmátras) and of the Atoms.—The subject of the

genesis and the structure of the Tanmátras and the Paramánus was a fascinating one to these ancient thinkers, and a wide divergence of views prevailed. I will here notice several typical views—those of the Vishnu Purána, Parásara, Patañjali, and a certain school of Vedántists reported in the तत्त्वनिरूपण.

I. A famous passage in the Vishnu Purána explains the genesis and the structure of the Tanmátras and of the Bhútas (Paramánus) in the following manner :—

The first Tanmátra originated from the rudiment-matter (Bhútádi), the individuated but still indeterminate potential-less Mass in Prakṛiti, under the action of Energy (उपहृतः परिणमयन्ति—प्रवचनभाष्य, Sutra 62, Ch. I.) by a process of disintegration and emanation (विकुञ्जाद्यः—विद्युत्पुराण—एकविकारारम्भः—व्यासभाष्य, Sutra 14, Pada IV. विकरणभावः विकीर्णतास्यभावा व्यापिता इति यावत्, योगवार्त्तिक on Pátañjali's Sutra—मनोजवित्तं विकरणभावः etc.) in the menstruum, or surrounding medium of the unindividuated cosmic mass (Mahat, महतावृतः).

This first subtile matter, the first result of “Mass-disintegration” and Energy-transformation, is charged with the sound-potential, the potential of vibration or oscillation (परिस्पन्द). It is called the sound-potential (शब्दतन्मात्र).

This is typical of the genesis (and structure) of the other Tanmátras (kinds of subtile matter). In each of the remaining cases, an atomic Mass charged with actual specific energies (भूतपरमाणु) disintegrates and emanates, and thus evolves a form of subtile matter (a kind of Tanmátra) under the action of Energy, and always in the same menstruum or surrounding medium

—that of Bhútádi, the super-subtile. Each kind of subtile matter becomes charged with a new potential in addition to the potentials already evolved. The genesis of an atom, a Bhúta-Paramánu, is a quite different process. Here the unit-potential (Tanmátra) receives an accretion of Mass, and by a sort of condensation and collocation evolves an atom (Bhúta-Paramánu).

The genesis and structure of the Tanmátras and the Bhúta-Paramánus are worked out below :—

1. The super-subtile individuated Mass (rudiment-matter, Bhútádi), under the action of the original Energy (रजः) disintegrates and emanates (विकुरुते) in the menstruum or surrounding medium (सनावरण) of Mahat cosmic super-subtile Mass, and evolves a form of subtile matter (तन्मात्र), which becomes charged with the sound-potential (vibration-potential, परित्यन्द), and is called the unit of sound-potential (शब्दतन्मात्र).
2. This subtile matter, the Mass, charged with sound-potential, receives an accretion of Mass from the rudiment-matter (Bhútádi), and by condensation and collocation evolves the Ákása Bhúta, the atomic Ákása, the proto-atom charged with the specific Energy of the sound-stimulus (actual vibratory motion). (स एव भूतादिः शब्द-तन्मात्रात् स्वद्वितीयात् शब्दगुणकम् आकाशं तस्यैव । तथाच अहङ्कारशब्दतन्मात्राभ्यां मिलित्वा आकाशं सृज्यते—योगवासिक on the Vishnu Purána passage, Sutra 14, Pada IV.)
3. This proto-atom, the atomic Ákása, charged with its actual specific Energy, again disintegrates and

emanates, under the action of the original Energy and in the menstruum of the rudiment-matter (super-subtile Mass), and thus evolves another kind of subtile matter (Tanmátra) which becomes charged with the touch-potential (the potential of impact or mechanical pressure—*प्रत्यागित्त्व, बहनशीलत्व*) in addition to the sound-potential (vibration-potential—*परिस्पन्द*) and is called the unit of touch-potential (*स्पर्शतन्मात्र*).

4. Next, this subtile matter, the Mass charged with touch- (and sound-) potential, *i.e.* with the potentials of vibration and impact, receives an accretion of Mass again from the rudiment-matter (Bhútádi), and by condensation and collocation evolves the Váyu Bhúta, a kind of gaseous matter or air of which the atoms are charged with the actual specific energy of the touch-stimulus, *i.e.*, with actual energy of impact in addition to the actual energy of vibratory motion.
5. Next, the atom of Váyu, so charged with the actual specific energy of impact and vibration, again disintegrates and emanates, under the action of the original Energy, and in the same menstruum or surrounding medium of the rudiment-matter (super-subtile Mass—Bhútádi), and thus evolves another kind of subtile matter (Tanmátra), which becomes charged with the heat-potential (*जीव्य—रूप*, heat-and-light potential) in addition to the impact-potential and the vibration-potential, and is called the unit of colour-potential (*रूपतन्मात्र*).

6. Now this subtile matter, this radiant matter, charged with light-and-heat potential, and also with impact- and vibration-potential, receives an accretion of Mass again from the rudiment-matter (Bhútádi), and by condensation and collocation evolves the Tejas Bhúta, the light-and-heat corpuscle, which is charged with the specific Energy of the colour-stimulus, *i.e.* radiates actual heat and light (चिकिरण) in addition to manifesting the energy of impact (impingency) and of vibration (or oscillation).
7. Next, this atom or light-and-heat corpuscle disintegrates, and emanates as before a form of subtile matter charged with the taste-potential (रसतन्मात्र), in addition to the three potentials already generated, and also with the physical potential of viscous attraction.
8. This subtile matter charged with the taste-potential and with the potential of viscous attraction condenses, and collocates as before into the water-atom, which manifests the actual specific energies of viscous attraction and the taste-stimulus.
9. The viscous water-atom charged with the actual specific energy of the taste-stimulus disintegrates, and emanates as before a form of subtile matter charged with the smell-potential in addition to the four potentials already generated and also with the potential of cohesive attraction.
10. This subtile matter charged with the smell-potential and with the potential of cohesive

attraction condenses, and collocates as before into the earth-atom, which manifests the actual specific energies of cohesive attraction and the smell-stimulus.

Vijñāna-bhikshu, in the *Yoga-Vártika*, briefly summarises the *Vishnu Purána* process as follows :—

Bhútádi as radicle in conjunction with Mahat produces the sound-potential, which as radicle in conjunction with Bhútádi produces *Ákása*, which as radicle in conjunction with Bhútádi produces the touch-potential, which as radicle in conjunction with Bhútádi produces *Váyu*, which as radicle in conjunction with Bhútádi produces the colour-potential, which as radicle in conjunction with Bhútádi produces *Tejas*, and so on.

In this brief summary he does not bring out the force of विकुञ्चयः (the disintegrating process) and the distinction between the genesis of subtile and gross matter (*Tanmátra* and *Bhúta*).

यथा प्रधानेन महान्, महता स तथावृतः ।
 भूतादिस्तु विकुञ्चयः सर्गे तन्मात्रिकं ततः ।
 ससर्गे शब्दतन्मात्रात् आकाशं शब्दलक्षणं ।
 शब्दमात्रं तदाकाशं भूतादिः स समावृणोत् ।
 आकाशस्तु विकुञ्चयः स्पर्शमात्रं ससर्गे ह ।
 बलवान् अभवत् वायुः तस्य स्पर्शो गुणो मतः । (विष्णुपुराण)

II. A famous passage in *Parásara* takes another view of the genesis and structure of the *Tanmátras* and the *Bhúta-Paramánus*. *Krishnapáda*, in the *तन्त्रत्रयविवरण*, represents the scheme as follows :—

The *Tanmátras* originate from one another in one

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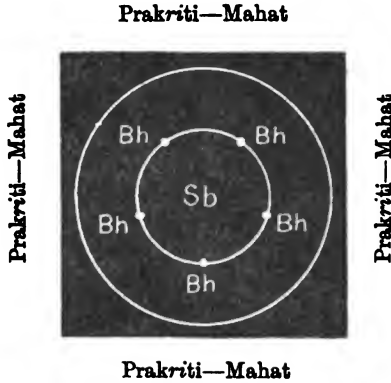
linear series, and each Bhúta originates in a separate line from its own Tanmátra :—

भूतादि	Bhútádi.
शब्दतन्मात्र	Sound-Tanmátra—as a radicle or centre surrounded or encircled by Bhútádi generates Ákása—
स्पर्शतन्मात्र	Touch-Tanmátra—as a radicle or centre encircled by sound-Tanmátra with Ákása-atom as a help generates Váyu—
रूपतन्मात्र	Colour-Tanmátra — as a radicle or centre encircled by touch-Tanmátra with Váyu-atom as a help generates Tejas—
रसतन्मात्र	Taste-Tanmátra—as a radicle or centre encircled by colour-Tanmátra with Tejas-atom as a help generates Ap—
गन्धतन्मात्र	Smell-Tanmátra—as a radicle or centre encircled by taste-Tanmátra with Ap-atom as a help generates Prithivi.

The genesis of a Bhúta-Paramánu (atom) from the subtile matter of a Tanmátra is not here so simple as in the view of the Vishnu Purána. The latter speaks of condensation and collocation, but in the passage under reference a Tanmátra is supposed to act as a radicle, as the centre of a system, surrounded or

encircled by Tanmátras of the immediately higher order in the medium of their own Bhúta.

Thus an atom of *Ákása* has the following structure :—

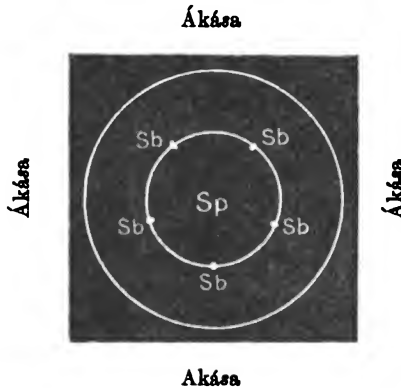


AN ATOM OF *ÁKÁSA*.

Sb = Śabda-Tanmátra (vibration-potential).

Bh = Bhútádi.

An atom of *Váyu* is constituted as follows (this takes place within the surrounding medium of *Ákása*) :—

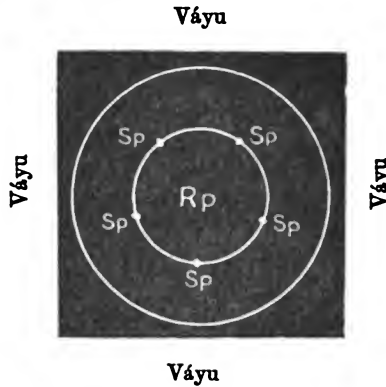


AN ATOM OF *VÁYU*.

Sp = Sparsa-Tanmátra (impact-potential).

Sb = Śabda-Tanmátra (vibration-potential).

An atom of Tejas (heat-and-light corpuscle) has the following structure :—



AN ATOM OF TEJAS.

Rp = Rúpa-Tanmátra (light-potential).

Sp = Sparsa-Tanmátra (impact-potential).

and so on.

A chemist will be disposed to push his chemical processes into the region of subtile matter. He may translate चावरण as a menstruum, and सहायक as a catalytic agent. In this case an atom of Váyu will be considered as generated from the impact-Tanmátra as a radicle, in the menstruum of vibration-Tanmátra, with Ákása-atoms as a catalytic agent.

अत्रायं क्रमः—भूतादेः शब्दतन्मात्रं जायते, शब्दतन्मात्रं भूतादिरावृणोति, तत आकाशं जायते, ततः अस्मात् शब्दतन्मात्रात् स्पर्शतन्मात्रं जायते, स्पर्शतन्मात्रं शब्दतन्मात्रमावृणोति, एवं शब्दतन्मात्रावृतात् आकाशसहायकात् स्पर्शतन्मात्रात् वायुर्जायते, ततः अस्मात् स्पर्शतन्मात्रात् रूपतन्मात्रं जायते, रूपतन्मात्रं स्पर्शतन्मात्रमावृणोति, एवं स्पर्शतन्मात्रावृतात् वायुसहायकात् रूपतन्मात्रात् तेजो जायते—and so on. अयं क्रमः तत्त्वत्रयविवरणे कृष्णपादैरुक्तः । वरवरमुनि, तत्त्वत्रयभाष्य (अधित्पकरण) ।

A slight variation of the above view is ascribed to a certain school of Vedántists in the तत्त्वनिरूपण.

The scheme may be represented as follows :—

A Bhúta-atom is evolved by integration (condensation and collocation, स्थूलावस्थारूप) from the corresponding Tanmátra (subtile matter). This is the same view as that of the Vishnu Purána.

The Tanmátras again evolve from one another in a lineal series, as in Parásara's view. But the process of this generation is somewhat more complex. A Tanmátra first disintegrates and emanates in a surrounding medium (a menstruum) of the Tanmátra just preceding it in the order of genesis, and, with the help of its own Sthúla Bhúta as a sort of catalytic, generates the Tanmátra next in order; *e.g.*, the infra-atomic impact-particles (स्पर्शतन्मात्र) disintegrate or emanate, in a surrounding "atmosphere" of the vibratory subtile matter (शब्दतन्मात्र), and then, with the help of their own atomic integration Váyu, gas, generate the Tanmátra next in order, the subtile matter of radiant light-and-heat (तेजः).

III. Patañjali's view, as expounded in the व्यासभाष्य and योगवार्त्तिक, is as follows :—

(a) The order of genesis of various forms of subtile matter (potentials) :—

(1) Bhútádi, the rudiment-matter, original Mass, acted on by Rajas (Energy) produces the sound-potential (vibration-potential), अन्यान्याभ्याम् सहकाराभ्यां स्वकार्यजनने राजसाहकारः सहकारीभवति ।

(2) This subtile vibration-potential, as a radicle, with accretion of rudiment-matter (Bhútádi), condensing and collocating, and acted on by Rajas, generates the subtile touch-potential

(impact-potential), which is impingent as well as vibratory (oscillating).

- (3) This subtile impact-potential, again, as a radicle, with accretion of rudiment-matter (Bhútádi), condensing and collocating, and acted on by Rajas, generates the subtile light-and-heat potential (रूपतन्मात्र) which radiates light and heat, in addition to being impingent and vibratory.
- (4) Next, the light-and-heat potential, as a radicle, with accretion of rudiment-matter (Bhútádi), condensing and collocating as before, generates the subtile taste-potential, which is charged with the potential of the taste-energy and of viscous attraction, in addition to being vibratory, impingent, and radiant.
- (5) Lastly, the subtile taste-potential as a radicle, with accretion of rudiment-matter as before, condensing and collocating, generates the subtile smell-potential, which is charged with the potential of the smell-energy, and also of cohesive attraction, in addition to being vibratory, impingent, and radiant.

(b) The order of genesis of the Bhúta-Paramánus (forms of atomic matter).

The five classes of atoms are generated as follows :—

- (1) The sound-potential, subtile matter, with accretion of rudiment-matter (Bhútádi), generates the Ákása-atom.
- (2) The touch-potentials combine with the vibratory particles (sound-potential) to generate the Váyu-atom.

- (3) The light-and-heat potentials combine with touch-potentials and sound-potentials (*i.e.* with impact particles and vibratory particles) to produce the Tejas-atom.
- (4) The taste-potentials combine with light-and-heat potentials, touch-potentials, and sound-potentials (*i.e.* with radiant, impingent, and vibratory particles) to generate the Ap-atom; and
- (5) The smell-potentials combine with the preceding potentials (*i.e.* with particles of taste-energy and with radiant, impingent, and vibratory particles) to generate the Earth-atom.

The Ákása-atom possesses penetrability, the Váyu-atom impact or mechanical pressure, the Tejas-atom radiant heat-and-light, the Ap-atom viscous attraction, and the Earth-atom cohesive attraction.

Vijñána-bhikshu in one passage gives the following scheme of the genesis of the Bhútas :—

A radicle of sound-potential with rudiment-matter gives Ákása-atom (Bhútádi), a radicle of touch-potential with Ákása-atom gives Váyu-atom, a radicle of light-and-heat potential with Váyu-atom gives Tejas-atom, a radicle of taste-potential with Tejas-atom gives Ap-atom, and a radicle of smell-potential with Ap-atom gives Earth-atom. On this view, an atom

$$\begin{aligned} \text{of Ákása} &= \text{Bh(Sb)} \\ \text{of Váyu} &= \{ \text{Bh(Sb)} \} \text{(Sp)} \\ \text{of Tejas} &= \{ \{ \text{Bh(Sb)} \} \text{(Sp)} \} \text{Rp} \end{aligned}$$

where Bh = भूतादि, Sb = शब्दतन्मात्र, Sp = स्पर्शतन्मात्र, Rp = रूपतन्मात्र, and so on.

Bhútas and Paramánus—Cosmo-genesis and its successive stages :—

The “five Bhútas” stand for a classification of substances on the basis of their generic properties, resulting, as the Sáñkhyas hold, from the structural type of their constituent atoms—a classification more physical than chemical, or properly speaking chemico-physical, unlike the purely chemical classification of the so-called elements of modern chemistry. A Paramánu, again, is a type of atoms corresponding to each Bhúta class, and indeed one and the same kind of Paramánu may comprehend atoms of different masses, if only these should agree in their structural type.

Cosmo-genesis: a Bird's-eye View.—Out of the all-pervasive rudiment-matter (Bhútádi) appeared Ákása (ether), first as a Tanmátra (subtile matter) charged with the potential energy of sound (vibration-potential), and then as an atomic integration of a mono-Tanmátric structure (the Ákása-atom—आकाशाणु) also ubiquitous and all-enveloping. In the next stage we find a new kind of Tanmátras, systems of the infra-atomic vibratory particles, so arranged as to manifest a new form of Energy, that of impact or mechanical pressure, and these Tanmátras (स्पर्शतन्मात्राणि) combining with the vibration-potentials (Ákása-Tanmátra) produced a new kind of atom, the di-Tanmátric Váyu-atom, which by aggregation formed a gaseous envelope composed of impinging (driving) vibratory particles (Váyu). Next appeared the third class of Tanmátras, infra-atomic systems of the impinging vibratory particles, which by their collocation developed a new form of Energy—the energy

of radiant heat-and-light. These Tanmátras (रूपतन्मात्राणि) combining with the potentials (Tanmátras) of vibration and impact, produced a new kind of atom—the tri-Tanmátric Tejas-atom, the light-and-heat corpuscle, which by aggregation enveloped the gaseous world in huge flames. In the next stage we have the fourth class of Tanmátras, new and complex infra-atomic systems of the radiant impinging vibratory particles, which evolved the energy of viscous attraction, as well as the potential energy concerned in the taste-stimulus. These Tanmátras (रसतन्मात्राणि) combining with the three previous ones, gave rise to another class of atoms, the tetra-Tanmátric Ap-atom, and the flaming gases were thus precipitated into cosmic masses of viscous fluid matters (Ap). Finally appeared the fifth class of Tanmátras, infra-atomic systems of the viscous radiant impinging vibratory particles which developed new forms of Energy—the energy of cohesive attraction, as well as the potential energy concerned in the stimulus of smell. These Tanmátras (गन्धतन्मात्राणि) uniting with the other four kinds of infra-atomic subtile particles, formed another class of atoms, the penta-Tanmátric Earth-atom. Thus the viscous fluid matters were condensed and transformed into the Earth-Bhúta, comprising the majority of the so-called elements of chemistry.

The Puránas, in their own fanciful way, conceive that, in the course of cosmic evolution, each succeeding Bhúta appeared within an outer envelope of its immediate predecessor, with a total mass (or volume?) a tenth less than that of the latter.

वियत् तत्राप्येकदेशगतो वायुः प्रकल्पितः ।
 चिन्तयेत् वह्निमप्येव मरुतो न्यूनवर्तिनं ॥
 ब्रह्मास्त्रापरखेप्येषां न्यूनाधिक-विचारणा ।
 वायोर्देशज्ञातो न्यूनो वह्निर्वैवायी प्रकल्पितः ॥
 पुराणोक्तं तारतम्यं दशांशैर्भूतपञ्चके ॥
 (पञ्चदशी-भूतविवेक, Ślokas 72, 81, and 82.)

Examples of the different Bhútas :—

1. *Ákása*. This is ubiquitous.
2. *Váyu*. Various substances composed of di-Tanmátric atoms—kinds of *Váyu*—must have been formed in the gaseous envelope, in the second stage of cosmic evolution, out of the proto-atoms of *Ákása* ; but they have either suffered a fresh transformation into substances of a more complex atomic structure, or have dissipated into the mono-Tanmátric *Ákása*, out of which they took their rise. The one familiar example now surviving is atmospheric air. Water-vapour (वाष्प) is but water (Ap), and smoke, fumes, etc., but earth-particles in gaseous diffusion.
3. *Tejas*. Various classes of *Tejas*-corpuscles — substances with tri-Tanmátric atomic structure, *i.e.* two grades subtler than the ordinary elements of chemistry (which are of a penta-Tanmátric structure)—are even now known (तेजो भीमादिभेदेन बहुविधं । भीमं दिव्यं चीदर्थं चाकरजं—वरवरमुनि, तत्त्वत्रयभाष्य).

First, there is fire, or the light and heat emitted by the burning log of wood or lamp (अग्निः-दीपः-भीमं तेजः).

Now it is important to note that the flame of a burning log of wood (इन्धन) or of an oil-lamp is not pure Tejas, a pure mass of light-and-heat corpuscles. There is chemical union with Earth-particles (particles of the hard penta-Tanmátric substance) acted on by Energy ; and then the Tejas-corpuscles, light-and-heat particles which are latent (absorbed) therein, come forth as flame (पार्थिवीपदभ्येन तदनुगतत्वात् तेजसः अग्निर्भवति—विज्ञानभिक्षु, प्रवचनभाष्य, Sutra 110, Chap. V.). Then there is the light of the sun and the stars (दिव्यं सौरं चादित्यादि) which are flaming masses of molten viscous matters (जलमाचेन्धनं तेजः दिव्यं तच्च सूर्यादि—तत्प्रवचनभाष्य, अचित्प्रकरणात्) or of molten earthy matters (सूर्यादीनि सर्वाणि तेजांसि पार्थिवद्रव्यसङ्घनेन अवस्थितानि—विज्ञानभिक्षु, प्रवचनभाष्य, Sutra 13, Chap. III.). There is also the lightning, which liberates a kind of Tejas latent in the aqueous particles and vapours, under the action of Energy, in the same way as an ordinary fire liberates the Tejas latent in the wood or other fuel. Next there are the stores of animal heat derived from the break-up of the nutritive material (जीव्यं). Lastly there comes the peculiar form of the Tejas Energy (radiant Energy) stored up in the metalliferous ores and igneous rocks which have been formed in the subterranean heat. Here earthy matters are mixed up, but the radiant Energy predominates in the composition of the metals (तेजसाधिभ्येन तेजसादिता सुवर्णादीनां—विज्ञानभिक्षु, प्रवचनभाष्य, Sutra 19, Chap. III.). Aniruddha, a late Sāṅkhya commentator, notes in reference to “igneous bodies” that the greater part of their mass is derived from the Earth Bhúta, though the Tejas particles determine the peculiar chemical combination which produces them ; and this must also be his view

of the composition of the metals (तत्र अपि (तैजसे झरोरे अपि) बहुतरपाधिवायववावहम्भकान्, अत्यन्ते चानुपभोगात्—अनिरुद्धवृत्ति, Sutra 112, Chap. V.).

4. Ap. This viscous fluid of a tetra-Tanmátric structure has but one pure example, viz., water, though the various organic acids, the juices of fruits and the saps of plants, are supposed to be transformations of watery radicles combined with different kinds of earthy accretions.
5. Lastly, the Earth Bhúta, the hard full-formed matter, with its penta-Tanmátric atoms, comprises by far the majority of the so-called chemical elements.

The question is,—how does one and the same Bhúta, of the same formal structure, comprise different kinds of elements, with different atomic masses and different characteristic properties? And the answer is not far to seek. The properties of a thing are only the energies that are manifested in the particular collocations of the three *Gunas*—Mass, Energy, and Essence; and a tri-Tanmátric or a penta-Tanmátric atom, *i.e.* an atom composed of three or five kinds of Tanmátras, may differ from another of the same class in respect of the number of constituent Tanmátras of any particular kind, as also of their collocation or grouping, and therefore in mass as well as in generic and specific characters.

The Sánkhyā-Pátañjala conceives the properties (or energies) of substances to result from the grouping or the quanta of the Tanmátras, or the *Gunas* themselves,

and hence any radical differences in substances of the same Bhúta class must characterise their atoms, though in an infra-sensible form. In the Nyáya-Vaisheshika, on the other hand, the atoms of the same Bhúta class are alike in themselves, homogeneous; and the variety of substances comprehended under the same Bhúta is ascribed merely to the different arrangements or groupings of the atoms (अणु) and not of their components, for components they have none.

As a typical and familiar instance of the variety of characteristic properties (or energies) that may result from variations in accompaniment or grouping, the Sāṅkhya-Pātañjala points to the various kinds of fruit acids and juices, all originating from one and the same Bhúta (water) with different accretions of earthy matters (भूषिकारः). In the same way, though we speak of only five classes of Tanmátras and atoms, the infinite variety of the world results from the infinitely varied collocations of the three original Gunas which underlie Tanmátra and atom alike. (सखरजसमसा अपकर्षकाहापक्षः संघातः परमाणुरिति—न्यायवार्तिक, उद्योतकर, reporting the Sāṅkhya view. अयुतसिद्धावयवः संघातः परमाणुरिति—आसभाष्य, Sutra 44, Pada III. परमाणुः सामान्यविशेषात्मा अयुतसिद्धावयवभेदानुगतः समुदायः—आसभाष्य, Sutra 44, Pada IV. योग्यतावच्छिन्ना धर्मिणः शक्तिरेव धर्मेः—*ibid.*, Sutra 14, Pada III. यो धर्मेण अनुपाती सामान्य-विशेषात्मा सोऽन्यो धर्मी—*ibid.*, Sutra 14, Pada III.)

स्यादेतत्—कथं एकरूपाणां गुणानां अनेकरूपा प्रवृत्तिः—इत्यत आह परियामतः सलिलवत् । यथा वारिद्विमुक्तं उदकं एकरसं अपि तस्यभूषिकारान् आसाद्य नारिकेल-ताली-विल्व-शिरविल्व-तिन्दुकामलक-कपित्थ-फलरसतया परियामात् मधुराम्ललवणतिक्तकटुकषायतया विकल्पते, एवमेकैकगुणसम्भवात्

प्रधानं गुणं चाश्रित्य अप्रधानगुणाः परित्यागभेदान् प्रवर्त्तयन्ति । तदिदमुक्तं
प्रतिप्रतिगुणाश्रयविज्ञेयान्, एकैकगुणाश्रयेण यो विज्ञेयस्तस्मात् इत्यर्थः ।

(वाचस्पति—कौमुदी—on Káriká 16.)

If we take a unit of rudiment-matter (Bhútádi) for the unit of mass (*cf.* the mass of an electron with a charge of motion, etc.), and represent the first Tanmátra by t_1 such units, and if further t_2, t_3, t_4, t_5 units of mass (Bhútádi) be successively added at each accretion to form a fresh Tanmátra, then the second, third, fourth, and fifth Tanmátras will respectively contain $t_1 + t_2, t_1 + t_2 + t_3, t_1 + t_2 + t_3 + t_4,$ and $t_1 + t_2 + t_3 + t_4 + t_5$ units of mass.

Also the Váyu-atom (bi-Tanmátric system) will contain $t_1 + (t_1 + t_2),$ *i.e.* $2t_1 + t_2$ units of mass; the Tejas-atom (tri-Tanmátric system) will contain $t_1 + (t_1 + t_2) + (t_1 + t_2 + t_3),$ *i.e.* $3t_1 + 2t_2 + t_3$ units; the Ap-atom (tetra-Tanmátric system) $t_1 + (t_1 + t_2) + (t_1 + t_2 + t_3) + (t_1 + t_2 + t_3 + t_4),$ *i.e.* $4t_1 + 3t_2 + 2t_3 + t_4$ units; and the Earth-atom (penta-Tanmátric system) $t_1 + (t_1 + t_2) + \dots + (t_1 + t_2 + t_3 + t_4 + t_5),$ *i.e.* $5t_1 + 4t_2 + 3t_3 + 2t_4 + t_5$ units.

If t units of mass be added to the first Tanmátra to form the atom of Ákása, the latter will contain $t_1 + t$ units of mass.

In other words, the numbers representing the mass-units (Tamas) in the different classes of atoms (gross matter) will form an ascending series, *viz.* $t_1 + t, 2t_1 + t_2, 3t_1 + 2t_2 + t_3, 4t_1 + 3t_2 + 2t_3 + t_4,$ and $5t_1 + 4t_2 + 3t_3 + 2t_4 + t_5.$

Now if a follower of the Sánkhyā-Pátañjala were

asked to account for differences among Paramánus of the same Bhúta class, he would perhaps suppose t_1 to vary from a_1 to β_1 , t_2 from a_2 to β_2 , t_3 from a_3 to β_3 , t_4 from a_4 to β_4 , and t_5 from a_5 to β_5 .

Therefore the mass-units contained in the Váyu-atoms of the different possible Váyu substances would be represented by $2a_1 + t$, $2a_1 + 1 + t$, $2a_1 + 2 + t$, $2\beta_1 + t$, in A. P. with unity as common difference, there being $2(\beta_1 - a_1) + 1$ possible Váyu substances.

The mass-units contained in the Tejas-atoms of the different possible Tejas substances would be represented by the series $3a_2 + 2a_2 + a_2$, $3a_2 + 2a_2 + a_2 + 1$, $3\beta_2 + 2\beta_2 + \beta_2$, increasing in A. P. by unity as common difference, there being $3(\beta_2 - a_2) + 2(\beta_2 - a_2) + (\beta_2 - a_2) + 1$ Tejas substances possible.

The mass-units contained in the Ap-atoms of the different possible Ap substances would form the series $4a_1 + 3a_2 + 2a_3 + a_4$, $4a_1 + 3a_2 + 2a_3 + a_4 + 1$, $4\beta_1 + 3\beta_2 + 2\beta_3 + \beta_4$, there being $4(\beta_1 - a_1) + 3(\beta_2 - a_2) + 2(\beta_3 - a_3) + (\beta_4 - a_4) + 1$ Ap substances possible.

The mass-units contained in the Earth-atoms of the different possible Earth substances would form the series in A. P., $5a_1 + 4a_2 + 3a_3 + 2a_4 + a_5$, $5a_1 + 4a_2 + 3a_3 + 2a_4 + a_5 + 1$, $5\beta_1 + 4\beta_2 + 3\beta_3 + 2\beta_4 + \beta_5$, there being $5(\beta_1 - a_1) + 4(\beta_2 - a_2) + 3(\beta_3 - a_3) + 2(\beta_4 - a_4) + (\beta_5 - a_5) + 1$ Earth substances possible.

Size (परिमाण).—As to size or volume, the Sánkhyas accept only two kinds—the infinitesimal, which is also without parts (अणु—निरवयव), and the non-infinitesimal, which consists of parts (महत्—सावयव). The latter varies from the excessively small (the so-called Anus, Tan-

mátras, and Paramánus) to the indefinitely great (परममहत्—विभु,—e.g. Ákása).

The Gunas alone are infinitesimal, with the exception of those ubiquitous ones that evolve into Ákása-atoms and Mind-stuff (आकाशात्, and चित्तःकरणम्); all the rest of the evolved products (whether subtile or gross matter) are non-infinitesimal.

Vijñána-bhikshu notes that all the Gunas (Reals) cannot be ubiquitous. If this were the case, that disturbance of equilibrium, that unequal aggregation with unequal stress and strain with which cosmic evolution begins, would be impossible. The Gunas, which give rise to Ákása and Mind-stuff, must be held to be ubiquitous, and this will suffice for the ubiquity of Prakriti. (न च अस्मद्दर्शने गुणाख्यप्रकृतेः विभुत्वमेवावगम्यते इति वाच्यम् । चित्तःकरणाकाशहेतुगुणानां विभुत्वेन तदुपपत्तेः । सर्वगुणानां विभुत्वे सति आद्यपरिणामहेतुस्योभसंयोगाद्यसंभवात्—योगवार्त्तिक, Sutra 51, Pada III.)

Chemical Analysis and Synthesis—Elements and Compounds.—What, then, is the equivalent in the Sákhya-Pátañjala of the distinction between a chemical element and a chemical compound, or is there none? Did or did not this physical analysis and classification of things lead on to a classification based on chemical analysis and chemical synthesis? These are questions of singular interest, the answer to which will disclose some new points of view from which the ancient Hindu thinkers approached the problems.

Aggregates (समूहाः) may, in regard to their structure, be divided into two classes: (1) those of which the

parts are in intimate union and fusion, being lost in the whole (चयुतसिद्धावयवाः समूहाः), and (2) mechanical aggregates, or collocations of distinct and independent parts (युतसिद्धावयवाः समूहाः).

A substance is an aggregate of the former kind, and may be divided into two classes : (1) the Bhútas and their "isomeric" modifications (भूत, भूतभेद, and भूतविकार), and (2) chemical compounds (मिलितद्रव्य, संहतभूताश्च). Chemical compounds, again, may be subdivided into two classes : (1) those composed of atoms of the same Bhúta class, *i.e.* of different isomeric modifications of the same Bhúta, and (2) those composed of atoms of different Bhúta classes. In the first case, there is contact between "isomeric" atoms (सजातीय-संयोग), in the second case between heterogeneous atoms (विजातीय-संयोग). The first contact leads to intimate union (सङ्गः,—सङ्गाख्यः यः संयोगविशेषः तेनैव द्रव्याणां विकारो भवति—विज्ञानभिन्नु, प्रवचनभाष्य) : the isomeric atoms by a peculiar liberation of Energy (सजातीयोपहृम्भ—the action of similars on similars) are attracted towards one another, and being riveted, as it were, form the so-called material cause (उपादानकारण) of the compound product. The second kind of contact (that between unlike atoms of heterogeneous Bhútas) begins with a liberation of Energy (उपहृम्भ), which breaks up each of the Bhútas ; and taking particles (or atoms) of one as nuclei or radicles, groups particles of the rest round these radicles in a comparatively free or unattached condition. In this case, one Bhúta, that which serves to furnish the radicles, not necessarily that which is numerically or quantitatively predominant, gets the name of material

cause (उपादानकारण), and the others, which by their collocation cause the liberation of Energy (उपहम्भ, अवहम्भ, or विहम्भ), are called efficient causes (निमित्तकारण)—(एवमेकैकगुणसम्भवात् प्रधानगुणं चाश्रित्य अप्रधानगुणाः परिक्रामभेदान् प्रवर्तयन्ति—वाचस्पति, कौमुदी on Káriká 16). The illustrations given (viz. the Rasas as modifications of Ap, water, with Earth-accretions) show that this process applies not only to the Gunas, but also to the Bhútas. (यथा चाकाशादेकरसं सलिलं पतितं नानारूपात् संश्लेषात् भिद्यते—गीड़पाद on Káriká 17. तत्र अपि (त्रैजसे शरीरे अपि) बहुतरपाधिवायव्यावहम्भात्, अत्यन्ते च अनुपभोगात्—अनिरुद्ध on Sutra 112, Chap. V. जातिसाहचर्यस्य अस्माकमदोषत्वात् सामग्र्योसमवधाने अनेकैरपि इन्द्रियैः एकदा एकवृत्तुत्पादने बाधकं नास्ति ।—विज्ञानभिद्यु, प्रवचनभाष्य ।)

Aniruddha goes so far as to hold that both “isomeric” and “heterogenic” combinations are real cases of constitutive contact. (आरम्भकसंयोग, e.g. भौतिकवायोर्देहारम्भकत्वम्—अनिरुद्ध on Sutra 113, Chap. V.). But in the later Sánkhya-Pátañjala the current teaching denied this—बहूनामुपादानायोगात् (Sutra 102, Chap. V.), where विज्ञानभिद्यु notes—बहूनां भिन्नजातीयानां उपादानत्वं न दृढमिति सजातीयमेवोपादानम् । इतरच्च भूतचतुष्टयमुपहम्भकम् ।

But besides these transformations of substance (द्रव्यान्तर-परिक्राम) by “isomeric” or “heterogenic” process, ceaseless changes go on in the characters, the modality, and the states of substances—changes which are due to the unequal distribution of force (or of stress and strain—pressure) among the Gunas, which are in themselves constant. (धर्मेणलक्षणावस्थापरिक्रामाः न द्रव्यान्तरतः—यथा एका रेखा ज्ञतस्थाने ज्ञातं दृश्यस्थाने दृश, एकचैकस्थाने, यथा चैकत्वेऽपि स्त्रो माता चोच्यते दुहिता च स्वसा चेति—गुणनिमित्तत्वेऽपि गुणानां विमर्दवैचिभ्यात्—व्यासभाष्य, Sutra 13, Pada III.)

“ Even as the same figure ‘ 1 ’ stands for a hundred in the place of hundred, for ten in the place of ten, and for a unit in the place of unit.”¹

Now the question is—in these mixed substances does the fusion take place by *Paramānu*s or by larger masses (or lumps)? Now a *Paramānu* is defined to be the smallest portion of any substance which exhibits the characteristic qualities of that substance ; in other words, it stands for the smallest homogeneous portion of any substance. It is not without parts, and there-

• This conclusively proves that the decimal notation was familiar to the Hindus when the *Vyāsa-Bhāshya* was written, *i.e.* centuries before the first appearance of the notation in the writings of the Arabs or the Greco-Syrian intermediaries. *Vāchaspati*, who comments on the *Vyāsa-Bhāshya*, composed his *Nyāya-Sūchī-Nibandha* in बल्लकवसुवत्सरे, *i.e.* Samvat 898 or 842 A.D. This cannot be Śaka 898, for apart from the decisive use of वत्सवर, which by this time had come to signify the Samvat era, *Vāchaspati*’s commentator, *Udayana*, wrote the *Lakṣhaṇāvalī* in Śaka 906—

तर्कान्तराङ्कप्रमितेष्वतीतेषु प्रकाशतः ।
वर्षेभूद्यमचक्रे सुबोधां लक्षबावर्त्ती ॥

and *Udayana*, who wrote the *Parisuddhi* on the *Tātparyyatikā* of *Vāchaspati*, could not have been a contemporary of the latter, as will also appear from the invocation to *Sarasvati* in the opening lines of the *Parisuddhi*. *Vāchaspati*, then, preceded *Udayana* by 142 years, and must have been himself preceded by the author of the *Vyāsa-Bhāshya* by a longer interval still, for *Vāchaspati* ascribes the *Bhāshya* to *Veda-Vyāsa* himself (वेदशास्त्रेण भाषिते शास्त्रे शास्त्रो विद्यास्यते). The internal evidence also points to the conclusion that the *Bhāshya* cannot have been composed later than the sixth century—*cf.* the quotations from *Pañchasikha*, *Vārshaganya*, and the *Shashthi-Tantra-Sāstra*, without a single reference to *Īsvara-Krishna*—which is decisive. I may add that I remember to have come across passages of a similar import in Buddhist and other writings of a still earlier date.

fore not indivisible. It is subject to disintegration. In a Bhúta or its isomeric modification, the Paramánu, the smallest homogeneous component particle, is unmixed, and therefore corresponds to the atom of modern chemistry. In a mixed substance (मिलितद्रव्य, संहतभूतार्थे), whether it be an "isomeric" or a heterogenic compound, the qualities are due to the mixture, and therefore its Paramánu (usually called Arambhaka Paramánu), the smallest homogeneous particle possessing its characteristic qualities, must result from the mixture of the Paramánus (in smaller or larger numbers as the case may be) of the component substances. In the Sánkhyas view, then, the Paramánu of a mixed substance (Arambhaka Paramánu) corresponds to what we now call molecule. (अपकर्षपर्यन्तं द्रव्यं परमाणुरिति—व्यासभाष्य । लोहस्य हि प्रविभज्यमानस्य यस्मिन्नवयवे अत्यन्तारतस्यै व्यतिष्ठते सः अपकर्षपर्यन्तपरमाणुः—वाचस्पति, तत्त्ववैशारदी—Sutra 52, Pada III. नायुनित्यता न निर्भागत्वं । पृथिवीपरमाणुः जलपरमाणुरित्यादिव्यवहारस्तु पृथिव्यादीनां अपकर्षकाडाभिप्रायेणैव ।—विज्ञानभिष्णु, प्रवचनभाष्य, Sutra 88, Chap. V.) That the Paramánus may form binary molecules (द्वयुक्त) in forming substances, is acknowledged by the Sánkhyas, as will appear from Gaudapáda: तथा अन्नोन्यान्नयाश्च द्वयुक्तवत्तुणाः । (गीड़पाद, on Káriká 12). Even the Vaiseshikas, with their prejudice against "poly-Bhautic" or "heterogenic" combination, acknowledge that in "poly-Bhautic" compounds the different Bhúta substances unite by their Paramánus (or atoms), though they rigidly insist that in such cases only one atom should be regarded as the "radicle" (उपादान or द्रव्यारम्भक कारण) and the others as co-efficient causes (निमित्तकारण—उपहम्भक, e.g. प्रशस्तपाद—एवं समुत्पन्नेषु चतुर्षु महाभूतेषु महेश्वरस्या-

भिध्यानमात्रात् तैजसेभ्योऽप्युभ्यः पार्थिवपरमायुसाहितेभ्यो महदसहमुत्पद्यते (प्रज्ञासूत्रपादभाष्य—where Śrīdhara notes पार्थिवा अथवा उपहम्भकाः and Udayana तैजसानां परमायुर्ना पार्थिवायुसाहितेन असहस्य हिरण्ययत्नं विवक्षितं).

It was only in the mediæval Sāṅkhya-Pātañjala that under the influence of the Nyāya-Vaisesika doctrine a radical difference was conceived to exist between the structure (or constitution) of a molecule composed of “isomeric” atoms, and that of one composed of heterogeneous atoms. In the former case there was believed to take place intimate union (सङ्ग), in the latter case only a grouping of comparatively free or loosely attached atoms round a radicle atom (सूहन), with liberation of Energy (उपहम्भ, अवहम्भ, or विहम्भ) and the setting up of unequal stress and strain (गुणवैषम्यविवर्ध—ईश्वरकृपा). At the same time it was of course admitted that this distinction does not apply to the forms of subtile matter (Tanmātra—सूक्ष्मभूत) which could unite in intimate fusion, whether homogeneous or heterogeneous. For example, the subtile body (सूक्ष्मशरीर) which is supposed to be the seat or vehicle of the conscious principle is acknowledged by Vijñāna-bhikshu to be penta-Bhautic (पञ्चभूतात्मक); in other words, all the five Tanmātras serve as material causes, though the gross body (the animal organism) is stated to be only a “heterogenic” compound with the Earth Bhūta as radicle or base. (अधिष्ठानशरीरं च सूक्ष्मं पञ्चभूतात्मकं वक्ष्यते। तन्मात्रकार्यं यत् भूतपदकं लिङ्गाधिष्ठानशरीरम्—प्रवचनभाष्य, Sūtras 11 and 12, Chap. III. सूक्ष्मशरीरं पार्थिवमेव अन्यानि च भूतानि उपहम्भकानि—*ibid.*, Sūtra 19, Chap. III.)

But in the original Sāṅkhya-Pātañjala it appears that the production of a new substance by mixture of unlike Bhútas (विजातीयसंयोग) was conceded as freely as in the Vedānta, and was conceived as in nowise differing from the formation of a compound of atoms of the same Bhúta class. The Sāṅkhya analysis of all change into transformations of Energy due to collocations of unchanging Gunas, in other words the prevailing chemico-physical (or physical) point of view, naturally recognises no distinction between collocations of "isomeric" and those of heterogeneous atoms. At bottom they are all collocations of the Gunas. Even Vijñāna-bhikshu, who, as one of the latest expounders of the Sāṅkhya-Pātañjala, has been most affected by the Vaiseshika prejudice against "poly-Bhautic" combination (विजातीयसंयोग), urges that the qualities of a compound substance are not necessarily the result of similar qualities in the component elements. (सजातीय-कारकगुणस्यैव कार्यगुणारम्भकता इति तु तेषां (तार्किकीकाशा) अपि न नियमः ।) Elsewhere he explains that, so far from the vital activity being independent, it is originated and maintained by the combined operation or fusion of the different sensory and motor reflexes of the living organism, and notes that the united operation of mixed (or miscellaneous) causes, where there is a fit collocation of matter, offers no difficulty to a follower of the Sāṅkhya-Pātañjala. (जातिसाहचर्यस्य अस्माकमदोषत्वात्, सामग्रीसमवधाने सति अनेकैरपि इन्द्रियैः एकदा एकवृत्तुहपादने बाधकं नास्ति—प्रवचनभाष्य, Sutra 32, Chap. II.) In the middle of the ninth century we find Vāchaspati instancing some "heterogenic" or "poly-Bhautic" compositions as typical examples of evolutionary change

(परिष्कार) and unhesitatingly accepting the substantive character of the products. In the Kaumudi he describes the various acids and juices of fruits as modifications of the same original water in the presence of different kinds of earthy accretions. The process is peculiar. The water-particle (or atom) serves as a radicle or centre of a system, and the different kinds of the Earth-Bhúta centering round this as a nucleus become the seat of forces, which bring in the development of new energies (and new qualities, *e.g.* tastes) in the water. (यथा वारिद्विमुक्तं उदकं एकस्मिन्पि तदद्भूतविकारान् आसाद्य नारिकेल-ताली-वित्त-कपित्वादि-रसतया परिष्कारात् मधुराम्लवखतिक्तकटुकपायतया विकल्पते । इति एकैकगुणसम्भवात् प्रधानगुणं चाश्रित्य सप्रधानगुणाः परिष्कारभेदान् प्रवर्तयन्ति ।—कौमुदी on Káriká 16.) Váchaspati also points out that different substances may be transformed into one and the same substance (*e.g.* the production of salt by the cow, the horse, the buffalo, and the elephant, thrown into the salt-factory of Sambara in Rajputana, or of the flame of a candle by the combination of wick, oil, and fire). (परिष्कारैकान्तं बहूनामपि एकः परिष्कारः दृष्टः । तद्यथा गवाश्च-महिषमातङ्गानां रुमानिश्चिमानां एकलवखतिज्जातीयलक्ष्यः परिष्कारः, वसितैलानलानां च प्रदीप इति ।—तत्त्ववैज्ञानरदी on आसभाष्य, Pada IV., Sutra 14.)

Earlier still, *i.e.* not later than the sixth century, the Vyása-Bhāshya, noting that inorganic matter, vegetable substances, and animal substances do not differ from one another essentially in respect of their potential energies and ultimate constituents, points out that various bi-Bhautic chemical compounds of water and earth substances, in the shape of saps, acids, and juices, are found in plants in their different parts

(जलभूम्योः पारिस्वामिकं रसादिवैभ्ररूपं स्वावरेषु दृश्यम्). In other words, bi-Bhautic compounds are here placed in the same category as compounds of substances of the same Bhúta class, for here the particles of both the Bhútas are regarded as forming the matter (material cause—उपादानकारण) of the smallest homogeneous portions of the compound substances.

N.B.—Váchaspati naturally interprets this to mean separate modifications of the two Bhútas.

The view of the earlier Sáṅkhyas, that atoms of different Bhútas may chemically combine to form molecules of compound substances as much as atoms of different modes of the same Bhúta, comes out clearly in Utpala's brief reference to the Sáṅkhya system in his commentary on Varáhamihira's *Vrihat Samhitá*. (शब्दः पचन्त्यः [तन्नाशेभ्यः] पचनहातूतानि भवन्ति । तेभ्यः झरीरादि झरीरादि । यतः पचनहातूतानि झरीरादि—Utpala, Chap. I, Śloka 7.)

CHEMISTRY IN THE MEDICAL SCHOOLS OF ANCIENT INDIA.

As a matter of fact, long before the fifth century, probably as early as the first century A.D., the prevailing schools of medicine and surgery which were based on the Sáṅkhya teaching with a methodology derived from the Nyáya-Vaiseshika doctrine (*cf.* Charaka, Śárírasthána, Chap. I.; Vimánasthána, Chap. VIII.; also Susruta, Śárírasthána, Chap. I.) had founded an elaborate theory of inorganic and organic compounds, which equally admitted iso-Bhautic and hetero-Bhautic com-

binations. Like the Vedántists, Charaka held that each of the gross Bhútas (Mahábhútas) is a peculiar ultra-chemical compound of five original subtile Bhútas. In this sense, every substance is penta-Bhautic, but for purposes of chemical analysis and synthesis, *i.e.* considered with reference to the Mahábhútas, all substances in their chemical constitution belong to one or other of the following classes: mono-Bhautic, bi-Bhautic, tri-Bhautic, tetra-Bhautic, and penta-Bhautic. Compounds of different Bhútas, again, may combine to form more complex substances, and these in their turn higher compounds still, and so on in progressive transformation, as is more specially the case with organic substances and products.

Physical Characters of the Bhútas.—The prevailing physical characters of the different Bhútas and their isomeric modes are enumerated as follows:—

Earth substances : Heavy, rough, hard, inert, dense, opaque, exciting the sense of smell.

Ap substances : Liquid, viscous, cold, soft, slippery, fluid, exciting the sense of taste.

Tejas substances : Hot, penetrative, subtile, light, dry, clear, rarefied, and luminous.

Váyu substances : Light, cold, dry, transparent, rarefied, impingent.

Ákása substances : Imponderable (or light), rarefied, elastic, capable of sound (vibrations).

गुरुत्वरकठिनमन्दस्थिराविषदसान्द्र-स्थूल गन्धगुणबहुलानि पार्थिवानि । द्रव-
स्निग्धशीतमन्दमृदुषिञ्जलसररसगुणबहुलानि आप्यानि । उष्णतीक्ष्णसूक्ष्मल-
घुणरूपविषदरूपगुणबहुलानि आग्नेयानि । लघुशीतरुच्यसरविषद सूक्ष्मस्पर्शगुण-
बहुलानि वायव्यानि । मृदुलघुसूक्ष्मस्पर्शरसगुणबहुलानि आकाशात्मकानि ।—
Charaka, Śárírasthána, Chap. XXVI. ; compare Susruta,
Sútrasthána, Chap. XLI.

Charaka points out that the primary qualities or specific physical characters of the five Bhútas are tactile qualities, *i.e.* sensible to touch, *e.g.* hardness (or roughness) for Earth, liquidity (or yielding to pressure) for Ap, impelling or moving force (pressure) for Váyu, heat for Tejas, and vacuum (non-resistance, penetrability) for Ákása.

सरद्रवचलोष्णान् भूजलानिलतेजसान् ,
आकाशस्याप्रतीघातो दृष्टं लिङ्गं यथाक्रमम् ।
लघुत्वं सर्वमेवेतत् स्पृशनेन्द्रियगोचरः ।

(Charaka, Śárírasthána, Chap. I.)

(*Cf.* the elaborate enumeration of physical characters quoted in Vijñána-bhikshu, Yoga-Vártika, Sutra 42, Pada I. ; also Varavara's commentary on Tattva-traya, Achit-prakarana.)

The Mahábhútas—Mechanical Mixtures.—Susruta notes that each of the gross Bhútas (Mahábhútas) is found mixed up with the other Bhútas—*e.g.*, the Mahábhúta Ákása is the receptacle (or vehicle) of air, heat-and-light, and water vapour ; the Mahábhúta Váyu, of water vapour, light-and-heat, and even fine particles of earth held in suspension ; the Mahábhúta Tejas, of earth particles in the shape of smoke, and also water vapour. (अन्योऽन्यानुप्रविष्टानि सर्वान्येतानि निर्विशेत्—Susruta, Śárírasthána, Chap. I. अन्ये पुनः अन्यथा व्याचक्षते । आकाशे

पवन-दहन-तोयानि । वायौ तेजोऽप्युनी भूरपि अयुताविशेषेण । भूमिरपि
भूमादिरूपेण तेजसि । तेजोद्रव्ये पानीयमपि ।—Dalvana on Susruta,
loc. cit.)

Mono-Bhautic Earth substances :—Charaka and Susruta regard the following as Earth substances : gold, the five Lohas (silver, copper, lead, iron, and tin) and their “rust,” arsenic, orpiment, various mineral earths and salts, sand, precious stones. (Charaka, Sūtrasthāna, Chap. I.; *cf.* also Susruta, Sūtrasthāna, Chap. I. पार्थिवाः सुवर्णरजतमथिमुक्तामनःशिलामृत्कपालादयः । सुवर्णस्य इह पार्थिवत्वमेवाङ्गीक्रियते गुरुत्वकाठिन्यस्यैर्थादिहेतुभिः । सूत्रे आदिग्रहणात् लोहमलसिकतासुधाहरिताललवणगेरिकरसाञ्जनप्रभृतीनां — Dalvana on Susruta, *loc. cit.*)

The salts include common salt, saltpetre, etc. Susruta mentions the alkalis, borax, natron, Yavakshāra (carbonate of potash), etc. The Audbhida salt, an inflorescence of the soil, stands for *reh* (चौत्रिदं पांशुलवणं यज्ज्ञानं भूमितःस्यन्).

Of these Earth substances some were known to be compounds, *e.g.* the chemical salts of the metals, collyrium, etc. Susruta describes the preparation of the metallic salts. The leaves of the metals were pasted over with the salts, and then roasted (अयस्कृति, Chikitsāsthāna, Chap. X.). These metallic salts are therefore mono-Bhautic Earth compounds. Susruta also gives the preparation of mild and caustic alkalis (Sūtrasthāna, Chap. XI.).

Origin of precious stones.—Some hazarded the guess that the precious stones are rocks (or earths) metamorphosed by natural process in the course of ages (Varāhamihira—केचित् भुवः स्वभावात् वैचिध्यं प्राङ्गुरूपलानाम् । Utpala notes—रत्नरूपत्वं प्राप्ताः कालान्तरेण ।).

Ap substances, simple and compound :—

Susruta, following Charaka, enumerates various classes of Ap substances (द्रवद्रव्य) as follows: waters, acids, milks, curds, butters, oils (vegetable as well as animal), fats, honeys, molasses, alcoholic liquors, urines, etc.

Pure Ap (Mahábhúta) is tasteless, and the six tastes are developed when the Mahábhúta Ap enters into combination, mechanical or chemical, with other Mahábhútas. Susruta notes that various kinds of Earths are dissolved in the waters of different localities, and where the particles so dissolved are predominantly earthy, the water tastes acid or salt; where predominantly watery, the resulting taste is sweet; where the Earth-particles are mixed up with Tejas, the water tastes pungent or bitter, etc. Such is the case with mechanical mixtures. In the case of bi-Bhautic or tri-Bhautic compounds Charaka mentions that substances with Mahábhúta Ap predominating in their composition taste sweet; with Mahábhútas Earth and Tejas predominating, acid; with Mahábhútas Ap and Tejas predominating, salt; with Mahábhútas Váyu and Tejas predominating, pungent; with Mahábhútas Váyu and Ákása predominating, bitter; and with Mahábhútas Váyu and Earth predominating, astringent. (Charaka, Sútrasthána, Chap. XXVI.; cf. Susruta, Sútrasthána, Chap. XLII.)

In fact, with the exception of Susruta's waters, which are mechanical mixtures, or rather solutions, all these Ap substances are organic products, and, as such, penta-Bhautic, *i.e.* compounded of all the five Mahá-

bhútas, and the particular "taste" which is developed depends on the relative proportion of the Mahábhútas and the predominance of one or more of them in the penta-Bhautic compound in question.

Qualities of Compounds.—The isomeric modes of each Mahábhúta have specific colours, tastes, etc., due to their structure, *i.e.* the arrangement of their atoms, and the physico-chemical characters of compounds, whether of the same or of different Mahábhútas, result from the collocation in unequal proportion of the different forces latent in the atoms of the component substances. Charaka adds that the varied forms (textures) and colours of organic substances, whether vegetable or animal, are derived in the same way. (एषमेतेषां रसानां बदन्नुपपन्नं नूनान्तिरेकविशेषात् महाभूतानाम् । भूतानामिव स्यावरजस्मानां नानावर्णोक्तिविशेषाः ।)

Susruta ignores Charaka's distinction between Mahábhúta and subtile Bhúta, and views every substance as in reality penta-Bhautic, and it is only the relative predominance of a particular Bhúta or Bhútas in any substance that determines its class. (पृथिव्यग्नेजोवाय्वाकाशानां समुदायात् द्रव्याभिवर्षितः । उन्कर्षस्तु अभिव्यञ्जको भवति इदं पार्थिवं इदं आप्यं इदं तेजसं इदं वायव्यं इदं आकाशीयमिति । —Susruta, Sútrasthána, Chap. XLI.)

The Extant Charaka and Susruta—Succession of Medical Authorities.—The extant Charaka and Susruta, the sources of our present information regarding the progress of scientific knowledge in the medical schools of ancient India, are both redactions of original authorities. The extant Charaka is a redaction by Dridhabala of the genuine Charaka *Samhitá*, which was

itself a redaction by Charaka of the original work of Agnivesa, the disciple of Átreya Punarvasu as distinguished from *Krishnátreya* and *Bhikshu Átreya*, also well-known medical authorities. The extant *Susruta* is a redaction by *Nágárjuna* of an original work (*Vridhdha Susruta*) by *Susruta*, the disciple of *Dhanvantari*. That *Charaka* preceded *Susruta* is almost certain. *Nágárjuna* was probably earlier than *Dridhabala*. At any rate, *Dridhabala* imported into *Charaka* much of the surgical knowledge which had till then been the traditional heritage of the *Susruta* school. And in the matter of the surgical treatment of certain diseases, the genuine *Dridhabala* is often as advanced as *Susruta's* redacteur himself. The latter was probably identical with the alchemist *Nágárjuna* (*Siddha Nágárjuna*), the metallurgist *Nágárjuna* (author of a treatise on metallurgy, *Lohasástra*), and the Buddhist *Nágárjuna*, author of the *Mádhyamika-sútravritti*. *Charaka* and *Susruta* continued to receive additions after *Dridhabala* and *Nágárjuna*, and even after *Vágbhata*, but the whole of the extant *Charaka* is probably much earlier than the commentator *Chakrapáni*, and the whole of the extant *Susruta* earlier than *Dalvana*, the commentator, and *Mádhaba*, the author of *Rugvinischaya*. The extracts in *Vágbhata* make it certain that the passages I have quoted or shall quote from the *Sútrasthána* and *Śárírasthána* of *Charaka* and *Susruta* cannot be later than the sixth century of the Christian era.

Preparation of Chemical Compounds.—The knowledge of chemical compounds and of their preparation

continued to make progress in the Charaka and Susruta schools. The great metallurgist, Patañjali, in his treatise on Metallurgy (लोहशास्त्र), gave elaborate directions for many metallurgic and chemical processes, especially the preparation of the metallic salts, alloys, and amalgams, and the extraction, purification, and assaying of metals. Probably it was Patañjali who discovered the use of the mixtures called *Vidas*, which contained aqua regia or other mineral acids *in potentia*. Unfortunately Patañjali's *magnum opus* appears to have been lost, but extracts from it are frequently found in mediæval works on Medicine and Rasáyana which leave no doubt as to its remarkable scientific value. The metallurgist Nágárjuna advanced the knowledge of chemical compounds by his preparations of mercury. The Harshacharita, in the seventh century, relates a fable concerning this Nágárjuna, and speaks of him as a friend and contemporary of Sátaváhana. The relative priority of Patañjali and Nágárjuna is a vexed question in the history of metallurgy. That Nágárjuna's Lohasástra was earlier than the final redaction of Patañjali will appear from the following circumstances:—(1) Chakradatta in his summary of Nágárjuna mentions that the chemical process of testing pure iron must be repeated twice before it can be regarded as decisive, whereas Śivadása Sen's extract from Patañjali shows that the latter directed the process to be repeated seven times; (2) Patañjali in the Abhraka-vidhi (mica operation) adds mercury, which in this particular operation is wanting in Nágárjuna's recipe (*cf.* Chakradatta, and Patañjali as reported in the Yogaratnákara-samuch-

chaya); and (3) Nágárjuna is quoted in the earlier compilations, Patañjali in the later.

Chemical Industries.—Early in the sixth century, Varáhamihira in the *Vrihat Samhitá* gives several preparations of cements or powders called Vajra-lepa, “cements strong as the thunderbolt”; and there was ample use for these in the temple architecture of the Buddhist period, the remains of which bear testimony to the adamantine strength of these metal or rock cements. (म्रासादहर्म्यैषलभीलिङ्गप्रतिमासु कुडनकूपेषु सनत्रो दातव्यो चर्चसहस्रायुतस्यायी । Chapter LVI., *ibid.*) Varáhamihira also alludes to the experts in machinery (यन्त्रविदः, यन्त्रज्ञः) and the professional experts in the composition of dyes and cosmetics (रागगन्धयुक्तिविदः Ch. XVI., also Ch. XV.). I would also refer to the interesting chapter on Perfumery (Ch. LXXVI.) where Varáhamihira gives various recipes for artificial imitations of natural flower-scents, as of the essence of Vakula, Utpala, Champaka, Atimuktaka, etc., arranges compound scents in a sort of scale according to the proportions of certain ground essences used in their preparation, and determines by the mathematical calculus of combination (लोहकप्रसार) the number of variations of the different notes in this scale. To these classes of professional experts were due three of the great Indian discoveries in the chemical arts and manufactures which enabled India to command for more than a thousand years the markets of the East as well as the West and secured to her an easy and universally recognised pre-eminence among the nations of the world in manufactures and exports: (1) the preparation of fast dyes for textile fabrics by the treatment of

natural dyes like Mañjishthá with alum (तुवरौ मंजिष्ठा रागचन्दिनी) and other chemicals (e.g. sulphate of iron) also cow-dung (cf. the "cow-dung substitute," Roscoe); (2) the extraction of the principle of indigotin from the indigo plant by a process which, however crude, is essentially an anticipation of modern chemical methods; and (3) the tempering of steel in a manner worthy of advanced metallurgy, a process to which the mediæval world owed its Damascus swords. It was this applied chemistry much more than handicraft skill which gave India her premier position in the Middle Ages and earlier (indeed from Pliny to Tavernier) in exports and manufactures; for in handicraft skill, as in design and workmanship, great as were her merits, India came to be surpassed by her disciples China and Japan.

The Vāsavadattá and the Dasakumára Charita in the sixth century allude to the preparation of a mass of fixed or coagulated mercury (वारदपिण्डश्च कालुषानुवादिनः—वासवदत्ता); a chemical powder, the inhalation of which would bring on deep sleep or stupor (योगचूर्ण—दशकुमारचरित); a chemically prepared stick or wick for producing light without fire (योगवर्तिका—दशकुमारचरित); and a powder which, like anæsthetic drugs or curare, paralyses sensory and motor organs¹ (स्तम्भनचूर्णमिव इन्द्रियाणाम्—वासवदत्ता—शोद्धियकर्म्मोन्द्रियाणां—Darpana). Vrinda (circa 950 A.D.) notices the preparation of sulphide of mercury (रसानृतचूर्ण),

¹ This last interpretation is doubtful; but in any case the familiar use of a technical term of alchemy like Stambhana-churnam (fixation-powder) shows that already in the sixth century this branch of knowledge was widely cultivated.

composed of one part of sulphur and half its weight of mercury ; and also of cuprous sulphide (पुषेडिनाच). Chakrapáni (circa 1050 A.D.) mentions the preparation of the black sulphide of mercury “by taking equal parts of mercury and sulphur.”

The Rasárnava (circa 1200 A.D.) notices the colours of metallic flames, probably after Patañjali—*e.g.* copper gives blue flame ; tin, pigeon-coloured ; lead, pale ; iron, tawny ; blue vitriol, red. It may be noted that the Rasárnava regards mercury as a penta-Bhautic substance.

The Rasaratna-samuchchaya divides the mineral kingdom (Earth substances, simple and compound) into the following classes : (1) The eight Rasas : mica, pyrites, bitumen, blue vitriol, calamine, etc. (2) The eight Uparasas (useful in operations of mercury) : sulphur, red ochre, green vitriol, alum, orpiment, realgar, collyrium, and medicinal earth, to which may be added the eight Sádharana Rasas, sal-ammoniac, cowrie, cinnabar, rock vermilion, etc. (3) The gems diamond, emerald, sapphire, cat's-eye, sun-stone, moon-stone, pearl, etc. (4) The metals gold, silver, iron, copper, lead, tin, and the alloys brass and bell-metal. Other Earth substances are six salts, three alkalis, mineral earths, and several poisons.

*Chemical Compositions and Decompositions—Metal-
lurgic Processes.*—In these writings¹ we frequently

¹ From Patañjali's and Nágárjuna's Lohasástra (circa 300–500 A.D.?) downwards—(practically everything material in the enumeration that follows was discovered by the end of the sixth century A.D.).

come across instances of chemical composition and decomposition by processes, more or less crude, of calcination, distillation, sublimation, steaming, fixation, etc. (भस्मीकरण, स्रवःपातन, ऊर्ध्वपातन, खेदन, सन्धन, etc.), e.g. the preparation of perchloride of mercury by taking common salt and mercury (रसकपूर—पारदस्य श्वेतभस्मीकरणे चन्द्रिकाकारः); of sulphide of mercury (हिङ्गुल) by taking sulphur and mercury; of Sindūra from lead (सिन्दूर नागसम्भवम्—Amarakosha, sixth century A.D.); of the medicinal compounds Svarnasindūra and Rasasindūra with mercury, sulphur, and gold, where gold may have been fancied to influence the resulting compound in some mysterious way, either as a “dynamic” or as a catalytic; also the extraction by chemical decomposition of mercury from sulphide of mercury (हिङ्गुल); of copper from sulphate of copper (तुरप, सस्यक) by heating this substance with one-fourth of its weight of borax (Rasaratna-samuchchaya,—cf. Bhāvaprakāsa, तुरपं तु तासोपधातु किञ्चित् तास्येयं तद्भवति); of zinc (वज्राभ, जसद) from calamine (रसक); of copper from pyrites (माञ्जिक, विमल), etc. (though the golden pyrites were supposed to be a semi-metal of gold, containing some gold along with the essence of copper); the purification of mercury by repeated distillation from lead and tin with which it was wont to be adulterated in the market. The various metallurgic processes described are—extraction, purification, killing (formation of oxides, chlorides, and oxy-chlorides for the most part), calcination, incineration, powdering, solution, distillation, precipitation, rinsing (or washing), drying, steaming, melting, casting, filing, etc., to all which each of the known minerals

was successfully subjected by the use of apparatus and reagents and the application of heat in different measures (सरपाक, मध्यपाक, and मृदुपाक)—methods which, if often crude, especially from the absence of independent and isolated mineral acids, were yet in several instances remarkably simple and effective, and which, after all, by the use of various *Vidas* potentially containing mineral acids (aqua regia, sulphuric acid, hydrochloric acid, etc.), virtually accomplished the practical ends kept in view. To these were added several special processes for mercury (*e.g.* fixation), bringing up the number of mercurial operations to nineteen.

It may be noted that the mixtures called *Vidas*, which potentially contained dilute mineral acids, were regularly employed not only in killing the metals (forming their oxides and chlorides), but—what is of fundamental importance—for purposes of chemical decomposition of metallic salts, etc., and the extraction and purification of metals.

Organic Compounds.—Organic compounds are either vegetable or animal substances (स्यावर जङ्गल भूत). The molasses, the fermented liquors, the saps and juices of plants, fruit acids, vegetable ashes and alkalis, together with the tissues of plants, are vegetable compounds (जौन्नद, स्यावर भूत). Honey, milk, curd, butter, fat, bile, urine, and other excreta, together with the organs and tissues of animals, are animal substances. Charaka notices vegetable as well as animal oils. The viscous (oily) substances are classed under four heads—butters, oils, fats, and marrows (सपिल्लैलं वसा मज्जा जेहो दृढचतुर्विधः). Salt may be either mineral or vegetable salt.

Susruta divides poisons into two classes—vegetable and animal, but several poisons expressly termed mineral poisons (धातुविष) are included in the first class.

All organic substances, whether animal or vegetable, are penta-Bhautic, being compounded of greater or less proportions of the five Mahábhútas.

Taking the human body, Charaka finds that the foetus is composed of sixteen organic substances, viz. four composing the sperm-cell which comes from the male; four composing the germ-cell which comes from the female; four added by the transformation of the nutritive material; and finally, four kinds of subtile matter, which together form the vehicle of the conscious principle. As to the four organic substances which compose the sperm-cell, or the other four which compose the germ-cell, it is not clear whether in Charaka's view they are also in their turn compounded of less complex organic substances, or whether their constituent elements are inorganic penta-Bhautic compounds.

The tissues that appear in the course of development of the foetus are further transformations (higher compounds) of these foetal substances. All the component substances of the body are penta-Bhautic compounds, though sometimes they are assigned to the particular Bhútas which predominate in their composition, *e.g.* bile to Tejas, lymph, chyle, blood, fat, urine, sweat, and other secretions to Ap, and skin, flesh, bones, nails, etc., to Earth. (शुक्रं वाय्वग्निभूम्यवगुणपादवत् ।—गर्भस्य चत्वारि षडुर्बिधानि भूतानि मातापितृसम्भवानि आहारजानि आत्मकृतानि च *et seq.*—Charaka, Śárírasthána, Chap. II., *vide* also Charaka, Śárírasthána, Chap. VII., *cf.* Gaṅgádhara's

Jalpalkalpataru. पित्तं तृतीयं भूतं शरीरारम्भकतेजःप्रधानपञ्चभूतविकाराम्बकं तेजःस्वरूपं अग्निर्ब्रह्म । कफश्चतुर्थं भूतमायः शरीरारम्भकसौमप्रधानपञ्चभूतविकारविशेषः । शरीरं तु पञ्चमहाभूतविकारसमुदायात्मकम् । Cf. Charaka, Śárirasthána, Chap. IV., मातृजादयोऽपि चस्य महाभूतविकाराः ।)

Formation of Molecular Qualities in Chemical Compounds.—The Charaka school, which we have seen was an offshoot of the Sáñkhya (cf. Charaka, Vimánasthána, Chap. VIII., यथा वादित्यः प्रकाशकः तथा सांख्यवचनं प्रकाशकमिति), supplemented the above account of inorganic and organic compounds with a characteristically Sáñkhya explanation of the formation of molecular qualities by chemical combination. In Charaka's view, the colours, tastes, etc., of the molecules of chemical compounds result from the collocation in unequal proportion and unstable equilibrium of the different forces latent in the atoms (Paramánus) themselves. (एवमेतेषां रसानां बद्वन्मुपपन्नं न्यूनातिरेकविशेषात् महाभूतानां । भूतानामिष स्यावरजस्मिनां नानावर्णाकृतिविशेषाः ।—Charaka.)

Chemistry of Colours.—As an interesting example of the way in which a follower of Charaka would account for the colours of chemical compounds, I may note the explanation given by the late Gaṅgádhara Kavirája Kaviratna in the Jalpalkalpataru, a commentary on the Charaka-Samhitá, published at Calcutta in 1869, premising that the Kavirája's view is pure and genuine Charaka doctrine. Gaṅgádhara begins with a simple statement. The qualities of the atom, he writes, tend to produce similar qualities in the molecule. A molecular quality is therefore the result of the conjunction or opposition, as the case may be, of the atomic

tendencies. When, for example, the five Bhútas combine to produce an organic compound (the human body), Tejas, Ap, and Earth tend to produce red, white, and black respectively, but in the body (compound substance) the yellow colour may happen to be produced as the result of these tendencies in that particular proportion and collocation. The point to note here is that the molecule forms a fresh collocation, *redistributes the Mass and Energy*, and sets up new forces in the system, which coming into play modify the potencies (or tendencies) in the component atoms, and thus determine the resultant. This is elaborated into a curious but complete theory of the colours of chemical compounds.

The colours (and other qualities) of a simple substance (an isomeric mode of any Bhúta) are the result of the potencies lodged in that particular collocation of Mass, Energy, and Essence. Now when two such substances unite, their colours, etc., tend to be produced, but the combination brings on a fresh distribution of Energy, Mass, and Essence, and the forces thus set free may powerfully modify or even extinguish the separate tendencies or potencies of the component simple substances. For example, when we prepare a collyrium by mixing equal parts of sulphur and mercury (the black sulphide of mercury) we find the resulting compound black. To explain this it has to be remembered that each of the substances (sulphur and mercury) contains Sattva (Essence), Rajas (Energy), and Tamas (Mass) in different proportions, and that predominant Tamas (Inertia, Mass) always produces black, predomi-

nant Sattva (Essence) white, and predominant Rajas (Energy) red. Now in the black sulphide of mercury the white of the mercury tends to produce white, and the yellow of the sulphur yellow, and if these tendencies were not obstructed the result would be a mixed colour. But, in the particular collocation in question, the Tamas of the mercury becomes intensive (तीव्र), and the black of the now intensive Tamas extinguishes the white in the uncompounded mercury, which was due to prevailing Sattva, as well as the yellow of the uncompounded sulphur, which was due to the combined operation of white-producing Sattva and red-producing Rajas. Again, when, with proper apparatus and by the application of heat, we combine mercury and sulphur to produce the red sulphide of mercury, the resulting colour is explained by the fact that in this new collocation the Rajas (Energy)—probably of the mercury, though Gaṅgādharma does not specify—becomes intensive (तीव्र), and extinguishing both the white-producing Sattva of the mercury and the yellow-producing Sattva-Rajas of the sulphur, imparts a red colour to the compound. In these cases, as also in the formation of red by mixing powdered turmeric with lime, *i.e.* whenever a new colour is produced in the compound, it is to be explained by the dominance of Tamas, Rajas, or Sattva, or their combinations, and the extinction of the uncompounded tendencies (or potencies) by the forces set free in the new collocation. But there are other cases where the colour of the compound is a mixed colour resulting from the colours of the combining substances, *e.g.*, when

sulphide of mercury and calcined tin are mixed, the resulting colour is evidently a mixed one (Pátala, pink), which is easily explained by the colours of the component elements (the red of the sulphide of mercury and the white of the calcined tin); in the same way, in a mechanical aggregate, as in a piece of cloth, the colour is white where the threads are white.

तत्कार्थारभ्णे पृथिव्यादिद्रव्यावस्थागुणा गन्धादयः सल्लु खस्रजातीयं गन्धविज्ञेयादिकं चारभमाद्यः यदारभ्यमाद्यं खस्रजजातीयं कार्यं खारभकं कारकञ्च अहङ्कारादिस्यं गुणांश्च उभयथा कुचचित् हत्वा कुचचित् न हत्वा खजातीयं गुणविज्ञेवं चारभन्ते । यथा पारदगन्धकयोः संयोगे कञ्जली-भूतद्रव्ये पारदस्यः शुक्लः शुक्लविज्ञेवं चारभमाद्यः गन्धकस्यपीतः पीतमारभ-माद्यः पारदस्यतीक्ष्णेन तैहस्यमारभमाद्येन विरोधिना वध्यते । सङ्घेवै शौकस्यं सङ्घगुणयोनिर्कं तमोगुणयोनिर्केन तैहस्येन विरोधिना वध्यते । गन्धकस्य-पीतस्यै च लोहितशुक्ली रजःसङ्घयोनिर्की वध्यते । तयोः शुक्ललोहितवधे तैहस्यसमानयोनिः कृष्णः अभिव्यज्यते । इति पारदगन्धकोभयात्मके कार्यं चेतपीतमेलनेन सम्भाव्यं कार्यं यद्वधे तत् तीक्ष्णगुणेन वध्यते, तत्रकारकं शुक्ललोहितं हत्वा । एवं हिङ्गुले पारदगन्धकाभ्यामारभ्यमाद्ये यन्नाविज्ञेवे वङ्गिना पच्यमाने रजोवहुलयोनिर्केन तीक्ष्णेन सङ्घतमोयोनिर्की शुक्लकृष्णौ वध्यते । पारदस्यशुक्लगन्धकस्यपीतमेलनेन सम्भाव्यं कार्यं वधे च वध्यते । रजोयोनिर्क-लीहितं च अभिव्यज्यते इति । एवं हरिद्राचूर्णसंयोगेऽपि लीहितं अभिव्यज्यते चूर्णस्यतैहस्येन हरिद्रास्यशुक्लकृष्णवधे । अथ अथवे यथा—हिङ्गुलवङ्गभस्मसंयोगे चेतलोहितवर्णमेव उभयात्मकं भवति पाटलवर्णं, न च तत्र हिङ्गुलस्य लीहितं वङ्गभस्मस्यं शौकस्यं च केनापि वध्यते । एवं शुक्लवर्णनिर्मितपटस्य शौकस्यमेव । (Jalpakalpataru, Sūtrasthāna of Charaka, pp. 198–200 ; edition published by Bhubanachandra Basák, Calcutta, Samvādaratnākara Press, Samvat 1925.) This is quite in a line with Charaka's explanation of the tastes of chemical compounds which has been already noticed.

Parináma-váda versus Árambha-váda.—Charaka's view of the formation of a new quality or a new substance is based on the Sánkhyā teaching as to the conservation and transformation of Energy, and brings chemical synthesis in a line with evolutionary change (परिवर्तन). On this view, a new substance may arise by spontaneous or isomeric change, *i.e.* by the interplay of Energies within the system of any given substance, in the absence of any action from without. New qualities like new substances are only readjustments of the old, and continual changes are going on by spontaneous disintegration and recombination. Opposed to this evolutional view of chemical synthesis is the Nyáya-Vaiseshika doctrine of Árambha-váda, according to which no change of substance or quality, no effect, in short, can take place except by the action of one component element (substance or quality) on another. A binary molecule, for example, cannot possess any "specific quality" (विशेषगुण) of a kind not represented in each of the two component atoms. In the cosmic process no atom can exist free and uncombined with another atom, and every "specific quality" in a substance can be ultimately analysed into the union of two "specific qualities" of the same class in two ultimate particles which cannot be further divided. A single colour, smell, or taste in a single particle, until it can link itself on to another specific quality of its own class in a second particle, cannot characterise any substance formed by the union of these particles as material causes. Hence an Earth-atom cannot unite with an Ap-atom to form a new substance of which

both the particles must be equally regarded as material causes. At any rate, such a compound, if effected, would be smell-less, as of the two constituent atoms only one, viz. the Earth-atom, possesses smell. A compound of Earth and Váyu would be smell-less, colourless, and tasteless, and so on. The Nyáya-Vaisesika does not deny that there may be compounds of different Bhútas, nor does it deny the causal operation of specific qualities as efficient or energising (dynamic) causes (उपहृतक, निमित्तकारण), but it refuses to place these compounds on the same footing as compounds of isomeric modes of the same Bhúta; and it accepts the "material" causality in such cases of only one of the Bhútas, regarding the others as co-efficients (निमित्तकारण).

The earlier Sāṅkhyas including the medical schools of ancient India brushed all this aside as a distinction without a difference. The Vedántists, as we shall presently see, flouted this doctrine of Árambha-váda. The Jainas, in opposing this Vaisesika view of atomic combination, hit upon a solution of the problem of chemical affinity. Others, again, found out a *via media*. They held, as we learn from the reports of Udyotakara in the Nyáya-vártika, and of Váchaspati Misra in the Tátparyyatiká, that a molecule of the structure EA (one atom of Earth and one of Ap) would exhibit some variety of colour and taste resulting from the joint action of the atoms and of their several colours and tastes. But as in the combination EA only the Earth-atom possesses smell, and the Ap-atom is smell-less, and as moreover no quality in a compound substance can result except from the joint action of the

similar (potential) qualities of at least two component elements, it follows that a molecule of the structure EA would not manifest the energy of smell potentially contained in the Earth-atom. Hence, admitting the combination EA for a smell-less compound, the upholders of this view would suppose a molecule of the type E_2A (*i.e.* two atoms of Earth and one of Ap) to explain any bi-Bhautic compound of Earth and Ap (like the plant saps and fruit juices) which exhibits smell in addition to the peculiarities of colour and taste. Cf. Váchaspati's comment on Udyotakara's refutation of this view :—

अयमभिसन्धिः । पृथिव्याप्यपरमाणु तापक्षेत्रं ब्रह्मकुमारब्रह्महेतुः तयोः
रूपरसस्पर्शवस्त्रेण तदारम्भसम्भवे अपि गन्धवस्त्राभावप्रसङ्गात् । एवं पार्थिव्याणु-
सम्भवेतस्य गन्धस्य एकत्वेन अनारम्भकत्वात् नापि पार्थिवपरमाणुद्वयं एकस्य
पापसीयपरसाणुः इति अणुनामारम्भकत्वे गन्धवस्त्रोपपत्तिः इति साम्प्रतं ।
परमाणुना ब्रह्मना अनारम्भकत्वात् । तथाहि त्रयः परमाणवः न कार्त्वीमारम्भे ।

Measures of Time and Space—Size of Atoms.—The Siddhánta-Śiromani gives the following measures of Time :—

30 Kshanas (क्षण) = 1 day, 30 Káshthás = 1 Kalá,
2 Ghatikás = 1 Kshana, 18 Nimeshas = 1 Káshthá,
30 Kalás = 1 Ghatiká, 30 Tatparas = 1 Nimesha,
and 100 Trutis = 1 Tatpara.

This makes a Truti of time equal to $\frac{1}{33750}$ of a second, which is nearly the measure of the Paramánu of time as given in the Vishnu Purána (*vide* Bháskara's Siddhánta-Śiromani—कालमानाध्याय).

The above measures were in use among the astro-
nomers, but the physicists computed according to the

following table given both in Udayana's *Kiranávali* and Śrídharma's *Nyáya-Kandalí* :—

30 Muhúrtas = 1 day (24 hours),	
30 Kalás = 1 Muhúrta,	2 Lavas = 1 Nimesha,
30 Káshthás = 1 Kalá,	2 Kshanas = 1 Lava.
18 Nimeshas = 1 Káshthá,	

अथद्वयं लवः प्रोक्तो निमेषस्तु लवद्वयम्,
 अष्टादशनिमेषास्तु काष्ठा त्रिंशत्तु ताः कला ।
 त्रिंशत्कला मुहूर्तैः स्यात् त्रिंशद्रात्र्यहणी च ते ।

(Udayana, *Kiranávali*.)

This makes 1 Kshana of the *Nyáya-Vaisheshika* equal to $\frac{2}{45}$ of a second. The *Nyáya* assumes that the unit of physical change (or the time occupied by any single antecedent step in a causal series before the succeeding step is ushered in) is equal to a Kshana (or $\frac{2}{45}$ of a second). The astronomers were familiar with far smaller measures of time. The astronomical *Truti* of time measures about the thirty-four-thousandth part of a second. This is of special value in determining the exact character of Bháskara's claim to be regarded as the precursor of Newton in the discovery of the principle of the Differential Calculus, as well as in its application to astronomical problems and computations. This claim, as I proceed to show, is absolutely established; it is indeed far stronger than Archimedes' to the conception of a rudimentary process of Integration. Bháskara, in computing the "instantaneous motion" (तात्कालिकी गति) of a planet, compares its *successive* positions, and regards its motion as constant during the interval (which of course cannot be greater than a *Truti* of time, though

it may be indefinitely less). This Tātkālika motion is no other than the differential of the planet's longitude, and Bāpudeva Śāstrī claims that both the conception of the instantaneous motion and *the method of determining it* plainly show that Bhāskara was acquainted with the principle of the Differential Calculus. On the data before him, Mr. Spottiswoode remarks that Bāpudeva Śāstrī "overstates the case." Bhāskara "makes no allusion to one of the most essential features of the Differential Calculus, viz. the infinitesimal magnitude of the intervals of time and space therein employed. Nor indeed is anything specifically said about the fact that the method is an approximate one." "With all these reservations," Mr. Spottiswoode continues, "it must be admitted that the formula he establishes and the method of establishing it bear a strong analogy to the corresponding process in modern mathematical astronomy" (viz., the determination of the differential of the planet's longitude—by no means the first step in transcendental analysis or in its application to astronomy). And Mr. Spottiswoode concludes by stating that mathematicians in Europe will be surprised to learn of the existence of such a process in the age of Bhāskara (*circa* 1150 A.D.—born 1114 A.D.). Mr. Spottiswoode's second objection, that Bhāskara does not specifically state that the method of the Calculus is only approximative, cannot be taken seriously. The conception of limit and the computation of errors came late in the history of the Calculi of Fluxions and Infinitesimals. For the rest, Bhāskara introduces his computation expressly as a "correction" of Brahma-

and one Pala as much as four Suvarnas or Tolás. A Pala of gold therefore weighs 320 *Krishnalas* (Manu, Chap. VIII.; Vishnu, Chap. IV.; and Yájñavalkya, Chap. I.).

A Máshá of gold therefore would weigh $6\frac{9}{16}$ grains; a Tolá, 105 grains (in current practice it weighs nearly double, as I have stated); and a Pala, 420 grains Troy.

The measures for silver were the following:— 1 silver Máshá = 2 *Krishnalas*, 1 Dharana = 16 silver Máshás, and 1 Pala = 10 Dharanas. A Pala of silver would therefore weigh 320 *Krishnalas*. In other words, the Pala was a fixed measure of weight, and was equal to about 420 grains Troy, or double this if we take the *Krishnala* of current practice.

A Pala, which equals 320 *Krishnalas*, was subdivided by 4, 16, and 5 successively for gold, and by 10, 16, and 2 successively for silver. A Suvarna (or Tolá) of gold corresponds roughly to a Dharana of silver, and a gold Máshá to a silver Máshá, but the sizes (or volumes) are not the same, and we must not therefore conclude that gold was supposed to be heavier than silver in the proportion of 5 to 2.

We find that 1296 *Trasarenu* equal one *Krishnala*. A *Trasarenu*, as a measure of weight, therefore, is the equivalent of $\frac{7}{12}$ of a grain Troy, or double this according to current measures.

But the *Trasarenu* of physics is a different conception. It stands for the *minimum visibile*, i.e., as the physicists define it, that which is *just discernible* as a glancing particle in the slanting beams of the

morning (or afternoon) sun coming into a dark room through a chink or orifice of a window. This is a measure of size (or rather *stimulus limen*).

Measures of Capacity.—Here the standard was furnished by the Kudava (कुडावा), a vessel described as 3 *Āṅgulis* long, 4 *Āṅgulis* broad, and $1\frac{1}{2}$ *Āṅguli* deep, with a cubical capacity of $13\frac{1}{2}$ cubical *Āṅgulis*. 4 Kudavas = 1 Prastha, 4 Prasthas = 1 *Ādhaka*, 4 *Ādhakas* = 1 Drona, and 4 Dronas = 1 Khári or Bhára.

24 *Āṅgulis* make 1 Hasta, cubit, which may be taken to be 18 or 19 inches. A Kudava was divided into 4 Palas, and there can be no doubt that originally water of the weight of 4 Palas was found to be actually contained in a vessel of the cubical capacity of a Kudava. If we take the ancient cubit to have been 19 inches, the Kudava would contain nearly 4 Palas of distilled water at 30° Centigrade. On a cubit of 18 inches, the Kudava would contain about $3\frac{3}{7}$ Palas.

The Kudava in current medical practice is supposed to represent a cubical vessel, each side being 4 *Āṅgulis*. This would give a capacity of 27 cubic inches, if we take the modern cubit of 18 inches. The Kavirájas take a Kudava to contain 8 Palas of water, and as 1 Pala = 320 *Krishnalas*, and 80 *Krishnalas* are now taken to be equal to 210 grains Troy, a vessel of a capacity of 27 cubic inches is accordingly supposed to contain about 6,720 grains Troy—which is not very wide of the mark, being about 1·3 per cent. short for distilled water at 86° Fahrenheit or 30° Centigrade.

Size of the Minimum Visible; Size of an Atom.—The

supposed thickness of the just-discernible mote in the sunbeam (called a Paramánu in Technology, Silpa-sástra, and a Trasarenu in Natural Philosophy) follows directly from Varáhamihira's table:—8 Paramánus make 1 Rajas (or Ratharenu,—*cf.* the Manasara), 8 Rajas make 1 Válágra (filament of hair), 8 Válágras make 1 Likshá, 8 Likshás make 1 Yúká, 8 Yúkás make 1 Yava, 8 Yavas (the Manasara has 4) make 1 Aᅅguli (superior), 24 Aᅅgulis make 1 Hasta (cubit, lesser cubit, 18 inches). The thickness of the *minimum visibile* (the finest perceptible mote in the slanting sunbeam) is therefore taken to be 3.2^{-20} , or $\frac{1}{349525}$ of an inch. The volume of a spherical Trasarenu (or Paramánu of the Silpa-sástra) would therefore be $\frac{4}{3} \cdot \pi \cdot 3^3 \cdot 2^{-63}$ of a cubic inch. It may be here noted that such a Trasarenu is supposed in the medical schools to contain 30 chemical atoms (Paramánus of Natural Philosophy) according to one estimate, or 60 according to another. The size of an atom must then have been conceived to be less than $\pi \cdot 3 \cdot 5^{-1} \cdot 2^{-62}$ of a cubic inch.¹

(परमायुरजोवालाग्रलिङ्गयुक्तं यथोष्णुलं चेति अष्टगुणानि यथोत्तरम् अक्षुलमेकं भवति संख्या.—Varáhamihira, *Vrihatsamhitá*, Chap. LVII., Śloka 2. जालानरगते भानी यद्युतरं दर्शनं रजो याति तद्विद्यार्थ परमायुं प्रथमं तद्वि प्रमायानाम् ।—*ibid.*, Śloka 1.—*Cf.* Utpala, तत्परमायुं नाम प्रमायं जानीयात् । प्रमायानां सर्वेषां तत् प्रथममात्रं प्रमायं परमायुसंज्ञम् । *Cf.* also बसरेयुस्तु विज्ञेयः पिञ्जता परमायुभिः)

The magnitude of a Paramánu is called Párimándalya (पारिमादल्य) in the Nyáya-Vaiseshika, the name suggest-

¹ Curiously enough, this is fairly comparable (in order of magnitude) with the three latest determinations of the size of the hydrogen atom!

ing that the Paramānu were conceived to be spherical in shape. The Nyāya-Vaiśeṣika calls a Paramānu a mere point with infinitesimal dimensions, *i.e.* less than any assignable fraction of any finite quantum; but in the Sāṅkhya-Pātañjala, a Paramānu, though indefinitely small, had still assignable dimensions, being divisible into Tanmātras, which were themselves integrations of Bhūtādi. The diameter of a spherical Paramānu must have been conceived to be less than 3.2^{-20} of an inch (*i.e.* less than the conventional Paramānu with which linear measures begin), and the volume of a Paramānu would, therefore, in accordance with Bhāskara's formula, be smaller than $\frac{3}{4} \cdot \pi \cdot 3^3 \cdot 2^{-63}$ or $\pi \cdot 3^2 \cdot 2^{-61}$ of a cubic inch, where $\pi = \frac{39}{1250}$. The Tanmātras were conceived as smaller still.

That these were conventional measures arbitrarily assumed goes without question, for of course the Hindus had no physical data for a mathematical calculation of these minute quantities. A Vālāgra (hair-tip, or finest filament of hair), for example, is taken to be 3.2^{-14} of an inch thick, *i.e.* less than one-five-thousandth fraction of an inch in thickness; and a fibril of the networks of Dhamaṇi or Nādi (nerve) that supply the pores of the skin (papillæ? मुखानि रोमकूप-प्रतिबद्धानि, Susruta) was supposed to be about a thousandth part of the finest hair in thickness, or $\frac{1}{125}$ of the *minimum visibile*, and, therefore, about $3 \cdot 10^{-3} 2^{-14}$ of an inch thick (*cf.* सूक्ष्मनाडीप्रचारतः रोमः सहस्रभागेनतुल्यासु प्रचरति, Pañchadaśī); but it is evident that these measures were arbitrarily fixed upon, instead of being arrived at by calculation or actual measurement. Indeed, Charaka

expressly states that the number of Śírás and Dhamañis in the body (three million fifty-six thousand nine hundred) is only a conjectural estimate (अनिर्देश्यमतः परं तस्मिन्नेव—Śárirasthána, Chap. VII.).

My account of the chemistry of the Sánkhyā-Pátañjala, and of the affiliated Yoga and medical schools, has anticipated in several points the views of the Vedánta and the Nyáya-Vaiseshika. The chemical facts, processes, and apparatus are indeed common to all the schools. In the following account of the chemistry of the schools other than the Sánkhyā-Pátañjala, I will confine myself to the theory of the subject, and even of this I will attempt only the briefest outline.

THE VEDÁNTIC VIEW.

The Vedántists believe Máya to be the “material cause” (उपादानकारण) of the world. The power of Máya is the power to realise the unreal—to impart practical Reality or mediate existence to that which does not and cannot possess absolute Reality or self-existence. Máya is at once real and unreal, while the Brahma (Self) is absolute Reality, absolute Intelligence, and absolute Bliss. The world evolves out of Máya (मायापरिणाम), so that Máya in the Vedánta replaces the Prakṛiti of the Sánkhyā. But Máya, and by implication the world, originate out of Brahma, not by a process of evolution (परिणाम), but of Vivarta (self-alienation). The self-alienation of the Absolute, acting through Máya, produces in the beginning Ákása—one, infinite, ubiquitous, imponderable, inert, and all-

pervasive. The world thus begun goes on evolving, in increasing complexity. The other Sūkshma Bhútas, classes of subtile matter, evolve from Ákása in an ascending linear order—Ákása giving off Váyu, Váyu giving off Tejas, Tejas giving off Ap, and Ap giving off Earth. Ákása (one, infinite, all-pervasive) has the capacity of sound. Váyu (subtile gaseous matter) emanates from the universal Ákása, and is instinct with the potential of mechanical energy (impact, pressure) (ईरक, प्रकाशित्व, वहन, चूहन,—वायोश्च सर्व्वेष्वेवाहेतुत्वेन सर्व्वविनाभूतत्वात्—Vidvanmanorañjiní). Tejas (subtile radiant matter) emanates from Váyu, and contains *in potentia* the energy of light and heat. Ap (subtile viscous matter) is the transformation of Tejas, and is instinct with the energy that stimulates the nerve of taste, and lastly, Earth (subtile hard matter), which is the transformation of Ap, possesses the latent energy of smell.

But the subtile rudiments of matter must be compounded in various ways to give rise to the gross constituent matter of the world. These forms of gross matter are called Mahábhútas. There are five kinds of Mahábhúta (gross matter) corresponding to the five Sūkshma Bhútas (subtile matter), and the process by which a Mahábhúta is produced from the Sūkshma Bhútas is called Pañchíkaraṇa (quintuplication). All the five Sūkshma Bhútas are present as ingredients, though in different proportions, in each Mahábhúta.

The Mahábhúta Earth, gross Earth-matter, is composed of four parts of subtile Earth-matter and one part each of the other forms of subtile matter. The Mahábhúta Váyu is composed of four parts of subtile

gaseous matter and one part each of the other forms of subtile matter. And similarly with other Mahábhútas.

Hence if ak, v, t, ap, e, represent the five forms of subtile matter (Ákása, Váyu, Tejas, Ap, and Earth), and AK, V, T, AP, E, stand for the corresponding Mahábhútas, we may represent the constitution of the Mahábhútas as follows :—

AK = ak₄ (v₁. t₁. ap₁. e₁), ak₄ being the radicle.

V = v₄ (ak₁. t₁. ap₁. e₁), v₄ being the radicle.

T = t₄ (ak₁. v₁. ap₁. e₁), t₄ being the radicle.

AP = ap₄ (ak₁. v₁. t₁. e₁), ap₄ being the radicle.

E = e₄ (ak₁. v₁. t₁. ap₁), e₄ being the radicle.

In forms of gross or compounded matter the potential energies (or qualities) become actualised. The Mahábhúta Ákása manifests sound; Váyu, sound and mechanical energy; Tejas, sound, mechanical energy, and heat-light; Ap, the energy of the taste-stimulus in addition; and finally, Earth, the energy of the smell-stimulus added to the foregoing.

The Pañchadáśī characterises the different Mahábhútas by their typical sounds: *e.g.*, Ákása by the echo (hollow booming sound); Váyu (air) by a sibilant sound, hissing, susurration (imitative symbol, Visi); Tejas (fire) by a puffing (or roaring) sound (imitative symbol, Bhugbhugu); Ap (water) by a liquid sound (imitative symbol, Culu-culu, gurgle, splash-splash, glut-glut); and finally, Earth by a splitting or rattling sound, a crack or a thud (symbol, Kad-kada). (Chap. II. Bhútaviveka, Śloka 3, Pañchadáśī. Cf. also Jayanta, Mañjari.)

Others hold that Ákása (ether) never enters as a

component part, and is always one and indivisible. In this view the four Mahábhútas—Váyu, Tejas, Ap, and Earth—alone are supposed to be compounded, and by a process which may be called quaternion (*cf.* the Neo-Platonist quaternion):—

$$V = v_3 (t_1. ap_1. e_1).$$

$$T = t_3 (v_1. ap_1. e_1).$$

$$AP = ap_3 (v_1. t_1. e_1).$$

$$E = e_3 (v_1. t_1. ap_1).$$

These compound forms, as before, are supposed to exercise their specific energies actively. Others again hold that the Mahábhútas Tejas, Ap, and Earth alone are compounded by a process named Trivrit-karana (triplication). Thus $T = t_2 (ap_1. e_1)$, $AP = ap_2 (t_1. e_1)$, $E = e_2 (t_1. ap_1)$.

The Súkshma Bhútas are forms of homogeneous and continuous matter, without any atomicity of structure; the Mahábhútas are composite; but even these are regarded as continuous, and without any atomic structure. The Vedánta speaks of Anu (Paramánu) not as an ultimate indivisible discrete constituent of matter, but as the smallest conceivable quantum or measure of matter. In the Sánkhyá doctrine the atomic structure is ordinarily accepted. The Gunas are supposed to be परिच्छिन्न and अणु, bounded and indefinitely small in size (except the Gunas giving rise to Ákása and Manas, which are unlimited अपरिच्छिन्न); and hence the Tanmátras and Paramánus must be conceived to have a discrete structure.

As I have already noted in my account of the

genesis of Tanmátras and Paramánus, various schools of Vedántists (*e.g.* the Rámánujists and the followers of Nimbárka) combined, in the orthodox fashion of the Smritis and the Puránas, the Vedántic theosophy with the Sáñkhya cosmology, especially as regards Prakṛiti and the order of creation and dissolution. For example, the Vedánta-kaustubhaprabhá, fortifying itself with texts from the Vishnu Purána and the Subala and Gopála Upanishads, contends that, at the cosmic dissolution (Pralaya), each Mahábhúta merges into the one that preceded it in the order of creation by first disintegrating into its own proper Tanmátric form (तन्मात्रकार), and that the Mahábhúta Ákása merges into the original Tanmátras, which then lapse into Bhútádi, the super - subtile rudiment - matter, proto - matter (Chap. II., Pada III., Sutra 14).

Parináma — Evolutionary Process. — When the Mahábhútas are once formed, the different kinds of substance are derived from them by the evolutionary process called Parináma (परिवर्तन, transformation). Matter is constantly undergoing change of state. The effect is only the cause in a new collocation (कारणस्यैव संस्थानमात्रं कार्यम्). Change is of two kind :—

(1) Change by a spontaneous process, without external influence, including isomeric change (स्वाभाविक परिवर्तन). The Vedántists believe in spontaneous disintegration and reintegration. Action from without, impressed force *ab extra*, is not, *pace* the Naiyáyikas, always a condition of change of state (whether of rest or of motion); nor is it necessary that more than one substance should combine to generate another substance

or variety of substance (*e.g.* the formation of curds from milk, of ice from water, etc.). All this is directed against the Nyáya doctrine (Árambhaváda).

(2) Change due to combination with other substances (द्रव्यान्तरसंयोग). Such combination may produce (*a*) a compound substance possessing like qualities with the constituents (समानजातोत्पत्ति), or (*b*) unlike compounds with new qualities, "heteropathic effects" (विजातोत्पत्ति). Any new quality thus evolved through (chemical) combination is called Samhata-bhúta-dharma (संहतभूतधर्मे), *e.g.* the intoxicating power of the fermented rice and molasses, which does not exist in the ingredients taken separately (मद्यवोजानां प्रत्येकं अवर्तमानापि समुदायशक्त्या मदशक्तिः दृश्यते). This Sambhúyakriyá (सम्भूयक्रिया, समुत्पान) corresponds to chemical combination, and the Vedántists, like the Sánkhyas, explain this only as the evolution of the latent Energy (शक्ति, अनुभूतशक्ति) in a new collocation (संस्थान, अवयव-सन्निवेश). But, unlike the mediæval Sánkhyas, the Vedánta freely recognises the combination of heterogeneous Bhútas. Thus Earth, Ap, Tejas, and Váyu freely combine in different proportions and groupings to produce the variety of substances in the world. For example, the animal organism is a compound of all the five Bhútas (पाच-भौतिक). It is not merely the concomitant or efficient causes that may be heterogeneous to the material cause, as the Naiyáyikas contend, but several heterogeneous substances (or Bhútas) may unite as "material causes" to produce a new substance.

The Vedántists resolve all activity—physical, vital, as well as psychical—into modes of motion, subtile

cosmic motion (परिस्पन्द, सर्वलोकपरिस्पन्द—Śāṅkara ; वायोः परिस्पन्दात्मकत्वात्,—प्राणस्य परिस्पन्दात्मकत्वादेव—यद्द्वैतं स्पूलं सूक्ष्मं च तत्सर्वं मनःस्पन्दितावत्—Śāṅkara) ; but they give a separate substantive existence to the agents, the vital principle (प्राण), and the mind (मनः), though these are also evolutionary transformations of the Sūkshma Bhútas (forms of subtile matter). What is common to the Nyáya, the Vedánta, and the Sāṅkhya is that Consciousness or Intelligence (चेतन्य) transcends Matter ; but the Naiyáyikas, as pluralists, hold that vital and psychical activities are also immaterial and cannot be resolved into motion (परिस्पन्द). The Vedántists resolve these activities into subtile motion, but ascribe them to a substantive quasi-material Life Principle and Mind, the all-mirroring Intelligence (चेतन्य) alone being immaterial and transcendent ; and the Sāṅkhyas accept the substantive existence of the Mind Principle (मनः) as derived co-ordinately with the Sūkshma Bhútas or Tanmátras from individualised Prakṛiti (Ahaṅkára), but resolve Life into a mere resultant activity of the bodily organs, viz. the organs of sense and movement and the psychic principle (मनः).

पञ्चीकरणः— द्विधा विधाय चैकेकं चतुर्धा प्रथमं पुनः ।

सस्तेतरद्वितीयांशैर्योजनात् पञ्च पञ्च ते ।

यथा त्रिसर्गश्रुती सृष्टानां भूतानां स्फुटतरव्यवहारनामरूपस्य करणोपायतया त्रिवृत्करणं श्रुतं तद्वत् भूतपञ्चकसर्गश्रुती अपि तथा । तदानौ पञ्चीकरणानंद आकाशे शब्दोर्गभ्यन्यते स्फुटतयेति सर्वत्र योजनीयं (विद्वन्मनोरंजिनी) — अस्ति हि शरीरे सर्वेषामपि भूतानां कार्यसंप्रतिपत्तिः अवकाशव्यूहनपवनज्ज्वेदनकाठिन्यानां सर्वजनानुभवसिद्धत्वात् । अतस्तत्कारणतया पञ्चानि भूतानि एकस्मिन् देहे सन्तीति स्थिते तन्मुपटयोरिव अवयवावयवित्वमेव पञ्चभूतदेह-

योर्दुर्लभं । न च स्पृशीशून्यत्वात् एकद्रव्यत्वात् च आकाशस्य आरम्भकत्वानुप-
पत्तिरिति वाच्यं । आरम्भवादस्य अनङ्गीकारात् । एकस्यापि दुग्धावयविनो
दध्मारम्भकत्वदर्शनात् । वस्तुतस्तु पद्धानां भूतानां पद्धानकत्वस्य दर्शितत्वात्
आरम्भवादस्य निराकृतत्वात् च । तस्मात् सिद्धं शरीरं पाञ्चभौतिकमिति ।
—Vidvanmanorañjini.

न तावत् समानजातीयमेव आरभते न भिन्नजातीयमिति नियमो वास्ति ।
समवायिकारणे एव समानजातीयत्वाभ्युपगमः न कार्याकारविषय इति तदपि
अनेकानिकम् । नापि अनेकमेव आरभते नैकमिति नियमोऽस्ति । अणुमनसो-
राक्षकर्मरम्भाभ्युपगमात् । एकैको हि परमाणुश्चाहं स्वकर्मरभते न द्रव्याकारं
संहत इत्यभ्युपगम्यते । द्रव्यारम्भे एव अनेकारम्भकत्वनियम इति चेत् न परि-
द्यानाभ्युपगमात् । तदेव तु द्रव्यं विशेषवदवस्थाकारं आपन्नमानं कार्यं नामाभ्यु-
पगम्यते । तच्च क्वचित् अनेकं परिणमते मृद्धीजाङ्गुरादिभावेन । क्वचिदेकं परि-
णमते क्षीरादि-द्रव्यादिभावेन । नेष्टरशासनं अस्ति अनेकं एव कारकं कार्यं
जनयति इति ।—Śaṅkara, Śārīraka - Bhāshya, Sutra 7,
Pada III., Adhyāya 2.

THE ATOMIC THEORY OF THE BUDDHISTS.

The Buddhists recognise four essentials of matter, viz. extension (with hardness), cohesion (with fluidity), heat, and pressure (with motion), and four sensibles, viz. colour, taste, smell, and touch (*vide* Dhamma-saṅgani, Attha-sālini, etc.).

The later Vaibhāshikas hold that the Vāyu-atoms are touch-sensibles, having impact or pressure for their characteristic property, and by aggregation form the element Vāyu; the Tejas-atoms are colour-and-touch-sensibles, having heat for their characteristic, and by aggregation form the Tejas Bhūta; the Ap-atoms are taste-colour-and-touch-sensibles with a characteristic viscosity, and form the Ap-element by

aggregation; and finally, the Earth-atoms are smell-taste-colour-and-touch-sensibles possessing a characteristic dryness or roughness (सरत्न), and by their aggregation form the Earth-element. The Bhútas thus originated combine to form aggregates, which are classed as inorganic substances, organisms, and organs. (कानेऽहद्रव्यकोऽयुः,—रूपरसगन्धस्पर्शा इति चत्वारि द्रव्याणि पृथिव्यपत्तेर्जोवायुः इति चत्वारि,—also सरत्नेहोष्णेरण्यसभाषानि भूतानि).

THE ATOMIC THEORY OF THE JAINAS.

Of the nine categories of the Jainas, that of Ajíva (the not-soul or non-Ego) consists of five entities, four of which are immaterial (अमूर्त्त), viz. merit, demerit, space and time, and the fifth, material (मूर्त्त, possessing figure). The last is called Pudgala (Matter), and this alone is the vehicle of Energy, which is essentially kinetic, i.e. of the nature of motion. Everything in the world of not-soul (the non-Ego) is either an entity (द्रव्य) or a change of state in an entity (पर्याय). Pudgala (Matter) and its changes of state (पर्याय), whether of the nature of subtile motion (परित्यन्द) or of evolution (परिणाम), must furnish the *physical* as opposed to the *metaphysical* basis of all our explanations of Nature. Pudgala (Matter) exists in two forms—Anu (atom) and Skandha (aggregate). The Jainas begin with an absolutely homogeneous mass of Pudgalas, which by differentiation (भेद) breaks up into several kinds of atoms qualitatively determined, and by differentiation, integration, and differentiation in the integrated (संचातात्, भेदात्, संचातभेदात्—Umásvátí, Chap. V., Sutra 26), forms aggre-

gates (Skandhas). An *Anu* has no parts, no beginning, middle, or end. An *Anu* is not only infinitesimal, but also eternal and ultimate. A Skandha may vary from a binary aggregate (द्वययुक्त) to an infinitum (अनन्तायुक्त). A binary Skandha is an aggregate of two *Anus* (atoms), a tertiary Skandha is formed by the addition of an atom (*Anu*) to the binary (द्वययुक्त), and so on *ad infinitum*. The ascending grades are (1) what can be numbered (संख्येय), (2) indefinitely large (असंख्येय), (3) infinity of the first order (अनन्त), (4) infinity of the second order (अनन्तानन्त), and so on.

General Properties of Matter.—The specific characters of the Pudgalas (Matter) are of two kinds, (1) those which are found in atoms as well as in aggregates, and (2) those which are found only in aggregates. Qualities of touch, taste, smell, and colour come under the first head. The original Pudgalas being homogeneous and indeterminate, all sensible qualities, including the infra-sensible qualities of atoms, are the result of evolution (परिणाम). Every atom thus evolved possesses an infra-sensible (or potential) taste, smell, and colour (one kind of each), and two infra-sensible tactile qualities, *e.g.* a certain degree of roughness or smoothness (or dryness and moistness?) and of heat or cold. Earth-atoms, Ap-atoms, etc., are but differentiations of the originally homogeneous Pudgalas. The tactile qualities (स्पर्श, विद्युत्, उष्ण, शीत) appear first, but qualities of taste, smell, and colour are involved in the possession of tactile qualities. An aggregate (Skandha), whether binary, tertiary, or of a higher order, possesses (in addition to touch, taste,

smell, and colour) the following physical characters: (1) sound, (2) atomic linking, or mutual attraction and repulsion of atoms, (3) dimension, small or great, (4) figure, (5) divisibility, (6) opacity and casting of shadows, and (7) radiant heat-and-light.

Sensible Qualities.—Tactile qualities are of the following kinds: hardness or softness, heaviness or lightness (degrees of pressure), heat or cold, and roughness or smoothness (or dryness and viscosity?). Of these the atoms (*Anus*) possess only temperature and degrees of roughness or smoothness, but all the four kinds of tactile qualities in different degrees and combinations characterise aggregates of matter from the binary molecule upwards. The Jainas appear to have thought that gravity was developed in molecules as the result of atomic linking. Simple tastes are of five kinds—bitter, pungent, astringent, acid, and sweet. Salt is supposed by some to be resolvable into sweet, while others consider it as a compound taste. Smells are either pleasant or unpleasant. Mallishena notes some elementary varieties of unpleasant smell, *e.g.* the smell of asafoetida, ordure, etc. The simple colours are five—black, blue, red, yellow, and white. Sounds may be classed as loud or faint, bass (thick) or treble (hollow), clang, or articulate speech.

The most remarkable contribution of the Jainas to the atomic theory relates to their analysis of atomic linking, or the mutual attraction (or repulsion) of atoms in the formation of molecules. The question is raised in Umásvāti's Jaina Sūtras (*circa* A.D. 40?)—what constitutes atomic linking? Is mere contact (or

juxtaposition) of atoms sufficient to cause linking? No distinction is here made between the forces that bind together atoms of the same Bhúta and the chemical affinity of one Bhúta to another. The Jainas hold that the different classes of elementary substances (Bhútas) are all evolved from the same primordial atoms. The intra-atomic forces which lead to the formation of chemical compounds do not therefore differ in kind from those that explain the original linking of atoms to form molecules.

Mere juxtaposition (संयोग) is insufficient; *linking* of atoms or molecules must follow before a compound can be produced. The linking takes place under different conditions. Ordinarily speaking, one particle of matter (पुद्गल) must be negative and the other positive (विचक्षणगुणयुक्त); the two particles must have two peculiar opposite qualities, roughness and smoothness (रुचान and शिथिलता, or dryness and viscosity?), to make the linking possible. But no linking takes place where the qualities, though opposed, are very defective or feeble (अव्यक्तगुण). We have seen that, ordinarily speaking, two homogeneous particles, *i.e.* both positive or both negative, do not unite. This is the case where the opposed qualities are equal in intensity. But if the strength or intensity of the one is twice as great as that of the other, or exceeds that proportion, then even similar particles may be attracted towards each other. In every case change of state in both the particles is supposed to be the result of this linking, and the physical characters of the aggregate depend on the nature of this linking. When particles of equal

intensity (negative and positive) modify each other there is mutual action; in cases of unequal intensity the higher intensity transforms the lower, it being apparently thought that an influence proceeds from the higher to the lower. All changes in the qualities of atoms depend on this linking. A crude theory, this, of chemical combination, very crude but immensely suggestive, and possibly based on the observed electrification of smooth and rough surfaces as the result of rubbing. The interpretation of **रूक्ष** and **क्लिग्ध** as dry and viscous must be rejected in this connection as untenable. The *Tattvārthādhigama* of Umāsvāti, which expounds the theory, most probably dates back to the first half of the first century A.D.

Cf. Umāsvāti-Tattvārthādhigama, Chap. V. :—

अजीवकाया धम्माधम्माकाशपुञ्जलाः । द्रव्याणि जीवाश्च । नित्यावस्थितानि अरूपाणि । रूपिणः पुञ्जलाः । आकाशादेकद्रव्याणि । निष्क्रियाणि च । पुञ्जलजीवास्तु क्रियावन्तः । (क्रियेति गतिकम्माह) । सर्वेषां प्रदेशाः सन्ति अन्यत्र परमाणोः । संस्थेयासंस्थेयाश्च पुञ्जलानां । नाणोः । स्पृशरसगन्धवर्षवन्तः पुञ्जलाः । तत्र स्पृशोऽण्विधः कठिनो मृदुर्गुरुर्लघुः शीत उष्णः क्लिग्धः रूक्ष इति । रसः पञ्चविधस्तिरूः कटुः कषायोऽम्लोमधुर इति । गन्धो द्विविधः सुरभिरसुरभिश्च । वर्षोः पञ्चविधः कृष्णो नीलो लोहितः पीतः शुक्ल इति ।

ज्ञन्दस्कन्धसीकन्यस्थौत्यसंस्थानभेदतमश्चायातपोद्योतवन्तश्च । तत्र ज्ञन्दः षड्विधः ततो विततो घनः शुश्रिरो घर्षो भावइति । अक्षयः स्कन्धाश्च । उरूश्च । कारणमेव तदन्यं सूक्ष्मो नित्यश्च भवति परमाणुः । एकरसगन्धवर्षो द्विस्पृशः कार्यल्लिङ्गश्च । तत्रायवोऽपञ्जाः स्कन्धास्तु षड्भा एव । स्कन्धास्तावत् संघातभेदेभ्य-उत्पद्यन्ते । संघाताद्भेदात् संघातभेदादिति । द्वयोः परमाणवोः संघाताद्विप्रदेशः । द्विप्रदेशस्यायोश्च संघातात् विप्रदेशः । एवं संस्थेयानामसंस्थेयानामनन्तानां अनन्तानन्तानां च प्रदेशानां संघातात् प्रदेशाः । भेदादयोः । भेदादेव परमाणुरुत्पद्यन्ते न संघातादिति । अत्राह । किं संयोगमात्रादेव संघातो भवति । आहोस्त्रिदक्षि कश्चिद्द्विज्ञेव इति । अपोच्यते । सति संयोगे षड्विध्य संघातो भवतीति । क्लिग्ध-

रुक्षत्वाद्बन्धः । न जघन्यगुणानाम् । अग्निग्रहणयोः पुद्गलयोः स्पृहयोर्बन्धो भवतीति । जघन्यगुणअग्निधानी जघन्यगुणरुक्षाणां च परस्परेश बन्धो न भवतीति । उक्तं भवता जघन्यगुणवर्ज्यानां अग्निधानीं रुक्षेण रुक्षाणां च अग्निधेन सह बन्धो भवतीति । अथ तुल्यगुणयोः किमत्यनाप्रतिबेध इति । अत्रोच्यते । न । गुणसाम्ये सदृशानां । गुणसाम्ये सति सदृशानां बन्धो न भवति । तद्वयथा । तुल्यगुणअग्निग्रहस्य तुल्यगुणअग्निधेन तुल्यगुणरुक्षस्य तुल्यगुणरुक्षेण इति । अत्राह सदृशग्रहणं किमपेक्षते इति । अत्राच्यते । गुणबैधम्ये सदृशानां बन्धो भवति इति । अत्राह किमविशेषेण गुणबैधम्ये सदृशानां बन्धो भवतीति । अत्रोच्यते । आधिक्यादिगुणानां तु आधिक्यादिगुणानां सदृशानां बन्धो भवति । द्विगुणाद्यधिकअग्निधेन । द्विगुणाद्यधिकअग्निग्रहस्य अग्निधेन । रुक्षस्यापि द्विगुणाद्यधिकरुक्षस्य रुक्षेण । एकादिगुणाधिकयोस्तु सदृशयोर्बन्धो न भवति । अत्राह परमाणुषु स्कन्धेषु च ये स्पृशादयो गुणास्ते किं व्यवस्थिताः तेषु आहोस्विदव्यवस्थिता इति । अत्रोच्यते । अव्यवस्थितायुतः । परिणामात् । अत्राह द्वयोरपि वध्यमानयोर्युगवत्त्वे सति कथं परिणामो भवति इति । उच्यते । बन्धे समाधिकी पारिणामिकी । बन्धे सति समगुणस्य समगुणः परिणामका भवति । अधिकगुणो हीनस्येति ।

THE NYÁYA-VAISESHIKA CHEMICAL THEORY: A BRIEF SUMMARY.

I must content myself here with a brief and rapid sketch of the chemistry of the Nyáya-Vaisesika, which I shall elaborate in connection with the mechanics and physics of the ancient Hindus in a separate paper.

The relation of the specific characters of molecules (and higher aggregates) to the original atomic qualities is reduced in the Nyáya-Vaisesika to the following canons: (a) कार्यगुणं कारणगुणपूर्वकम् । (b) समानजातीयसंयोगः द्रव्यारम्भकः न विजातीयसंयोगः (here द्रव्य is used in a narrow technical sense, so as to exclude the quasi-compound substances); (c) अपाकजरूपरसगन्धस्पर्शपरिमायैकत्वैकपृथक्गुरुत्वद्रवत्वज्वलनेः कारणगुणपूर्वकाः । (d) रूपरसगन्धानुष्णस्पर्शशब्द-परिमायैकत्वैक-

वृषद्वयैः समानजातारम्भकाः । No separate explanation is necessary, as the canons are embodied in the following exposition.

Theory of Atomic Combination.—Atoms are eternal, ultimate, indivisible, and infinitesimal.

The four kinds of Atoms are Earth, Ap, Tejas, and Váyu atoms, possessed of characteristic mass, numerical unit, weight, fluidity (or its opposite), viscosity (or its opposite), velocity (or quantity of impressed motion—Vega); also characteristic potential colour, taste, smell, or touch, not produced by the chemical operation of heat (अपाकजरूपरसगन्धस्पर्शपरिमाथैकत्वैकपृथक्गुरुत्वद्रवत्वज्वेहवेगाः). Ákása has no atomic structure (निरवयव), and is absolutely inert (निष्क्रिय), being posited only as the substratum of sound, which is supposed to travel wave-like in the manifesting medium or vehicle of Váyu (air). Only the other four Bhútas unite (or disunite) in atomic or molecular forms. The orthodox view is that the presence of Earth-atoms is necessary whenever chemical transformation under the operation of heat (पाकजोत्पत्ति) takes place.

Atoms cannot exist in an uncombined state in creation (Śiváditya, Saptápadárthí, *vide* commentary), where, however, it is noted that still atmospheric air is believed to be monatomic in structure, *i.e.* to consist of masses of atoms in a loose uncombined state (क्लिप्तवायुस्तु परमाणुसमूह एव अनारब्धद्रव्यः).

The atoms may combine in one or other of the following ways :—

I. One Earth-atom, by an original tendency, unites with another to form a binary molecule (द्वयुक्). In

the same way binary molecules of the other Bhútas are formed. The atoms are possessed of an inherent Parispanda (rotary or vibratory motion), and when they unite in pairs, *so long as there is no chemical operation under the action of heat-corpuscles*, the original qualities of the atoms produce homogeneous qualities in the binary molecules.

The question as to the existence of a triad, a tetrad, a pentad, etc., of atoms is one of the moot points of the Nyáya-Vaisheshika. The orthodox view is that the primordial infinitesimal particles (atoms) start with an incessant vibratory motion (अनवरतपरिस्पन्दमानापरिमितपवनादिपरमाणवः, Raghunátha Śiromani; गतिशीलत्वात् पतव्यपदेशाः पतनीति, Udayana, Kusumāñjali) and an inherent impulse that drives them to unite in pairs—a sort of “monovalency,” as it were, exhausted with the formation of a binary molecule. The binary molecules now combine by threes, fours, fives, etc., to form larger aggregates as well as the variety of elementary substances, the particular collocation in any case being not only determined by physical causes, but also serving to satisfy the ends of the moral law in creation (अदृष्ट, कर्म). (अणुकैवैहुभिरारभ्यते इत्यपि नियमो, न द्वाभ्यां । बहुभुवननियमः । कदाचित् त्रिभिरारभ्यते इति व्ययुक्तमित्युच्यते, कदाचित् चतुर्भिरारभ्यते कदाचित् पञ्चभिरिति यथेष्टं कल्पना । अदृष्टवशात् तथा तथा तेषां व्यूहो यथा यथा तदारब्धेषु अपरजातयो व्यज्यन्ते । अदृष्टकारिता सर्वभावानां सृष्टिः ।—Śrīdhara, Nyáya-Kandali, पृथिवीनिरूपणम् । Cf. Váchaspati's report, Bhámatī, Chap. II., Pada II., Sutra 2. यदा चतुरणुकमारभते चतुर्यीं अणुकानामारम्भकत्वात् ।) Prasastapáda appears to have originated this view (परमाणुअणुकेषु बहुत्वसंख्या—तैरारब्धे व्ययुक्त-दिलक्षणे—Prasastapáda, परिमाणनिरूपणम्); but that another

view was also maintained in the Vaisesika school is evident from the brief summary of Kanáda's system given in Utpala's commentary on the *Vrihatsamhitá*, and this indeed also follows from Śrídharma's admissions in the *Kandali*. On this view, also, atoms have an inherent tendency to unite; but some unite in pairs, others in triads, others in tetrads, etc. This may happen in two ways—either by the atoms falling into groups of threes, fours, etc., direct, or by the successive addition of one atom to each preceding aggregate.

A triad (*Tryanuka*), then, holds together three atoms (*Anus*), not three binary molecules (*Dvyanukas*), as on the orthodox hypothesis. Similarly with tetrads, pentads, etc. (चतुर्विधाः परमाणवः द्वितिजलाग्निवायूनाम् । द्वाभ्यां परमाणुभ्यां द्व्युकमारभ्यते त्रिभिः परमाणुभिस्तत्रयुकमारभ्यते इति क्रमेण सूक्ष्मकार्म्यद्रव्यस्योत्पत्तिः ।—Utpala, Chap. I., Śloka 7; cf. also Śrídharma's admission, अथवा यदि परमाणवो द्व्युकमारभ्य तत्सहितास्त्रयुकमारभन्ते त्र्युकसहितास्तु द्रव्यानन्तरम् तथापि कुता विघ्नस्य अयमहयम्). Śaṅkara seems to speak of two binary molecules in the Vaisesika as forming a tetrad (यदापि द्वे द्व्युके चतुर्युकमारभेत—Śáríra-ka-Bhášhya, Chap. II., Pada XX., Sutra 2, where the *Bhámati* gives a forced interpretation).

In *Prasastapáda*'s view, these binary molecules are grouped by threes, fours, fives, etc. (त्र्युक, चतुर्युक) to form different isomeric modifications. The variety of Earth substances is due to differences in the arrangements of the molecules (*e.g.* their greater or less density, and, above all, their grouping or collocation, गूह, अवयवसन्निवेश), which account for the specific characters (अपरजाति) manifested by these isomeric substances. सा (पृथिवी) च स्वैर्ब्यावयवसन्निवेशविशिष्टा

अपरजातिबहुत्वोपेता । — Prasastapáda, पृथिवीनिरूपणम् । स्वैर्यं निविद्धत्वं । आदिज्ञान्यात् प्रक्षिपितत्वादिपरिग्रहः । परमात्म्यादिषु अपरजात-भावेऽपि अदृष्टवशात् तथा तथा तेषां व्यूहः यथा यथा तदारम्भेषु अपरजातयो व्यज्यन्ते ।—Śrīdhara, Kandalī, *ibid.*

स्वैर्यं स्थिरता चिरकालावस्थायित्वमिति यावत् । आदियहणाद्विद्वम्भकत्वं जलादिव्यूहविरोधित्वञ्च । अवयवसन्निवेशः तत्तत्सामान्याविज्ञेयाभिव्यञ्जकसंस्था-नविज्ञेयाः । न हि शतद्रव्यान्मरे सम्भवति । जलादीनां यत्किञ्चित्स्पर्शवद्-वेगवद्द्रव्योपनिपातमात्रेणैव भङ्गुरत्वात् ।—Udayana, Kiranāvalī, *ibid.*

These original differences in molecular grouping, leading to distinctions of genera and species, however mechanically or physically explained, come also under the operation of moral and metaphysical causes (अदृष्ट, कर्मे), *i.e.* of ideal ends in the moral government of the Universe, which are superimposed upon the physical order, but which do not come within the scope of Natural Philosophy. An elementary substance thus produced by primary atomic combination may, however, suffer qualitative change under the influence of heat (पाकजोत्पत्ति). The process is as follows:—(1) The impact of heat-corpuscles decomposes the binary (tertiary, or quaternary) molecules into homogeneous atoms possessing only the generic characters of the Bhūta concerned; (2) the impacts of heat-particles continue, and transform the characters of the atoms, determining them all in the same way; (3) the heat-particles continue to impinge, and reunite the atoms so transformed to form binary (or other) molecules, in different orders or arrangements, which account for the specific characters or qualities finally produced. The Vaisesika holds that there is decomposition into homogeneous atoms, transformation of atomic qualities, and finally

re-combination, all under the influence of heat (पिलुपाक). The Nyáya, on the other hand, thinks that the molecules and larger aggregates assume the new characters under the influence of heat without decomposition into homogeneous atoms or change of atomic characters (पिठरपाक).

तेषामनुमानेन विनाशः परिकल्प्यते । सञ्जीवयवेषु अन्तर्वैहिंस्य पाकपूर्वक-
पूर्वकपादिविलक्षणगुणोपलवधेरन्तःप्रवेशः कृष्णानोरनुमीयते तेन वेगवता वह्नि-
द्रव्येण नोदनात् अविभातात् वा नूनं घटाद्यारम्भकेषु अवयवेषु क्रिया जायते
क्रियातो विभागः विभागात् द्रव्यारम्भकसंयोगविनाशः । तद्विनाशात् द्रव्य-
विनाशः । पक्षाच्च श्यामादिगुणानवज्ञहतः रक्तादिगुणान्तरयोगमनुभवन्तः—
अदृष्टप्रैर्मन्थाः परस्परं संयुज्य ज्ञानुकादिप्रक्रमेण तादृशमेव घटादिकाथ्यमारभन्ते ।
एवं तपनात्पदुश्यमानेषु आद्यादिफलैषु एव एव न्यायः । झरीरे अपि उदर्येण
तेजसा पच्यमानेषु अन्नपानादिषु रसमलधातुभावेन परिणाममुपगच्छत्सु प्रायेण
प्रतिष्यन्मुत्पादविनाशी संभवत इति । (Jayanta, Nyáyamañjarī,
भूतचतन्य-पूर्वपक्षः.) This is the Vaisesika view, but Jayanta
himself inclines to the opposite view : प्रकृतिसुधिरतयैव
काथ्यैद्रव्यस्य घटादेः आरम्भात् अन्तस्तेजःकथानुप्रवेशकृतपाकोपपत्तेः अलं
विनाशकल्पनया । पिठरपाकपक्ष एव पेशलः । *ibid.* The Nyáya
view : ये वीजावयववास्ते पूर्वव्यूहपरित्यागेन व्यूहान्तरमापन्नान् व्यूहान्तरापत्तौ
च पृथिवीधातुरब्धातुना संगृहीत आन्तरेण तेजसा पच्यमानो रसद्रव्यं निर्वर्त्तयति
स रसः पूर्वजावयवसहितोऽङ्कुरादिभावमापद्यते । परमात्मवस्थानि वीजानि
भवन्तीत्येतन्न प्रतिपद्यामहे । यस्माच्चात्यादिवोजमुच्चूनावस्थानादिं कृत्वा
यावदुपान्तं ज्ञालिबीजकार्यं तावन्न कदाचित् परमात्मवस्थं भवति । यदि
तु स्यात् कदाचित् नोपलभ्येत ।—Udyotakara, Chap. III.,
Áhnika 1, Sutra 4.

II. Chemical Combination (सम्भयक्रिया, संहत्क्रिया).—

Chemical combination takes place either between two or more substances which are isomeric modifications of the same Bhúta, or between substances which are modes of different Bhútas.

A. *Mono-Bhautic Compounds*.—The simplest compounds are mono-Bhautic compounds, *i.e.* compounds of different substances which are isomeric modes of the same Bhúta.

(a) *Mono-Bhautic compounds of the first order.*

Under the impact or impulse (अभिघात or नोदन) of heat-corpuscles, the substances in chemical contact (आरम्भक संयोग) break up into their atoms. These atoms are homogeneous, possessing only the original physical and chemical characters of the Bhúta concerned. As the specific differences between isomeric substances arise from the arrangement or collocation of the atoms, the substances lose their distinctive marks on decomposition into the latter.

(न च परमाणुषु अपरजातिभेदो विद्यते न च यवबीजज्ञालिबीजपरमाणूनां कश्चिद्विशेषः।—Udyotakara, Chap. III., Áhnika 1, Sutra 4.

न च शुक्रशोणितपरमाणूनां कश्चिद्विशेषः पार्थिवत्वविशेषात्।—Śrídharma, Nyáya-Kandali, पृथिवीनिरूपणम् ।)

Under the continued impact (or, it may be, impulse) of heat-particles (वेगवता वहिद्रव्येण नादनात् अभिघातात् वा—Jayanta), these atoms take on new characters. It is heat, and heat alone, that can cause this transformation of the colours, tastes, smells, etc., in these original Bhúta-atoms. What particular colours, tastes, smells, or physical characters will be produced in the atoms depends (1) on the

colours, etc., of the constituent substances in contact ; (2) the intensity or degree of the heat (स्वर, मृदु, or मध्यम पाक) ; and (3) the species of Tejas-corpuscles that impinge on the atoms, or the nature of the impact (विलक्ष्यतेजःसंयोग). (न ब्रह्मोऽग्निर्संयोगात् एकस्मात् रूपादय इति अपि तु पूर्वरूपादिविशेषापेक्षात् । यद्द्रव्यं पच्यते अग्निर्संयोगेन तस्य ये पूर्वरूपादयस्तेषां यः स्वगतो विशेषस्तमपेक्षमाद्यः अग्निर्संयोगः उत्तरान् रूपादीन् विशिष्टानारभते । *Vide also Udyotakara, III., 2, Sutra 14. Cf. also Vāchaspati, I., 1, Sutra 4. अस्माकमभेदे अपि उपादानस्य पिठरस्य औपस्थापरास्यस्य च वहिःसंयोगस्य पूर्वरूपादिप्रध्वंसानां कारखानी भेदात् भिन्नजातीया जायन्ते गन्धरूपरसस्पर्शा इति सिद्धान्तः ।)*

Now when the atoms have all been determined in the same way, they begin to re-combine again under the impact (or impulse) of the heat-particles in binary molecules (or tertiary, etc.), and these in higher aggregates. It seems to be generally held that at the final step one or more atoms of one constituent substance unite with one or more atoms of the other constituent substance or substances to form a molecule of the compound ; but the question is not of much significance for mono-Bhautic compounds of the first order, as in these cases the atoms have before this all lost their distinctive characters and become

homogeneously transformed. The compound so produced will possess the new characters of the transformed atoms, so far as taste, colour, smell, etc., are concerned, but as the molecular arrangement or structure (ब्रूह, अचयवसतिविशेष) may vary, different compound substances may result from the same components.

- (b) Mono-Bhautic compounds of higher orders. Again, mono-Bhautic compounds of the first order may chemically combine to form higher compounds, and as the ultimate Bhúta substratum is the same, the process of decomposition and re-composition will be essentially the same as before. The only doubtful point is whether in this case the component compound substances are broken up only into their constituent molecules, or into the original homogeneous Bhúta-atoms. Some of the later Vaiseshika scholiasts hold that the latter happens in every case of chemical composition, however complex, but the earlier Vaiseshika conceived that in the case of compounds of compounds the decomposition does not proceed so far as the original Bhúta-atoms, but that it is the specifically determined atoms constituting the molecules of the component compounds that are transformed under the impact of the heat-corpuscles; and then

one such transformed atom (one or more according to another version) from the molecule of one component unites with one similarly transformed atom (one or more according to the other version) from the molecule of the other component. Prasastapáda, the great Vaiseshika doctor, holds this view. When, for example, in the fertilised ovum, the germ and the sperm substances, which, in the Vaiseshika view, are both isomeric modes of Earth (with accompaniments of other Bhútas), unite, both are broken up into homogeneous Earth-atoms, and it is these that chemically combine under the animal heat (and biomotor Energy, वायु) to form the germ-plasm (कलल). But, next, when the germ-plasm develops, deriving its nutrition from the chyle (blood) of the mother, the animal heat breaks up the molecules of the germ-plasm into its constituent atoms (कललारम्भकपरमाणवः), i.e. into atoms specifically determined, which by their grouping formed the germ-plasm, and then these germ-plasm atoms as radicles chemically combine with the atoms of the food-constituents, and thus produce cells and tissues. (समुत्पन्नपाकजैः कललारम्भकपरमाणुभिः अदृष्टवशात् उपजातक्रियैः आहारपरमाणुभिः सह सम्भूय शरीरान्तरमारभ्यते इत्येषा कल्पना । पितुः शुक्रं मातुः शोणितं तयोः सन्निपातानन्तरं

मठरानलसम्बन्धात् शुक्लशोणितारम्भकेषु परमाणुषु पूर्वे-
रूपादिविनाशे सति समानगुणान्करोत्पक्षौ द्रव्यकादि-
प्रक्रमेण कललशरीरोत्पत्तिः । . . . तत्र मानुराहाररसः
माषया संक्रानति अदृष्टवशात् तत्र पुनर्मठरानलसम्बन्धात्
कललारम्भकपरमाणुषु क्रियाविभागादिन्यायेन कललशरीरे
नष्टे समुत्पन्नपाकनैः कललारम्भकपरमाणुभिः अदृष्टवशात्
उपजातक्रियः आहारपरमाणुभिः सह सम्भूय शरीरान्तर-
मारभ्यते इत्येषा कल्पना ।—Śrīdhara, Kandalī,
पृथिवोनिरूपणम् ।) In this hypothesis (कल्पना)
it is assumed that the atoms are similarly
transformed, *i.e.* become endowed with
the colour, taste, smell, etc., of the
product (the cell or tissue) the moment
before the chemical combination takes
place. Similarly, when milk is trans-
formed into curd, one view is that the
transformation takes place (under internal
heat) in the constituent atoms of the
milk-molecules, atoms specifically deter-
mined as milk, and not in the original
atoms of the Bhūta (or Bhūtas) entering
into the composition of milk. (*Cf.* एवं
महादुग्धारम्भकैः परमाणुभिरेव दध्यारभ्यते । एकमहिषेव
दध्यारम्भकैरेव परमाणुभिर्नैवनीतारम्भः इति दिक् ।
Nyáyabodhinī, on Annam Bhatta's Tarka-
saṅgraha. *Cf.* Dinakarī—द्रव्यकरूपदुग्धसं-
जन्यत्वेऽपि तस्य (दग्धः) ।) In these cases the
atomic contact is called constituent con-
tact (आरम्भकसंयोग), and all the atoms are
equally regarded as material causes (उपादान-
कारण or समवायिकारण) of the compound.

B. *Hetero-Bhautic* "Quasi-compounds."—The Nyāya-Vaiśeṣika maintains that in the case of bi-Bhautic (or poly-Bhautic) compounds, which are only quasi-compounds, there is another kind of contact between the heterogeneous atoms of the different Bhūtas, which may be called dynamic contact, and is distinguished in its operations as Upaṣṭambha, Viṣṭambha, or Avaṣṭambha (उपहृत्म्भ, विहृत्म्भ, or अहृत्म्भ). In some cases it so happens that the atoms of different isomeric modes of the same Bhūta do not chemically combine under the mere application of heat; they require to be surrounded (and "excited," "energized") by atoms of different Bhūtas. For example, in the case of the oils and fats, as well as of plant saps and fruit juices, the Earth-atoms must be dissolved in water (Ap), and it is only when the water-atoms (Ap-atoms) congregate round the former that dynamic intra-atomic forces are set up, and the Earth-atoms (with the water-atoms in dynamic contact) now take on peculiar infra-sensible characters (colours, tastes, smells) under the impact of the heat-corpuscles, and then, under further impact, fall into groupings or collocations (of a very peculiar nature, to be presently explained) which determine the nature of the composite substance thus produced. Here it is the water-atoms that are dynamic (उपहृत्म्भक), and excite the Earth-atoms, and these substances, oils and fats (तेलवर्ग and वृत्तवर्ग), as well as acids (अम्लवर्ग) are, because of the Earth-radicles, regarded

as Earth compounds (or Earth substances). (पाकज्ञ-तथाविधगन्धरसरूपादिमन्निः परमायुभिर्द्वैतुकादिक्रमेण घृतादिद्रव्यमारभ्यते । तत्र च उपहम्भकतया निमित्ततामापन्नाः पानीयावयवाः । तेषां संयुक्तसमवायेन ज्वहेस्तत्रोपलभ्यते । तैलक्षीरादिषु पार्थिवत्वसिद्धिः । तैलस्य भीमानलेन्धनत्वात् घृतवत् ।—Udayana.) In the above instances, Ap (water) acts as dynamic (Upashāmbhaka, उपहम्भक), but Tejas and Vāyu can also act in the same way on Earth-particles. Conversely, Earth-particles may act dynamically on the atoms of the other Bhūtas. For example, in the case of mercury and the metals which are conceived in the Nyāya-Vaiśeṣika to be igneous bodies (in fact, they are supposed to be formed under the subterranean heat, चाकरम), the Tejas-corpuscles are believed to form the radicles, and the Earth-particles are dynamic (उपहम्भक). (सुवर्णादि निरन्तरं ध्यायमानमपि न पूर्णरूपं जहाति । तेनैव द्रव्यानरेण प्रतिवहत्वात् उपहम्भकोऽपि पार्थिवभागः सदृशरूप एवानुवर्त्तते, यत्तु पुटपाकादिना रक्तसारता दृश्यते तन्निष्पन्नाभिभावकतत्सद्द्रव्योपगमात् । एतेन पारदादिव्याख्यातम् ।—Udayana, Kiranāvalī, तेजोनिर्हणम् । Cf. also योग्यं तेजसमिच्छति सुवर्णं तेनाप्यथ पार्थिवोभाग उपहम्भक एहव्यः ।)

It may be here noted that Gaṅgesa, the author of the Tattvachintāmani, conjectures that even gold can be evaporated or made to disappear by the application of intense heat : अथ द्रुतद्रुततरादेः क्रमशः प्रतीतेः प्रबलानलसंयोगेन सुवर्णनाशात् तद्द्रवता नश्यति । But Mathurānātha notes here : भस्मप्राक्कालोच्चेदसमये । (सन्निकर्षवादरहस्य).

But while every Bhūta can act dynamically

as उपहम्भक, "energizer," "exciter," it is the Earth Bhúta alone which is capable of exercising (1) the power of arrest or inhibition of molecular motion, or the motion of particles due to gravity as in fluids (Vishṭambha, विहम्भ); or (2) the power of counteracting the tendency in a given set of atoms to fall into a peculiar order or group (व्यूहविरोधित्वम्). (न च पार्थिववत् अम्भो द्रव्यान्तरं गच्छद्विहम्भाति पूष्ट्वैव्यूहं वा विरुहयति ।—Udayana, Kiranávalí, पृथिवी-निरूपणम्। विहम्भकत्वं स्वाभाविकगुरुत्वात्पतनप्रतिबन्धकत्वम् । व्यूहविरोधित्वं च स्वाभाविकगुरुत्ववत्पतनप्रतिबन्धकत्वम् । —Vardhamána, Kiranávalíprakása, *ibid.*)

Oils, Fats, Milks.—Bi-Bhautic quasi-compounds, with Ap as energizer : Oleaginous substances (आज्यतैलादयः जेहाः) are divided by Udayana into (1) oils derived from vegetables, (2) butters derived from milk, and (3) fats derived from animals. The medical schools, as we have seen, recognise animal oils as distinguished from vegetable oils. Vegetable fats (*e.g.* विडङ्गवृत्त) are also mentioned. Váchaspati and Udayana contend that among oils, fats, milks, etc., differences in flavour and odour imply differences in kind (जाति) and in molecular structure, since it is only a variation in such structure that constitutes a variation in natural kind (अवयव-सन्निवेशः—तत्कालानान्यविशेषाभिष्यञ्जकसंस्थानविशेषाः—Udayana, Kiranávalí). Mustard-oil, for example, has not the flavour and smell characteristic of sesamum-oil (Taila), and is classed with the latter only by reason of similarity of specific qualities and structure. Judged by the flavour test, Ámikshá (the casein substance formed by mixing milk curd with hot boiled milk) is to be classed with

milk substances. So also Takra, whey ; but Vájina, the thin fluid that is left after the Ámikshá (casein substance) is separated, cannot be classed as milk. It may be added that the milks and curds, as well as oils and fats derived from different species of vegetables or animals, are supposed to differ in their ultimate structural arrangement, and therefore in kind ; but Vallabha thinks that the ghees (clarified butters) prepared from different kinds of milk are of the same kind ; in other words, the milks and curds are "polymeric," the ghees (clarified butters) "isomeric," using these terms, as before, in a loose general sense. (. . . तैलघृतवसानां षीजक्षीरमांसयोनिनात् । अतएव नारिकेलक्षेहस्यापि तैलत्वं रसादिसारूप्यादपि तु घृतव्यपदेशश्च ।—Udayana, Kiranávalí, पृथिवीनिरूपणम् । Vallabha notes that ghees do not differ in kind as milks (and curds) do : अतः अतः नाहिषगव्यादिदुग्धेषु दधित्ववत् घृतादिषु जातिभेदश्चास्तीति चेत् ।—Vallabha, Lilávatí. Compare Váchaspati, II., 2, 65 : अज्यतैलादीनां जातिस्तु गन्धेन वा रसेन वा व्यज्यते । अतएव न सारिषादीनां तैलत्वमस्ति । तद्व्यञ्जकयोगेन्द्ररसयोरभावात् । भास्वस्तु तैलव्यञ्जकयोगः । क्षीरजातिरपि रसव्यञ्जकेव । अतएवामिक्षायाः क्षीरत्वम् । न तु वाजिनस्य तद्व्यञ्जकस्य रसभेदस्य वाजिने अभावात् आमिक्षायां च भावात् ।)

III. *Mixtures like Solutions, etc.*—A solution (of an Earth substance in Ap or water) is a physical mixture of a peculiar kind, from which evaporation (or precipitation) ordinarily sets the water free. Udyotakara notices gruels, baths, and lyes (alkaline solutions) as mixtures of this class (इत्तेन पाककाश्चिकविषेकावधारादयः प्रत्युक्तः—Udyotakara). A soup is also a physical mixture. When meat is boiled in water there is the

application of heat with chemical changes in the meat, but the combination of meat particles and water particles in the soup is only physical combination and not a chemical one. It is, of course, not a true compound, neither is it a quasi-compound like milk (in which the water particles are "energizers" of the Earth particles). Milk, for example, retains its milky substance when it coagulates or becomes solid (this, of course, is also the case with mono-Bhautic substances whether elementary or compound, *e.g.* water, which becomes ice), but the substance we call a soup or solution ceases to be a soup or solution the moment it solidifies. (यूषो हि नाम उत्पन्नपाकजानां द्रव्याणां कालविशेषानुग्रहे सति द्रव्यान्तरसंपृक्तानां पाकजोत्पत्तौ यः संयोगः स यूष इति । एतेन पाककाश्चिकविवेकावक्षारादयः प्रत्युक्ताः ।—Udyotakara, Vārtika, Chap. I., Āhnika 1, Sutra 14. *Vide* also Vāchaspati's comment : उत्पन्नपाकजानां तैले सर्पिषि वा पिष्टनांसपिष्टावयवानां द्रव्यान्तरेण तोयेन संपृक्तानां पाकजोत्पत्तौ सत्यां न चासौ सहसा इत्युक्ते कालविशेषानुग्रहे सतीति । स च संयोगभेदश्च तोयमांसयोर्नतु अथयवौ विजातीययोरनारम्भकत्वात् । नापि यूषजातीयं तोयसंयोगि द्रव्यं क्षीरजातीय-मिवेति युक्तम् । तोयधिरहे काठिन्येऽपि क्षीरबुद्धिम्यपदेश्योक्तादवस्थ्यात् । इह तु काठिन्ये न यूषबुद्धिम्यपदेशी इति सन्बन्धभेद एव तोयमांसयोर्बुध इति न्याय्यम् । स च अनुभवसिद्धः संयोगिष्यतिरिक्तः ।—Vāchaspati, Tātparyyatīkā, *ibid.* For earthy salts in sea-water, *vide* Kiranāvalī : यत् पुनरम्बुधिसिन्धुभेदेन क्षारादिरपि रसः पाचसे उपलभ्यते स दशमूलकषायस्येव पार्थिवद्रव्योपाधिकः । कषयनन्यथा तस्यैव घनपीतनुक्तस्य रसो नधुर एव ।—Udayana, Kiranāvalī, जलनि-रूपणम् ।)

Chemical Action and Heat.—The operation of heat is of course universally implied in chemical combinations. Where the application of external heat is

wanting, Vátsyáyana, the great doctor of the Nyáya, points to the operation of internal heat (*e.g.* पृथिवीधातुः अर्थात्संगृहीतः आन्तरेण तेजसा पच्यमानः रसद्रव्यं निर्वर्त्तयति ।— Vátsyáyana-Bhášhya, Chap. IV., Áhnika 1, Sutra 47). In the case of combustion we have seen Vijñána-bhikshu explain the heat as latent in the Earth substance, the fuel, from which it breaks forth. Udayana points out that the solar heat is the source of all the stores of heat required for chemical change in the world. The change of colours in grasses, for example, is due to Tejas in the form of latent (invisible) heat, not in the form of Agni; and the cold in winter cannot take away this store derived from the sun. (नृणादिविकारो हि यदि रूपादिपरावृत्तिमात्रहेतुः स नूनमीश्यापेक्षेण तेजसा कर्त्तव्यः । तादृशं च पाके अग्निमिदं हिममिति । न किञ्चिदनिष्टमापद्यते । न हि सौरस्य तेजसः त्रैलोक्यपाकहेतोर्हिमादपगमः क्षमते । अप्यविकारो भस्मादिरूपो विवक्षितः सोऽसिद्ध एव हिमहेतेषु नृणादिषु क्व विरोधो बाधो वा । अप्यरूपादिपरावृत्तिमात्रेणैव अग्निः साध्यते तदज्ञकम् । तस्य दर्शनस्पर्शन-प्राप्तस्य योग्यानुपलम्भबाधितत्वात् अतादृशस्य तेजोमात्रस्य निवृत्तेरज्ञकत्वात् अनिष्टत्वात् च ।—Udayana, Kiranávalí, सृष्टिसंहारविधिनिरूपणम् ।) Similarly it is under this solar heat that the unripe mango ripens, *i.e.* changes colour, taste, smell, etc., showing that there is chemical transformation or subtile decomposition and recomposition going on; and this is also the case with the rusting of the metals, which is a combustion due to the solar heat (सूर्यपाक) even as the conversion of food into chyle and of chyle into blood are instances of chemical action due to the internal animal heat (अठरानल or अदीर्घं तेजः). But the kind of contact with heat-corpuscles, in other words, the kind of chemical action (पाक) which transforms colours, is

supposed to differ from that which transforms flavour (विलक्षणतेजःसंयोग and पाक), and this last from that which produces a change of smell, or tactile quality. (पाको नाम विजातीयतेजःसंयोगः । स च नानाजातीयः । रूपजनको विजातीयतेजः-संयोगस्तदपेक्षया रसजनको विजातीयः । एवं स्पर्शादी अपि तथा । एवंप्रकारेण भिन्नभिन्नजातीयाः पाकाः कार्यवैलक्षण्येन कल्पनीयाः । तथाहि तृणपुञ्ज-निक्षिप्ताम्वादी उष्णलक्षणविजातीयतेजःसंयोगात् पूर्वहरितरूपनाश रूपान्तरस्य पीतादेरुत्पत्तिः पूर्वरसस्य अन्नस्यैवानुभवात् । क्वचित् पूर्वहरितरूपसस्त्रेऽपि रसपरावृत्तिर्दृश्यते विजातीयतेजःसंयोगरूपपाकवशात् पूर्वेतानां रसनाशे मधुर-रसस्यानुभवात् । तस्माद्रूपजनकापेक्षया रसजनको विलक्षण एवं गन्धजनको विलक्षण एवाङ्गीकार्यैः रूपरसयोरपरावृत्तौ अपि पूर्वगन्धनाशे विजातीयपा-कवशात् सुरभिगन्धोपलभ्येः । एवं स्पर्शजनकोऽपि पाकवशात् कठिनस्पर्शनाशे मृदुस्पर्शानुभवात् । अतएव पापिवपरमाणुनामेकजातीयत्वेऽपि पाकमहिम्ना विजातीयद्रव्यान्तरानुभवः । यथा गोभुक्तृत्यादीनां आपरमाणवन्तं भङ्गे तृणा-रम्भकपरमाणुषु विजातीयतेजःसंयोगवशात् पूर्वरूपादिचतुष्टयनाशे तदनन्तरं दुग्धे यादृशं रूपादिकं वर्त्तते तादृशरूपरसगन्धस्पर्शजनकास्तेजःसंयोगा ज्ञायन्ते । तदुत्तरं तादृशरूपादय उत्पद्यन्ते । तादृशरूपादिविशिष्टपरमाणुभिर्दुग्धशुक्लमा-रभ्यते । ततः अणुकादिक्रमेण महादुग्धारम्भइति ।—Nyáyabodhini on Annam Bhatta's Tarkasaṅgraha.) Heat- and light-rays are supposed to consist of indefinitely small particles which dart forth or radiate in all directions rectilineally with a sort of conical dispersion and with inconceivable velocity. They may either (1) penetrate through inter-atomic (or inter-molecular) spaces as in cases of conduction of heat, which when applied under the pot boils the water or fries the paddy, where there is no chemical action in the pot, no decomposition and recomposition of its atoms, no change in the molecular collocation; or, as with light-rays in cases of translucency or transparency (सञ्चता), penetrate through the inter-atomic spaces with Parispanda of the nature of

deflection or refraction (तिर्य्येगुगमन, Udyotakara), in the same way as when fluids penetrate through porous bodies (तत्र परिस्पन्दः तिर्य्येगुगमनं परिस्रवः पात इति—Udyotakara, commenting on Vātsyāyana's परिस्पन्दपरिस्रवौ, Sutra 47, Āhnika 1, Chap. III.); or (2) impinge on the atoms, and rebound back—which explains reflection (मूर्च्छन, किरणविचट्टन—Varāhamihira, रश्मिपरावर्त्तन—Vātsyāyana), or otherwise be obstructed by the atoms in their path, which would explain degrees of opacity, the casting of shadows, etc., all these operations being also physical, and unattended by decomposition and recomposition or alteration of molecular grouping; or (3) lastly, strike the atoms in a peculiar way, so as to break up their grouping, transform the physico-chemical characters of the atoms, and again recombine them, all by means of continual impact with inconceivable velocity, an operation which explains all cases of chemical combination. (अपिन्वो हि तेजसो लावशातिशयेन वेगातिशयः यत् प्राचीनाचलच्छूडावलम्बिनि एव भगवति मयूसमालिनि भवनोदरेषु आलोकइत्यभिमानो लौकिकानाम् ।—Udayana, Kiranāvalī, तेजोनिरूपणम्, taken from Vāchaspati, Tāt-paryyatikā, प्रत्यक्षलक्षणसुचम् । Cf. also चाक्षुर्षं तेजः वेगवता साविचेन तेजसा न प्रतिहन्यते ।—Vāchaspati. वसिंदेशे पिङ्गितमपि तेजः प्रसर्पेत् प्रासादोदरं व्याप्नोति । तत् कस्य हेतोः पृथग्यत्वात् । स्वभावतः प्रसरदपि न स्वपरिमाणानुविधायिनं प्रत्ययमाधत्ते किं तु विषयभेदानुविधायिनम् ।—*ibid.* Cf. स्फटिकाङ्गनरितोपलक्ष्धिरपि प्रसादस्वभावतया स्फटिकादीनां तेजोतेरप्रतिबन्धकतया प्रदीपप्रभावादेवोपपन्ना ।—Udayana, तेजोनिरूपणम्, in reply to the objection: यदि हि प्राप्य गृहीयात् प्रतिघातिना स्फटिकद्रव्येण विहम्भादप्राप्तं प्रसर्पेन्नृणादिकं नाददीत तस्मादप्राप्यकारि ततो न तेजसम् ।—Udayana, *ibid.* Definition of स्वच्छता—द्रव्यान्तरा-सम्पृक्तद्रव्यसमवायः स्वच्छता । दृष्ट्याप्रतीघातः काचाध्रपटलस्फटिकाकारितो-पलक्ष्धः । स्यात्स्यादिषु च पाचकस्य तेजसाप्रतीघातात् ।—Udyo-

takara, Chap. III., Áhnika 1, Sutra 38. चादित्यरश्मेः स्फटिकानारितेऽपि दाह्येऽविधातात्—Sutra 47, where Udyotakara notes : कौश्ल्यमविधातः—यस्य द्रव्यस्यावयवा न व्यूलान्ते तस्य अन्नरावयवैः अव्यूलमानस्य योऽभिसम्बन्धः सोऽविधात इति । Váchaspati explains यस्य द्रव्यस्य भर्जनकपालादेः अवयवा न व्यूलान्ते पुञ्जोत्पन्नद्रव्यारम्भकसंयोगनाशेन द्रव्यानारजनकसंयोगोत्पादनं व्यूलनं तत्र क्रियन्ते तस्य द्रव्यस्य भर्जनकपालादे-रव्यूलमानस्य अन्नरावयवैर्योऽभिसम्बन्धो दह्येः सोऽप्रतिधातः । Cf. Vátsyáyana on Sutra 47, Áhnika 1, Chap. III. On the other hand, in chemical combination, अन्नःप्रवेशः कृशानोरनुमीयते । जेन वेगवता वहिद्रव्येण नीदनात् अविधातात् वा अवयवेषु क्रिया, क्रियातो विभागः, विभागात् आरम्भकसंयोगविनाशः etc.—Jayanta, Mañjarí, भूतचैतन्यपुञ्जपक्ष । For opacity, shadows, etc., vide छाया तु तेजःपरमाखोरावरणात् भूक्षिप्ता परमायुना तेजःपरमायुरात्रियते । यत्र च अस्य आवरणं तत्र छायेति । विरलतेजःसम्बन्धीनि द्रव्यगुणकर्मणि छाया इत्यभिधीयते । सर्वतो व्यापृततेजःसम्बन्धीनि तु तानि तमःसंज्ञकानि ।—Udyotakara, Chap. IV., Áhnika 2, Sutra 25. For reflection and its laws, I quote passages in my Paper on Hindu Physics, to which the student of the history of Optics is referred.)

Arrangement of Atoms in Space.—The Nyáya conceives atomic magnitudes as Párimándalya, a term which indicates a spherical shape. (नित्यं परिमण्डलम्—परिमण्डलमेव पारिमाण्डल्यम्—Sāṅkaramisra). To conceive position in space, Váchaspati takes three axes, one proceeding from the point of sunrise in the horizon to that of sunset, on any particular day (roughly speaking, from the east to the west); a second bisecting this line at right angles on the horizontal plane (roughly speaking, from the north to the south); and the third proceeding from the point of their section up to the meridian position of the sun on that day (roughly

speaking, up and down). The position of any point in space, relatively to another point, may now be given by measuring distances along these three directions, *i.e.* by arranging in a numerical series the intervening points of contact, the less magnitude or distance being that which comes earlier in this series, and the greater that which comes later. The position of any single atom in space with reference to another may be indicated in this way with reference to the three axes. But this gives only a geometrical analysis of the conception of three-dimensioned Space, though it must be admitted in all fairness that by dint of clear thinking it anticipates in a rudimentary manner the foundations of solid (co-ordinate) geometry. (एकत्वेऽपि दिशः आदित्योदयदेश-प्रत्यासन्नदेशसंयुक्तो यः स इतरस्माद्विप्रकृष्टप्रदेशसंयोगात् परमाणोः पूर्णः एवमादित्यास्तमयदेशप्रत्यासन्नदेशसंयुक्तो यः स इतरस्माद्विप्रकृष्टप्रदेशसंयोगात् परमाणोः पश्चिमः ती च पूर्णपश्चिमी परमाणू अपेक्ष्य यः सूर्योदयास्तमयदेश-विप्रकृष्टप्रदेशसंयागः स मध्यवर्ती । एवमेतयोर्वा तिर्य्यग्देशसम्बन्धिनी मध्यस्य आर्जवेन व्यवस्थिता पार्श्ववर्तिनी ती दक्षिणोत्तरी परमाणू । एवं मध्यन्दिन-वर्तिसूर्य्यसन्निकर्षविप्रकर्षौ अपेक्ष्य उपर्य्यभोभावो द्रष्टव्यः । संयुक्तसंयोगात्पत्न-भूयस्त्वे च सन्निकर्षविप्रकर्षौ पूर्णसंस्थावच्छिन्नत्वं च अत्यन्तं परसंस्थावच्छिन्नत्वं च भूयस्त्वम् ।—Vāchaspati, Tātparyyatikā, Chap. IV., Āhnika 2, Sutra 25.)

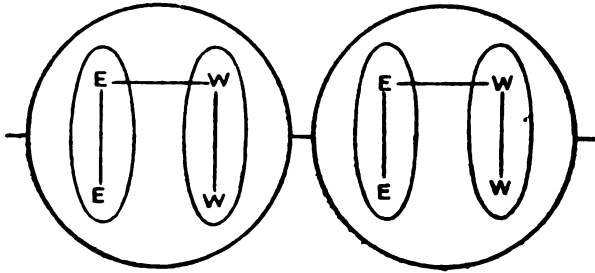
The original physical arrangement of atoms is also given. Each (spherical) atom is in contact with six other atoms. एवं दिशोऽपि एकस्या अपि संयोगा एव भागाः सोऽयं परमाणोः षट्केन युगपद्योगे मूर्त्तत्वाच्चप्रयुक्तः न सावयवत्वप्रयुक्तः ।—*ibid.* Cf. also the objection in the Buddhist Kārikā, षट्केन युगपद्योगे परमाणोः षडंशता । षष्ठी समानदेशत्वे पितृः स्यादशुभावकः ॥ This is the typical primordial arrangement, and variations in the collocation of atoms and molecules (ब्यूह, अवयवसन्निवेश),

as we have seen, were conceived to account for the variety of isomeric modes of the same Bhúta, as well as of mono-Bhautic and poly-Bhautic compounds.

The molecular arrangement in the case of bi-Bhautic compounds is very peculiar. Two substances, say Earth and Ap (water), form a quasi-compound first, and each substance breaks up into atoms; one atom of Earth comes into contact with one of Ap. But the two do not form a binary molecule. Instead, this contact of heterogeneous atoms leads to a curious result. The atom of Earth combines with a neighbouring atom of its own class, and forms a binary molecule. Simultaneously the atom of Ap combines with another Ap-atom, and forms a binary molecule. Now the first binary molecule links on to the atom of Ap, and similarly the second binary molecule links on to the atom of Earth. The moment after, the two binary molecules take on the physico-chemical characters of Earth and Ap respectively, and simultaneously with the assumption of these physico-chemical characters, the binary molecules enter into complex contact (संयोगसंयोग). In all this process work is done only in the first instant, in the contact of an atom of Earth with one of Ap; the resulting contacts, of atom with binary molecule and of the binary molecules with each other, involve no further expenditure of Energy. Thus we get a particle holding two binary molecules (of Earth and Ap respectively) in complex contact, and such particles continue to be formed. In this way the particles of the two substances arrange themselves, and the peculiarity of this molecular arrangement explains the resulting mixed or compound qualities

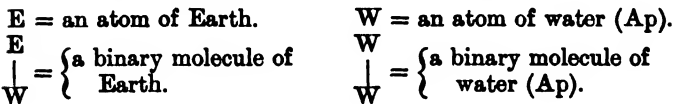
of this class of quasi-compounds. (संयोगजस्तु (संयोगः) उत्तपन्नमात्रस्य चिरोत्पन्नस्य वा निष्क्रियस्य कारखसंयोगिकारखः कारखा-कारखसंयोगपूर्वकः कार्थ्याकार्थ्यगतः संयोगः । . . . एकस्माच्च द्वयोरुत्पत्तिः । कथम् । यदा पार्थिवाप्ययोरखोः संयोगे सति अन्येन पार्थिवेन पार्थिवस्य अन्येन आप्येन च आप्यस्य युगपत्संयोगो भवतस्तदा ताभ्यां संयोगाभ्यां पार्थिवाप्येद्वयुके युगपदारभ्येते । ततो यस्मिन् काले द्वयुक्तयोः कारखगुणपूर्वक्रमेण रूपाद्भुत्पत्तिः तस्मिन्नेव काले इतरेतरकारखाकारखगतात् संयोगात् इतरेतरकार्थ्याकार्थ्यगती संयोगी युगपद्भुत्पद्येते । किं कारखम् । कारखसंयोगिना हि अकारखेन कार्थ्यं अवश्यं संयुज्यते इति न्यायः । अतः पार्थिवं द्वयुक्तं कारखसंयोगिना आप्येन अणुना सम्बध्यते । आप्यनपि द्वयुक्तं कारखसंयोगिना पार्थिवेनेति—Prasastapāda-Bhāshya, गुणग्रन्थे संयोगनिरूपणम् ।)

The whole process may be graphically represented as follows :—



MOLECULES OF A BI-BHAUTIC QUASI-COMPOUND :

GRAPHIC FORMULA OF COMPLEX CONTACT.



I will conclude this account of ancient (and mediæval) Hindu chemistry with a note on the conception of molecular (atomic) motion, Parispanda, and the different varieties of such motion which were conceived to account for the physical phenomena of sound, light, and heat. Any attempt to differentiate

rigidly between Mechanics and Physics on the one hand and Chemistry on the other at this primitive stage would be an idle affectation. My Paper on Hindu Mechanics and Physics will give a detailed exposition in a separate treatise.

PARISPANDA :—RESOLUTION OF ALL PHYSICAL
ACTION INTO MOTION.

Parispanda sometimes stands for motion molar as well as molecular, but more often for the subtile motion of atoms or molecules. The radical meaning of the term is whirling or rotary motion, a circling motion, but it may also include simple harmonic motion (*e.g.* vibration). All action, operation, work (क्रिया, व्यापार) is ultimately traced to this form of subtile motion lodged in the atoms or in the matter-stuff. The Vedánta, for example, speaks of a cosmic vibratory motion (सर्वलोकपरिस्पन्दनम्—Sañkara). Ákása, in the Vedánta, as we have seen, is the first stadium in the evolution of Matter, which gives off Váyu, which gives off Tejas, and so on; but Ákása (ether) itself passes through two stages before the emanation of the Sūkshma-bhúta Váyu: (1) the motionless ubiquitous primordial matter-stuff (answering to the Sāñkhya Bhútádi) called Puránam Kham (पुराणं खं); and (2) a subtile integration, the pure un-quintuplicated Sūkshma Bhúta called Váyuram Kham (वायुरं खं), answering to the Sāñkhya Tanmátra stage. It is this subtile Ákása, in its Tanmátric integration, *i.e.* in the derivative form, which is subject to an incessant Parispanda. The gaseous stage of matter (the Vedántic Váyu) is indeed

matter in a state of Parispandic motion (वायोः परिस्यन्दात्मकत्वात्—Sāṅkara). So also the biomotor and sensorimotor principles apart from the directive intelligence of the Self (प्राणस्य परिस्यन्दात्मकत्वादेव—यद्भूतेन स्थूलं सूक्ष्मञ्च तत्सर्वं मनःस्यन्दितात्मन्—Sāṅkara). The Sāṅkhya also conceives this Parispanda to characterise every process and phenomenon of cosmic evolution (अर्कं सक्रियं परिस्यन्दत्—Vāchaspati, Kaumudī). Bhūtas, organisms, mental organs, as modes of Prakṛiti (considered apart from the Intelligence of Puruṣa) are all subject to this Parispanda (बुद्धादयो देहं त्यजन्ते देहाकारं उपाददन्ते इति तेषां परिस्यन्दः । झरीरपुषिष्यादीनां च परिस्यन्दः प्रसिद्ध एव ।—Vāchaspati on Kārikā 10). On the other hand, Prakṛiti as the Avyakta, the a-cosmic, the un-manifest ground, with resolution only of like to like (सदृशपरिणाम), is devoid of all Parispandic motion (यद्यपि अव्यक्तस्यापि परिणामलक्षणा क्रिया, तथापि परिस्यन्दो नास्ति ।—*ibid.* on Kārikā 10). The Nyāya-Vaiśeṣhika finds Parispanda in all forms of matter, except Ākāśa, which in that system is non-atomic and incapable of any change or activity (निष्क्रिय). But all atoms, from those of Vāyu downwards, are in incessant motion. The world at bottom is an infinitude of continually whirling (or vibratory) particles (अनवरतपरिस्यन्द्मानापरिमितपवनादिपरमाणवः—Raghunātha; compare also Udayana-Kusumāñjali, Stavaka V.—परमाणवः हि गतिङ्गीलत्वात् पतत्रव्यपदेशाः पतन्तीति ।). All physical action consists in motion. The Nyāya-Vaiśeṣhika rejects force, power, operation (शक्ति) except as modes of motion. Jayanta, indeed, states: We do not acknowledge any mysterious power or operation which the senses do not and cannot report to us. But this denial of Force (शक्ति) and of

unperceived and unperceivable operation (अतीन्द्रियव्यापार) is put forward as a philosophical (epistemological and metaphysical) proposition to justify the Nyáya analysis of the causal *nexus* into mere invariable and unconditional antecedence among phenomena without productive power or efficiency (अन्यथासिद्धिशून्यस्य नियतपूर्ववर्तिता—Bhāshá-Parichchheda). It is not, of course, intended to question the existence of Parispanda, which is of the nature of motion, and which, though subtle and therefore infra-sensible (सूक्ष्म and अनुभूतरूप, not अतीन्द्रिय), is the ultimate form of all physical activity. (परिस्पन्द एव भौतिको व्यापारः करोत्यर्थः । अतीन्द्रियस्तु व्यापारः नास्तीति ब्रूयते । . . . तस्मात् कारकचक्रेण चलता जन्यते फलम् । न पुनश्चलनादन्यो व्यापार उपलभ्यते—Jayanta, Nyáyamañjarí, Áhnika 1.) The effect (no less than the action) is, in all cases of material causation, the resultant of the combined motions of the various (material and efficient) causes involved (*e.g.* in the case of पाक, समुदितदेवदत्तादिसकलकारकनिकरपरिस्पन्द एव विशिष्टफलावच्छिन्नः पाक इत्युच्यते । . . . अथ व्यापार एवैवः सर्वैः संभूय साध्यते । किं फलेनापराङ् वः तद्धि संभूय साध्यताम् ।—Jayanta, Nyáyamañjarí, Áhnika 1.)

But, in the Nyáya-Vaisesika, though all action of matter on matter is thus resolved into motion, conscious activity is sharply distinguished from all forms of motion, as against the Sāñkhya-Vedánta, which, as we have seen, considered everything other than Intelligence, the Purusha or the transcendental Self, to arise in the course of cosmic evolution, and therefore to be subject to Parispandic motion. (क्रियाविज्ञेय एवार्थं व्यापारो ज्ञानुरान्तरः । स्पन्दोऽस्य कवहिर्युक्तक्रियालक्षणाविलक्षणाः ।—Quoted in Jayanta's Nyáyamañjarí, Áhnika 4.)

ADDENDA.

EMPIRICAL RECIPES FROM VARÁHAMIHIRA (*circa* 550 A.D.) RELATING TO CHEMICAL TECHNOLOGY.

A. Searing of hard rocks to enable them to be cut (or pulverised) (शिलादारण).

Sprinkle on the rock taken red-hot from the fire of Palasa and Tinduka wood (*Butea Frondosa* and *Diospyros Embryopteris*):—(a) diluted milk, or (b) a solution of wood ashes (the ashes of the *Mokshaka* mixed with those of reeds), or (c) a decoction of (the fruit of) the jujube (*Zizyphus Jujuba*) kept standing for seven nights in a mixture of whey, vinegar, and spirits, in which *Kulattha* (*Dolichos Uniflorus* or *Biflorus*) has been steeped, or (d) a solution of the ashes of the *Neema* bark and leaves (*Azadirachta Indica*), the sesame-pod, the resinous fruit of the *Diospyros Embryopteris*, and the *Guduchi* (*Tinospora Cordifolia*), with cow's urine. Repeat the process seven times (in the last case six times).—(Varáhamihira, *Vrihat Samhitá*, Chap. XXXIII., Ślokas 112–117.)

B. Hardening of steel (शस्त्रपान).

(1) Plunge the steel red-hot into a solution of plantain ashes in whey, kept standing for twenty-four hours; then sharpen on the lathe.

(2) Make a paste with the juice of the *Arka* (*Calotropis Gigantea*), the gelatine from the horn of the sheep, and the dung of the pigeon and the mouse;

apply it to the steel after rubbing the latter well with (sesame) oil. Plunge the steel thus treated into fire; and when it is red-hot, sprinkle on it water, or the milk of the horse (or the camel or the goat), or ghee (clarified butter), or blood, or fat or bile. Then sharpen on the lathe.—(Varāhamihira, *ब्रह्मस्मृत्यम्*, Chap. XLIX., Ślokas 23–26.)

C. Preparation of cements (for rocks, metals, etc.)
(*वज्रलेप*).

Varāhamihira gives the following recipes among others :—

(1) First, prepare a levigated powder with lac, the resinous exudation of the *Pinus Devadara*, the *Balsamodendron Mukal*, the *Feronia Elephantum*, the kernel of the fruit of the *Ægle Marmelos* (the *bel*), the *Diospyros Embryopteris*, the *Neem* (*Azadirachta Indica*), the *Mhow* (*Bassia Latifolia*), the Indian madder (*Rubia Manjistha*), the *Phyllanthus Emblica*, and the resin of the *Sala* tree (*Shorea Robusta*); then make a decoction of this in 256 Palas of water reduced by boiling to 32 Palas, and apply the decoction hot.

(2) The horns of cows, buffaloes, and goats, asses' hair, buffaloes' skin, with *gavya* (cow's urine, etc.), the *Neem* (*Azadirachta Indica*), and the *Feronia Elephantum*, similarly treated.

(3) A mixture of eight parts of lead, two of "bell-metal," and one of brass, melted and poured hot (*Maya's cement*).

The first, it will be seen, has lac, gum, and turpentine as principal ingredients; the second makes use of gelatine; and the third is a metallic cement.

D. Nourishment of Plants (from Varáhamihira, Chap. LIV., on वृक्षारुद्धे).

The most suitable ground to plant in is soft soil that has been sown with the Sesamum Indicum, and dug up or trodden over with the sesame in flower. Grafts should be smeared with cow-dung. For transplanting, the plants should be smeared with ghee (clarified butter), sesame oil, the honey of the Kshudra variety of the bee, the oil of the Usira (Andropogon Laniger or Andropogon Citrarum), the Vidanga (Embelia Ribes), milk, and cow-dung. Trees should be planted at intervals of 20 or 16 cubits.

As a sort of general prophylactic, mud kneaded with ghee (clarified butter) and Vidanga (Embelia Ribes) should be applied to the roots, after which milk diluted with water should be poured. As a remedy against barrenness a hot decoction should be made of Kulattha (Dolichos Uniflorus or Biflorus), Masha (Phaseolus Roxburghii), Mudga (Phaseolus Mungo), Tila (Sesamum Indicum), and Yava (barley), which, when cooled, should be poured round the roots.

To promote inflorescence and fructification, a mixture of one Ádhaka (64 Palas) of sesame, two Ádhakas (128 Palas) of the excreta of goat or sheep, one Prastha (16 Palas) of barley powder, one Tula (100 Palas) of beef, thrown into one Drona (256 Palas) of water, and standing over for seven nights, should be poured round the roots of the plant. The measures given are for one plant.

To ensure inflorescence, etc., the seed before being sown should be treated as follows :—The seeds should

be taken up in the palm greased with ghee (clarified butter) and thrown into milk; on the day following the seeds should be taken out of the milk with greased fingers and the mass separated into single seeds. This process is to be repeated on ten successive days. Then the seeds are to be carefully rubbed with cow-dung, and afterwards steamed in a vessel containing the flesh of hogs or deer. Then the seeds are to be sown with the flesh, with the fat of hogs added, in a soil previously prepared by being sown with sesame and dug up or trodden down.

To ensure the formation of *Ballarís* (*i.e.* sprouting and the growth of luxuriant stems and foliage), the seeds should be properly soaked in an infusion of powdered paddy, *Masha* (bean), sesame, and barley, mixed with decomposing flesh, and then steamed with *Haridrâ* (turmeric). This process will succeed even with the *Tintidî* (*Tamarindus Indica*). For the *Kapittha* (*Feronia Elephantum*), the seeds should be soaked for about two minutes (*lit.* such length of time as it would take one to make a hundred rhythmic claps with the palms—*नालुक्क*) in a decoction of eight roots (*Ásphota*, *Ámalaki*, *Dhava*, *Vásika*, *Vetasa*, *Suryyavalli*, *Syâma*, and *Atimukta*, *i.e.* the jasmine, the myrobalan, the *Grislea Tomentosa*, the *Justicia Ganderussa*, the *Calamus Rotang*, the *Gymanropsis Pentaphylla*, the *Echites Frutescens*, and the *Dalbergia Oujeinensis*) boiled in milk. The seeds should then be dried in the sun. This process should be repeated for thirty days. A circular hole should be dug in the ground, a cubit in diameter and two cubits deep, and this should be filled

with the milky decoction. When the hole dries up, it should be burnt with fire, and then pasted over with ashes mixed with ghee and honey. Three inches of soil should now be thrown in, then the powder of bean, sesame, and barley, then again three inches of soil. Finally, washings of fish should be sprinkled, and the mud should be beaten and reduced to a thick consistency, then the seed previously prepared should be placed in the hole under three inches of soil, and fish-washings poured. This will lead to luxuriant ramification and foliage, which will excite wonder. The *Agnipurána* adds that the mango is specially benefited by cold fish-washings (मत्स्योदकेन ज्ञीतेन चाक्षानां सेकः इष्यते—वृक्षायुर्वेद, *Agnipurána*). It will be seen that these elaborate recipes are empirical contrivances for supplying the requisite nitrogen compounds, phosphates, etc., these being potentially contained in the mixtures and infusions prescribed.

CHAPTER II.

HINDU IDEAS ON MECHANICS (KINETICS).

SECTION 1.

ANALYSIS OF MOTION.

IN his Bhâsya¹ on the Vaiśeṣika¹ Aphorisms, written probably in the third or fourth century of the Christian era, if not earlier, Prâśastapâda begins the Section on Motion (कर्मग्रन्थ) with the definition of *karma* (motion, *lit.* work) as the unconditional cause of conjunction and disjunction, *i.e.* of change of place in a particle (संयोगविभागनिरपेक्षकारणं). He regards *karma* (motion) as instantaneous (क्षणिक) in its simplest form, distinguishing it from *vega* (impressed motion, momentum), which is a persistent tendency, Sanskâra, and implies a series of motions. Accordingly in one and the same particle there can be only one motion (*karma*) at any given moment, since its change of place at that moment is one and definite (एकदा एकस्मिन् द्रव्ये एकमेव कर्म वर्तते । प्रशस्तपादभाष्य, कर्म पदार्थनिर्दयत्वं). The supposition of two (instantaneous) motions in the same particle is superfluous. They may be so opposed as to neutralise each other, in which case the particle would be at rest. If they are not so opposed, and motion (*i.e.* an instantaneous change of place) follows, then, since this change of place is a definite change, one

¹ The system of transliteration adopted in Chapters II.-VI. differs from that adopted in Chapter I. and Chapter VII.

motion would be sufficient to account for it, and the hypothesis of two motions would be meaningless (अथ अविहङ्गकर्मैश्चयसमावेशः तदा एकस्मादेव उपपत्तेः द्वितीयकल्पनावैयर्थ्यम्—Prasastapāda). One and the same motion can effect only one particle, as the changes of place of different particles must be different (एकं कर्म न अनेकत्र वर्त्तते—*Ibid.*).

Now motion is always marked by a certain direction (दिग्बिम्बिहङ्गायोरम्भकत्वमस्य विशेषः).

(i) The successive motions of a particle may be in the same direction (rectilinear), *e.g.* (a) upward or downward vertical motion, as in throwing upwards or downwards in the case of objects moved by volition directly or indirectly (उत्क्षेपणं, अपक्षेपणं), or (b) other forms of rectilinear motion, contraction, dilation (आकुचनं, प्रसारणं); or

(ii) the directions of the successive motions may be different, as in curvilinear motion (यदनियतदिक्प्रदेश-संयोगविभागकारणं तद्गमनं), *e.g.* भ्रमण (rotatory motion), स्पन्दन (vibratory motion), etc. All these are varieties of Gamana (गमन, curvilinear motion). उत्क्षेपणादिज्ञेयैः अनावहङ्गानां भ्रमणपतनस्पन्दनादीनां अवरोधार्थं गमनग्रहणं कृतम्—*Ibid.*; *cf.* Śankara Miśra, गमनत्वं च जातिविशेषः भ्रमणरेचनस्पन्दनोद्धर्ष-ञ्जलननमनोज्वलनादिष्वपि. In another sense, all kinds of motion in material (inanimate) objects, whether rectilinear or curvilinear, are called Gamana (गमन).

(एतत् पञ्चविधमपि कर्म शरीरावयवेषु च तत् सङ्घट्टेषु तत् प्रत्ययं असत्-प्रत्ययं च । यत् अन्यत् अप्रत्ययमेव तेषु अन्येषु च तत् गमनमिति Prasasta-
pāda, कर्मैशान्यम्) ।

Single particles, then, may have a serial motion. When particles (अवयवाः) combine to form a body (अवयवणी), they may move continuously in a straight line, in

which case the body is said to move in that direction (अवयविक्रियाया यावदवयवक्रियानिबन्नात्, the action of a composite whole is determined by the action of the constituent parts taken together). But different particles may move in different directions, or again, the particles may have a curvilinear motion, and in such cases it appears as if different motions are impressed on the body, e.g. the falling leaf driven by the wind may have a rotatory or vibratory motion (भ्रमण, स्पन्दन) and a vertical downward motion (पतन) at the same time. Here each particle of the leaf taken separately has only one motion or change of place at the same moment, but from the point of view of the observer द्रष्टा, the particles have a rotatory or vibratory motion in one relation, and the leaf as a whole has a downward motion in another relation. The motion at any instant is really one, but for convenience of analysis we consider the rotatory change of place as separate from the change of place in the downward direction. एकस्मिन् कर्मेति युगपत् द्रष्टृणां भ्रमणपतनप्रवेक्षणप्रत्ययाः कथं भवन्ति । अत्र नूनं अवयवावयविनो दिग्विशिष्ट-संयोगविभागानां भेदात्—*Ibid.*

SECTION 2.

MOTION CONSIDERED IN RELATION TO ITS CAUSES

Various kinds of motion are observed :—

I. Movements which are not caused by contact with matter :—

(1) Movements caused by volition (प्रयत्न), e.g. the movement of the hand.

(2) Movement as of a falling body. This is caused

by gravity (गुरुत्व), which in the astronomical treatises of Āryabhata, Brahmagupta, and Bhāskara is ascribed to the attraction (आकर्षण, pulling force) exercised by the earth on a material body. The force of gravity may be counteracted by volition (विचारकप्रयत्न), as in holding up the hand, or by contact, as when a body rests on a support, or by Vega (वेग), impressed motion, as in the flying arrow which is kept from falling by the motion impressed on it.

(3) Motion of fluids, as the downward flow in a stream (स्यन्दन). This is due to fluidity (द्रवत्व), which is a characteristic property of certain kinds of atoms, in some cases original, in others produced by the contact of these atoms with the atomic particles of heat (*e.g.* in the fire). But Śankara Miśra points out that this property, fluidity, is only a concomitant condition (असम्भवाधिकारण); the efficient cause (निमित्तकारण) is even in this case gravity (गुरुत्व) in the particles of the fluid. यत्पूर्वसर्वं स्यन्दनं तद् द्रवत्वात् असम्भवाधिकारणात् उत्पद्यते, गुरुत्वात् निमित्तकारणात् असम्भवाधिकारणे (Śankara Miśra, Upaskāra, on Sūtra 4, Āhnika 2, Chap. V., of the Vaiśeṣika Sūtras).

(4) Certain motions, not due to material contact, of which the mechanical causes are unknown, and which may be ascribed to the universal final cause, Adriṣṭa (अदृष्ट), *e.g.* the first motion in atoms at the beginning of Creation, the upward motion of fiery particles or atoms, and the oblique motion of gaseous particles, *vāyu* (वायु), the movement of iron towards the magnet, capillary motion (अभिसर्पण) as of liquid particles from the root to the stem of a plant. The upward motions

(आरोहण) of water-particles in evaporation and in boiling do not require the hypothesis of *Adriṣṭa*, as these are caused by the pressure of heat-corpuscles (तेजः परमाणु) and the contact with air-particles (नोदनापीडनात् संयुक्तसंयोगाच्च—*Vaiśeṣika Sūtra*, Chap. V., *Âhnika* 2).

MEANING OF *ADRIṢṬA* (अदृष्ट).

Adriṣṭa (*lit.* unseen) stands for “unknown cause” or “unexplained Nature” in the earlier *Vaiśeṣika* writers. Several classes of cases falling under *Adriṣṭa* are distinguished, *e.g.*—

(1) The operation of merit and demerit (कर्मा and अकर्मा), a transcendental cause, which has to be posited in explaining the conjunctions and disjunctions of souls with their organic vehicles (bodies), which cannot be ascribed to natural causes, but presuppose the law of Karma, or the operation of moral causation, as superimposed on the natural order.

(2) Various kinds of motion in the different classes of elements, *e.g.* their natural modes of operation, such as the dispersion of *vāyu* (air, gas), the upward motion of fire, the attraction of the needle by the magnet, etc., motions which serve the ends of Creation and of created beings (उपकारकं अउपकारकं). Such natural properties must be ascribed to *Adriṣṭa*, final causality (उपकारावधारणार्थं अदृष्टकारितं), provided the cause cannot be ascertained by observation or inference.

1. लज्जवृत्तिभ्याम् धर्माधर्माभ्याम् कर्मोत्पत्तौ—*Ibid.* उपसर्गकर्म उपसर्गकर्म, etc.

2. स्वप्नस्येति महाशूतेषु ब्रह्मत्वज्ञानानाम्भानुपलब्धमानकारकं उपकारावधारणार्थं च भवति तदपि अदृष्टकारितं—*Ibid.*

Jayanta in the Nyâya-Manjarî notes that Adriṣṭa is resorted to in explanation of observed phenomena only when these cannot be derived in any way from the operation of known causes—यदि अदृष्टमनरेण दृष्टं न सिद्धति काम्मदृष्टं कल्पयाम् अन्यथा अपि तु तदुपपत्तौ किं तदुपकल्पनेन । दृष्टसिद्धयेहि अदृष्टं कल्पत्ये ननु दृष्टविघाताय । न्यायमञ्जरी—Âhnika 1.

Similarly, Jayanta notes that, when anything is put down as natural (स्वाभाविक), we may mean either that it has no cause or no uniform cause, or no known cause. Of these the first two alternatives must always be dismissed; and “natural” can only mean something of which the cause has not yet been ascertained (स्वाभाविकं नाम किमुच्यते किमहेतुकं अविज्ञातहेतुकं अनियतहेतुकं वा । न तावदहेतुकं कार्यं सम्भवति नापि अनियतहेतुकं कार्यं किञ्चिदस्ति - न्यायमञ्जरी-चार्वाकमतनिरास ।)

This sound interpretation of Adriṣṭa was afterwards obscured. In modern writers of the Nyâya-Vaiśeṣika school, physical and mechanical ideas have suffered a set-back, and even the formation of the hail-stone is ascribed to the operation of moral causes (धर्मोपधर्म).

II. We come now to motions produced by contact (संयोग). Such motions may be classed as follows, according to the nature of the contact originating them:—

(1) Motion due to direct contact with a body exercising continued pressure (नोदन), e.g. the motion of an object pushed or pulled by the hand, the motion of the mud under heavy stones, the motion of the arrow due to the pressure exercised by the bow-string, the motion of the bow-string due to the pressure of the elastic bow as it recovers its original shape, the motion of clouds, of volumes of dust, of balloons, sailing vessels and other

vehicles under the impelling force (pressure, नोदन, प्रेरण) of the wind, etc. वायुर्मेघादिप्रेरणधारणादिसमर्थः Praśasta-pāda, वायुनिरूपण-मेघादीत्यादिपदेन यानपोतादिपरिग्रहस्तेषामपि वायुना प्रेर्येनाशङ्कत् । Śrīdhara मेघादीति आदियहयात् वेहायसानां विमानादीनां (balloons in the sky) भीमादीनां च यानपात्रपाशुपटलादीनां जलानलयोश्च परिग्रहः (Udayana, Kiranāvalī, वायुनिरूपणम्) .

N.B.—Udayana makes a similar reference to balloons filled with gas or smoke (घनापूरितचर्मपुटकं) in discussing the opinion that air has weight (Kiranāvalī, वायुनिरूपणम्). These passages show that balloons were known in Udayana's time (970 A.D.—*vide* उदयन, Lakṣaṇāvalī).

(2) Motion due to direct contact for an instant with a body that strikes and produces an impact (अभिघात), *e.g.* in the cases of a stone falling against a hard object (पाषाणादिषु निवृत्तेषु नि अभिघातेषु—Śrīdhara), the potter's rod striking the wheel, the mortar struck against the pestle. Instantaneous disjunction is necessary to impact. If there is continued contact, the result is pressure (नोदन). In some cases there may be disjunction (*i.e.* a rebound) after continued pressure (यत्र अभिघातकं द्रव्यं भूप्रदेशं अभिहत्य किञ्चिदधो नीत्वा उत्पतति—अधीर—न्यायकन्दली).

(3) Motion due to direct contact with an elastic body which exercises a moving force by means of its elasticity (स्थितिस्थापकत्व) in the act of restitution of the original form (यथास्थितं स्थापयति), *e.g.* the motion of the bow-string due to the force exercised by the piece of bamboo (the bent bow). This force of restitution in an elastic body is a kind of *sanskāra*, *i.e.* persistent tendency (धनुःशाखाङ्गुलदन्तास्थिसूत्रवस्त्रादिषु भुग्नसम्बन्धितेषु स्थितिस्थापकत्वकार्यं संलक्ष्यते—प्रशस्त्रपादभाष्य, bows, twigs, tooth-bones, horn, thread, cloth, etc., are noted as elastic).

(4) Motion due to contact with a body which is itself in contact with another which possesses Vega (impressed motion or momentum) (वेगवद्द्रव्यसंयुक्तसंयोग). This is the fact of the transmission of pressure or moving force, and the consequent production or communication of motion, as, for example, in the pulling of an object by means of a string, the pushing of the potter's wheel by the potter's rod, etc.

SECTION 3.

CAUSE OF MOTION, OR FORCE.

Force is of the following kinds :—

1. Continued pressure (नोदन).
2. Impact (अभिघात).
3. Persistent tendency (संस्कार), of which there are two kinds : (a) Vega (वेग, impressed motion, momentum), the persistent tendency to motion in a moving body, and (b) the tendency to restitution of shape in an elastic body (स्थितिस्थापकसंस्कार).

N.B.—The psychical *sanskâra* (भावना) is here omitted.

4. Transmitted force, as in pulling by a string, pushing by a rod, etc.
5. Gravity.
6. Fluidity.
7. Volition.
8. Adriṣṭa, comprising various unknown agencies.

In every case of motion produced by contact, Vega is a contributory cause, as the body originating the motion must possess Vega (impressed motion, momentum).

The Concept of Vega (वेगासंस्कार).

A motion (*karma*) being conceived as a change of place in a particle is held to be incapable of producing another motion; but the pressure, impact, or other force which produces the first motion produces through that motion a *sanskâra* or persistent tendency to motion (*Vega*), which is the cause of continued motion in a straight line, *i.e.* in the direction of the first motion (नियतदिक्क्रिया प्रबन्धहेतुः यददिगाभिमुख्येन क्रियावेगो जन्यते तद् दिग्भिमुख्यतेवेव क्रियासन्तानस्य हेतुरिति—श्रीधर, व्याख-कन्दली, संस्कार-निरूपणम्).

The *Vaiśeṣikas* accept one *sanskâra* (impressed motion, momentum) lasting till the cessation of the motion. Udyotakara and other writers of the *Nyâya* school suppose a series of *sanskâras*, each generating the one that succeeds it. (संस्कारेण उत्तरोत्तरकर्मसन्तानो जायते स्वजन्योत्तरसंयोगेन कर्मणि नष्टे संस्कारेण कर्मान्तरजननात् एक एव संस्कारः कर्मसन्तानजनकः ननु कर्मसन्तानवत् संस्कारसन्तानोऽपि अभ्युपगन्तुमुचितः—शङ्करनिम्न १) It will be seen that the *Nyâya* view is adequate to explain acceleration, which it logically implies. The force of *sanskâra* (शक्ति) diminishes by doing work (कार्यकरणात्) against a counteracting force, and when the *sanskâra* is in this way entirely destroyed, the moving body comes to rest (संस्कारो यावत्पतनमनुवर्तते । यथा यथा चास्य कार्यकरणात् शक्तिः क्षीयते तथा तथा कार्यमन्दतरतमादिभेदभिन्नमुपजायते—श्रीधर—व्याख-कन्दली-कर्मग्रन्थ). *Vega*, it will be seen, corresponds to inertia in some respects, and to momentum (impressed motion) in others. This is the nearest approach to Newton's First Law of Motion in the *Vaiśeṣika* theory of motion.

Vega (impressed motion), or this tendency to move on in a straight line, is counteracted by contact with tangible objects (स्पर्शवद्द्रव्यसंयोग), e.g. by impact or friction, including friction with the still atmosphere (स्तिमितवायु), as in the case of the arrow.

Vega (momentum) produces work in opposition to the resisting force, and thereby becomes weaker and weaker (मन्दतर मन्दतम) until it comes to an end (तत्र वेगो नृत्तिमन्तु पक्षसु द्रव्येषु निमित्तविशेषापेक्षात् कर्मणा जायते, नियत-दिक्-क्रिया-प्रबन्धहेतुः स्पर्शवद्द्रव्यसंयोग-विज्ञेयविरोधी Praśastapāda, संस्कार-निरूपणम्—मन्दस्तु वेगः स्पर्शवद्द्रव्यसंयोगमात्रेण विनश्यति यथा क्षतिदूरगतस्य इषोः स्तिमितवायु-प्रतिवर्धस्य—अधीर, संस्कारनिरूपणम्).

Causes of Pressure (नोदन) and of Impact (अभिघात).

Pressure is produced by contact acting in conjunction with Vega (impressed motion), elasticity, gravity, fluidity or volition, e.g. the Vega of the wind produces pressure (नोदन) on the grass, that of a current of water on the reed, that of the bow-string on the arrow. Gravity with contact produces pressure, as when the earth sinks under a heavy load.

Impact is produced by contact with a body possessing Vega (impressed motion) where the contact is instantly followed by disjunction (or rebounding). If the contact continues, the result is pressure (नोदन). (तत्र नोदन गुरुत्व-द्रवत्व-वेग-प्रत्याप्तान् समस्त-व्यस्तान् अपेक्षामानः यः संयोग-विज्ञेयः नोदनं अविभाग-हेतुः एकस्य कर्मणः कारणं तस्मात् अतुष्टौ अपि महाभूतेषु कर्मै भवति वेगापेक्षो यः संयोग-विज्ञेयः विभागहेतुः एकस्य कर्मणः कारणं स अभिघात तस्मादपि अतुष्टौ-महाभूतेषु कर्मै भवति—प्रशस्तपाद-भाष्य ।)

It is expressly noted that the four elements, earth,

water, air, and fire, are all subject to the forces of pressure and impact. Pressure and impact may be of different degrees (नीचमन्ददिभेद). So also Vega (impressed motion, momentum).

Illustrations of Combination of Forces.

(1) Pressure acting concurrently with impressed motion or Vega, as when the moving hand possessing Vega throws the quoit or a projectile. (पाणिमुक्तेषु गमनविधिः) (ततः संस्कारनोदनाभ्यां तावत् कर्माणि भवन्ति यावत् हस्ततोमर-विभाग इति—प्रज्ञस्तपादभाष्य ।)

Similarly, in the case of the bow-string impelling the arrow, or the potter's wheel impelled by the rod, the first motion is due to pressure (नोदन), and results in a *sanskâra* (persistent tendency to motion, impressed motion or momentum), but the subsequent motions are produced by the pressure acting concurrently with the *sanskâra* (impressed motion). (तस्मात् संस्कारात् नोदन-सहायात् तावत् कर्माणि भवन्ति यावत् इषुन्या-विभागः—प्रज्ञस्त-पाद, कर्मग्रन्थ—प्रथमं चक्रायविनि दृढसंयोगात् कर्म उत्पद्यते उत्तरोत्तराणि कर्माणि अभिघातात् कर्मजात् संस्कारात् च भवन्ति दृढविगने तु चक्रं तदवयवेषु च संस्कारादेव क्लेशात् । ग्रीधर, न्याय-कन्दलो, कर्मग्रन्थ ।)

(2) Impact (अभिघात) with impressed motion (संस्कार), as when the mortar thrown by the hand rebounds after striking the pestle (संस्कारापेक्षात् अभिघातात् मुसले उत्पत्तन-कर्म—प्रज्ञस्तपाद भाष्य).

(3) Pressure (नोदन) acting concurrently with impact (अभिघात), as when the mud sinks when we strike against the ground with the feet. Here, if the feet be not in contact with the mud, but only with the surrounding ground, there is transmitted force (संयुक्तसंयोग).

(यदादिभिर्नुष्ठमानायामभिह्वमानायान् वा पंकास्वायां पृथिव्यां वा संबो-
गोमोदनाभिघातयोरन्वतरापेक्षो उभवापेक्षो वा स संयुक्तसंयोगः । तस्मादपि
पृथिव्यादिषु कर्म भवति ।—Prāsastapâda.)

(4) Gravity concurrently with *sanskâra* or persis-
tent tendency, as in the case of a falling body in the
second and following instants. Also the case of a stone
thrown against the mud, where gravity (the weight of
the stone) combines with the Vega of the stone to
produce motion in the mud (Prāsastapâda). (जाह्नं कर्म
गुरुत्वात् भवति । तेन कर्मैवा संस्कारः क्रियते तदनन्तरं उद्भूतकर्मैश्चि
गुरुत्वसंस्काराभ्यां जायते द्वयोरपि प्रत्येकं अन्यत्र ज्ञानार्थोपधारणात्—श्रीधर,
न्याय-कन्दली, कर्मस्यन्धे सम्प्रत्यय-कर्मैर्निरूपकम् ।) This case will be
further noticed below.

Udyotakara, the commentator on the Nyâya-Bhâṣya,
states that a heavier body falls to the ground with
greater Vega (and velocity) than one that is lighter.
Udyotakara also holds, and Śrīdhara agrees with him,
that the gravity (गुरुत्व) of a body (जवयवो) as a whole
composed of particles (जवयवाः) is not the same as the sum
of the gravities of the particles. There is a difference
in amount which is, however, so small as to be im-
perceptible. The concept of mass in the New Mechanics
of Lorenz may lend some countenance to this curious
metaphysical speculation. (Śrīdhara, गुरुत्वस्य, गुरुत्वनिरूपकम् ।)

(5) Volition acting concurrently with gravity, as in
lifting up the hand. This is accompanied by transmission
when an object, e.g. the quoit, is lifted by the hand.

Sanskâra (impressed motion, momentum), with or
without pressure (मोदन) or impact (अभिघात), may be
transmitted (दक्षसंयुक्तस्य जवयवस्य उद्भूतकर्मैश्चि संस्कारात् मोदनाच्च
अपरेषां संस्कारात् संयुक्तसंयोगाच्च ।—Śrīdhara).

Composition of Gravity with Vega (Momentum).

When a body is let go and falls to the ground, the force acting on it is gravity (गुरुत्व), which the astronomers ascribe to the attraction of the earth. Motion is produced in the first instance by gravity alone, and this leads to a *sanskâra* (impressed motion) in the same direction. But the force of gravity continues to operate, so that, in the moments following the first, the motion is due to gravity as well as *sanskâra*. The resultant motion is one, but both the causes must be conceived as contributing to the resultant. The reason for supposing this combined action is that both gravity and *sanskâra* (impressed motion or momentum) are seen elsewhere to produce motion separately.

In the case of the falling body, therefore, there is the composition of the two, gravity and Vega, acting in the same direction (उभयसमावेशः) from the second instant onwards. It is as if two motions coalesced and resulted in one.

Here a good foundation is laid for the explanation of the accelerated motion of falling bodies, but Galileo's discovery was not anticipated, as Galileo's observations and measurements of motion were wanting. (चाङ्गं कर्म गुरुत्वात् भवति तेन कर्मैवा संस्कारः क्रियते तदनन्तरं उत्तरकर्मैषि गुरुत्व-संस्काराभ्याम् जायते द्वयोरपि प्रत्येकं अन्यत्र ज्ञानार्थोपधारणात्— श्रीधर, कर्मसंघ—तत् चाङ्गं गुरुत्वात् द्वितीयादीनि तु गुरुत्वसंस्काराभ्याम्.—प्रज्ञापदा, कर्मसंघ ।)

But in the case of the flying arrow or other projectile, the impulsive force which produces Vega counteracts the force of gravity ; in the end, this Vega is lost through

friction with air, and then gravity (गुरुत्व) brings the arrow to the ground. The meaning of this "counter-action" is not clear. Is it intended that the action of gravity is suspended as long as the Vega continues? We have seen that, in the case of a body let fall, Praśastapâda expressly states that gravity (गुरुत्व) and *sanskâra* (Vega, momentum) both act in the second and following instants. Praśastapâda seems to have thought that some *sanskâras* (e.g. the Vega of an arrow or other projectile) suspend the action of gravity (गुरुत्वं संयोगप्रयत्न संस्कारविरोधि, Praśastapâda, गुण्यन्य। वेगेन प्रतिबन्धात् अपतनं बहिःषिप्तस्य शरशलाकादेः निवृत्ते नोदने कर्मैषि उन्नरोत्तराणि इव संस्कारादेवापतनादिति Praśastapâda, कर्मैयन्य). Other *sanskâras* (e.g. in the case of a falling body) coalesce with gravity to produce a single resultant motion. The later commentators (from Śrīdhara downwards) certainly interpret the Vaiśeṣika Sūtras in this sense.

Motion of a Particle in the Case of a Composition of Forces.

Any number of motions or Vegas may be impressed on a particle, but so long as these are in a uniform direction (नियतदिग्बिंशद्) the resultant motion or Vega is in a straight line, and may be conceived as one (द्वितीयकल्पना-वैयर्थ्यम्, Praśastapâda, कर्मैयन्य). It is only when we come to Gamana (curvilinear motion) and its causes that the question of composition assumes a real significance. In all such cases, each separate particle has only one Vega (impressed motion) in a definite direction (नियतदिग्बिंशद्) at any given instant, but the composition of the successive motions and Vegas in the

same particle produces the curvilinear motion (गमन), e.g. the rotation of each constituent particle of the potter's wheel. The motion of the body (अवयवी, e.g. the wheel) results from the combined motions of the particles (अवयवाः). If pressure or impact produces motion in an opposite direction to the Vega already impressed on the body, the original direction would be changed, as is seen in the case of rebounding (उत्पतन) after impact (अभिघात). The mortar rebounding after striking the pestle is a typical instance of such change of direction in Vega or motion. The impressed force, e.g. impact (अभिघात), produces a changed motion in a different direction. One view is that the original Vega (momentum) is destroyed before a new motion and a new Vega are produced by the impact. Others hold that the impact does not destroy the original Vega (momentum), but conjointly with it produces the changed motion and, through such motion, a changed Vega in a new direction. (उलूखलमुसलयोरभिघाताख्यः संयोगो-मुसलगतवेगमपेक्षनाथः मुसले उत्पतनकर्म करोति यद्यपि प्राक्नसंस्कारो विनष्टः तथापि मुसलोऽलूखलयोः संयोगः पदुकर्मोत्पादकः तस्य संस्कारारम्भादिष्वसमर्थो भवति अथवा प्राक्न एव पदु संस्कारः अभिघातात् अविनश्यन् अवस्थित इति et seq., Prasastapâda, कर्मैयन्य ।)

Typical Cases of Curvilinear Motion (Gamana).

Vortical Motion.—This is due to the contact of two bodies moving in opposite directions with a like or equal Vega, e.g. two currents of air or water meeting from opposite directions. The change of direction is seen in the fact that water which flows downwards, or air which moves obliquely, may receive an upward



motion as the result of such collision. (अथ किमिदं संसृज्जनं नाम । समानवेगयोः (गुत्यवेगयोः) वाय्वोर्बिहृद्-दिक्क्रिययोः सन्निपातः Prasastapâda, वायुनिरूपणं). The scholiast Udayana adds : वाय्वोरितिप्रकृतत्वेन स्पृष्टवतोऽपि तु विवक्षितम् । अपां यथा द्रव्यान्तर-संसृज्जनात् ऊर्ध्वगमनं परस्परभिहतनदीपयः — उदयन, द्रव्यकिरणावली. Śrīdhara notes : तिर्य्योगतिस्वभावाद्-द्रव्यीर्ध्वगतित्वात् परस्परभिहत-अलतरङ्गीर्ध्वगमनवत् असमानवेगयो संसृज्जनं न भवति एकेन अपरस्य विजयात् — Śrīdhara.)

Vibratory Motion (कम्पन, स्पन्दन).

This will be analysed in the chapter on Acoustics.

Rotatory Motion (घनन).

Each particle of the rotating body, e.g. the potter's wheel (चक्र), has, at any given instant, a motion in a definite direction. The rotatory motion of the body results from the separate motions of the particles and their persistent tendencies (संस्कारः), joined with the fact of the rigid conjunction of the particles. When the rod strikes one part of the wheel, the motion in the part struck is in the first instant produced by impact (अभिघात); while the other parts move through the transmission of force due to the rigid cohesion of parts. The subsequent motions in the part struck are due to continued pressure (नोदन) and the persistent tendency (संस्कार) set up by the first motion ; while the subsequent motions in the other parts are explained by their own persistent tendencies and the transmission due to rigid cohesion. When the rod is disjoined from the wheel the rotatory motion continues, being due merely to the

persistent tendencies in the constituent parts and the resultant persistent tendency in the whole.

Other varieties of curvilinear motion in bodies are to be similarly explained (*i.e.* by the composition of Vegas) (तथा चक्रादिषु अवयवानाम् पाञ्चवर्तः प्रतिनियतदिग्देशसंयोगविभागोत्पत्तौ यदवयविनः संस्कारादनियतदिग्देशसंयोगविभागनिमित्तं कर्म तदभ्रमयमिति । एवमादयो गमनविज्ञेयाः—Prasastapâda,—कर्मग्रन्थ । एवं वेगात् दक्षसंयोगचक्रावयवे आद्यं कर्म दक्षसंयोगात् । अवयवान्तरेषु च संयुक्तसंयोगात् दक्षसंयुक्तस्य अवयवस्य उत्तरोत्तरकर्मैषि संस्कारात् नोदनात् च । अपरेषां संस्कारात् संयुक्तसंयोगात् च दक्षविगमेषु चक्रे तदवयवेषु च संस्कारादेव क्रेवलात् एवमादयो गमनविज्ञेयाः—Śrīdhara).

SECTION 4.

MOTION OF FLUIDS.

Current motion (स्यन्दन, downward flow in a stream), upward motion (आरोहण, *e.g.* evaporation, boiling, etc.), and capillary motion (अभिसर्पण, as in plants and porous vessels) are three varieties of fluid motion which require explanation. To this may be added vortical motion (संयुञ्जन्), and स्यन्दन, wave motion, which will be noticed in the chapter on Acoustics.

1. Current Motion (स्यन्दन).

This is conditioned by fluidity in particles, but Śankara Miśra notes that in the downward flow of water, gravity in the fluid-particles is the efficient cause (गुरुत्वात् निमित्तकारणात् असमवायिकारणेषु—Śankara Miśra, उपस्कार). When the water is enclosed on all sides, as in a vessel, the downward flow (स्यन्दन) is counteracted. Here the fluidity does not produce motion, because, in the case of the particles in contact with the enclosing

body, there is the resistance (प्रतिबन्ध) of the latter, which is transmitted to the other particles, and this counteracts the fluidity. (ओतोभूतानामपीं स्थलाधिष्ठाभिसर्पणं यत् तत् द्रवत्वात् स्थन्दनं कथं समन्नात् रोधः संयोगेन अवयविद्रवत्वम् प्रतिबन्धं उत्तरोत्तरावयवद्रवत्वानि संयुक्तसंयोगैः प्रतिबन्धानि — Prasastapāda, कर्मसूत्रम् ।)

2. Upward Motion (आरोहण, e.g. evaporation).

In evaporation the fluid-particles are rarefied, and remain in a fine state of suspension ; the rarefaction is due to the impulse (नोदन) or impact (अभिघात) of the heat-particles in the sun's rays, and the upward movement is due to their contact with the air under this impulse or impact. Śankara Miśra notes that in boiling there is a similar upward movement of water-particles under the impact of heat-rays. (नाड्यो वायुसंयोगात् आरोहणं नोदनापीडनात् संयुक्तसंयोगात् च । Sūtras 5 and 6, Âhnika 2, Chap. 5, Vaiśeṣika Aphorism. यथा स्थालीत्यां आपः क्वथमानाः वायुनुचवहिरङ्गमय ऊर्ध्वेन नयन्ति—Śankara Miśra, उपस्कार ।)

N.B.—These two Sūtras of Kanāda have been interpreted by the late Gangādhara Kaviratna in his commentary to refer to the upward conduction of water in pipes by the pressure of air.

The mention of the transmitted pressure (संयुक्तसंयोग) of the air seems to lend some countenance to Gangādhara's view, and the word Nādi (नाड्यः) offers no difficulty, being taken in its usual sense, "pipe" (नालिका, Nalikā), while the current interpretation does violence to the common acceptance of the word.

3. Capillary Motion (अभिसर्पण).

Two instances are given—the ascent of the sap in plants from the root to the stem (अभिगतः सर्पणं मूले निषिक्ता-

नामयां वृद्धे—Śankara Mīśra), and the penetrative diffusion of liquids in porous vessels, e.g. of the oil or ghee in an earthen jar (कुम्भादीं जलनिर्हितानां तैलघृतादीनां स्यन्दनं जपनञ्च). Heat-particles have a like penetrative power (दृढश्चानिरोधो भस्मनकपालादीं तेजसः पच्यमानद्रव्यपाकशिष्टैः कलशे च निविक्तानां जयां शीतस्यर्शैर्ग्रह्यादनिरोधः—Jayanta, न्यायनञ्जरी, Âhnika 8, इन्द्रियाणां प्राप्यकारित्वम्).

This is ascribed to *adrīṣṭa*, as the cause cannot be ascertained by either perception or inference (including hypothesis) (प्रत्यक्षानुमानाभ्यां अनुपलभ्यमानकारणम्—Śrīdhara).

SECTION 5.

INTERESTING EXAMPLES OF MOTION ASCRIBED TO ADRĪṢṬA (UNKNOWN CAUSE, UNEXPLAINED NATURE, FINAL CAUSE).

The first motions in primordial atoms at the beginning of Creation are attributed to *adrīṣṭa*. Among movements in masses of matter so caused are noted the motion of the globe of the earth and similar other bodies (महाभूतानां भूगोलकादीनां प्रक्षोभनं चलनम्—Praśastapāda with Śrīdhara's commentary, कर्मसम्बन्ध). Most probably this means earthquakes, tides, etc. Âryabhata and his school would no doubt bring under this head the diurnal motion of the earth. It is interesting to note in this connection that Bhâskara refutes the Buddhist hypothesis of the earth falling perpetually *in vacuo* by arguing that the earth must remain balanced in space as there is nothing outside to attract it.

The movement of the needle (iron in general, as Śankara Mīśra notes) towards the magnet is another

example of unexplained motion in matter. Cleaning and right-placing of the magnet (संमाचनम्, चतुस्त्यापनम्) are necessary (सूचीनां लोहशलाकानां, अयस्कान्ताभिसुखगमनम्, सूचीसुपलब्धम् अयस्कान्ताकृद्दलोहमाचनभिप्रेतम्—Śankara Mīśra).

Similarly, amber attracts grass, straw, etc. (नृशकानन-स्वाकृष्टानां नृशानां गमने—Śankara Mīśra, on Sūtra 15, Āhnika 1, Chap. V.).

Involuntary movements of the hand under the influence of the hypnotist's *mantras* (incantations) are also attributed to *adriṣṭa*.

SECTION 6.

MEASUREMENT OF MOTION.—UNITS OF SPACE AND TIME.

The solar day was taken as a natural measure or division of time. In the Nyāya-Vaiśeṣika school the day of twenty-four hours (solar) is stated to contain $30 \times 30 \times 30 \times 18 \times 2 \times 2$ units of time (*kṣaṇas*). The Nyāya unit of time therefore measures $\frac{2}{45}$ of a second. The smallest measure of time mentioned by the astronomers is the Truti, which is $\frac{1}{33750}$ of a second.

The natural measure of length was the cubit (*Hasta*), of which there were two fixed standards, the greater and the lesser cubit. The smallest measure of length mentioned in the Śilpa-śāstra (Technology) is the Paramānu, which is about $\frac{1}{349525}$ of an inch. This is the same as the *Trasareṇu* of the Nyāya-Vaiśeṣika school, which stands for the thickness of the *minimum visibile* (the finest mote perceptible in the sunbeam as it comes slanting into a dark room through a chink).

Average velocity (सूत्रगति—Bhâskara) was measured in accordance with the formula $v = \frac{s}{t}$, but no unit of velocity appears to have been fixed upon. There was no idea of acceleration, and of course no measurement of force. Mahavîrâchâryya gives formulæ for computing the space travelled over in cases of Sankalita-gati (velocity with regular increment at stated intervals), but this does not amount to acceleration, as the intervals are not indefinitely small. Where the velocity is uniform, the interval of time may be of any amount (सूत्रकाल), but where the velocity is variable (प्रतिक्षणं न समागतिः—Bhâskara), an indefinitely small quantity of time (सूक्ष्मकाल) must be taken; in other words, the positions of the particle in two successive *instants* must be considered, and the velocity must be supposed to be uniform during this interval (conceived as indefinitely small, सूक्ष्म). It was in this way that Bhâskara determined the instantaneous motion of a planet (तात्कालिकी गति).

Component of Velocity.

The astronomers measured the motion of a heavenly body in different directions (longitude, right ascension, etc.), and calculated separately the components of motion (गतिकलाः) in these directions, and they adopted the device of transferring such component velocities from one body to another in the computation of relative motion (*e.g.* एवं सति आचार्येण लाघवार्थे इहषटीसप्तमिनो गतिकला ज्ञेये प्रविष्टाः—Bhâskara, Siddhânta-Śiromaṇi, Ganitâdhyâya, Ghatîsphutî-prakarana).

SECTION 7.

NOTION OF THREE AXES.

Motion, we have seen, was defined as the change of position of a particle in space. To conceive position in space, Vâchaspati takes three axes, and the position in space of one particle relatively to another may be indicated by distances measured along these three axes. This remarkable analysis (*circa* 842 A.D. : ब्रह्मसूत्रसूत्रसूत्रे, Vâchaspati, Nyâyasûchnibandha) anticipates in a rudimentary manner the foundations of solid (co-ordinate) geometry, eight centuries before Descartes (*vide* p. 118, *supra*).

The Principle of the Differential Calculus applied to the Computation of Motion (Variable Motion).

Bhâskara (1150 A.D.), in computing what he calls the "instantaneous" motion (तात्कालिकी गति) of a planet, compares its successive positions in two successive instants, and regards the motion as constant during the interval, which he conceives to be indefinitely small (सूक्ष्मकाल). This is equivalent to the determination of the differential of the planet's longitude, and the process bears "a strong analogy" (to quote the words of Mr. Spottiswoode, the Astronomer Royal) "to the corresponding process in modern mathematical astronomy." I have elsewhere shown that Bhâskara's process was not merely analogous to, but virtually identical with, that of the Differential Calculus, Mr. Spottiswoode's cautious reservation having been due to his want of acquaintance with the original and the insufficiency of the materials placed before him (*vide* pp. 78-79 *supra*).

SECTION 8.

RELATIVE MOTION.

The phenomenon is noticed among the hallucinations of sense (नाय्याकडाश्च गच्छतः पर्यन्तादीनि विज्ञाननि भ्रमेण भ्रमन्तश्च तान् —Kumârila, Śloka-Vârtika, p. 520). Astronomers like Âryabhata and Lalla, who believed in the diurnal revolution of the earth from the west to the east, explained the apparent revolution of the starry heavens in the opposite direction by the principle of relative motion.

SECTION 9.

SERIAL MOTION.

Several Santânas (series) of motions are incidentally noticed, e.g. vibration (स्पन्दन, कम्पसन्तान), wave motion (वीचित्ररङ्ग), current motion (स्पन्दन).

In an interesting passage, Charaka notes three instances of serial motion, viz. those of water, sound, and light (जलसन्तान, शब्दसन्तान and अग्निःसन्तान), to which he compares the course (सन्तान) of chyle (or chyle-blood) in the Dhmanâs (veins) and other ducts of the body.

Dalvana thinks that downward, oblique, and upward currents of chyle are respectively intended by the three illustrations; but Chakrapâni points out that the Santâna (wave) of sound travels in all directions (the same is of course true also of light), and that differences in speed (and not in direction) are here meant. In other words, a Santâna of sound travels more rapidly than that of water, and less rapidly than one of light (अग्निःसन्तान), and Charaka's meaning is that the metabolic

course may complete its circuit with greater or less speed. Whether, in this passage, the three Santānas are viewed as waves or currents, is not specified; but the difference between a wave (वीचि) and a current (स्यन्दन) was well known.

A current of water (स्यन्दन, downward flow) consists of particles moving in an uninterrupted series under the action of gravity and fluidity (गुरुत्व and द्रवत्व, Śankara Miśra). A wave (वीचितरङ्ग), on the other hand, is constituted by the transmission of vibratory motion (स्यन्दन) in the water-particles (*e.g.* Jayanta, पतद्भवनपयोविन्दुसन्दोहस्यन्दनक्रमात् —Nyāya-Manjarī, Âhnika 2).

A ray of light, on the other hand, was supposed to imply the rectilinear propagation of indefinitely minute corpuscles in all directions, with inconceivable velocity, and a sort of conical dispersion (अचिन्त्यीहि वेगातिशयः तेजः प्रसरति पृथ्वयत्नात्—Udyotakara, Vāchaspati).

CHAPTER III.

HINDU IDEAS ON ACOUSTICS.

SECTION 1.

ANALYSIS OF SOUND.

The Mimâmsakas.—In their analysis of Sound, the Mimâmsakas distinguish between three elements: (1) Nâda, a quality of Vâyu (air), which is the physical basis of audible sound; (2) Dhvani, sound as heard, audible sound; and (3) in the case of significant sound, Sphota, “transcendental” or “intelligible” sound, representing the Platonic ideas or *logoi*, which are eternal (नित्य), ubiquitous (व्यापक), and noumenal (निराधार, *lit.*, without substrate or ground—Kumârila). The Sphotas are manifested by the Dhvanis (audible sounds), of course only in the case of words (शब्द, वक्त्र). Upavarsa, the teacher of Panini, rejected the Sphotas in favour of the Varnas, which were conceived to be “phonetic moulds” with natural significance.

As regards sound in its physical aspect and the mode of its propagation, some of the Mimâmsakas content themselves with saying that Vâyu (air) has a special quality (Nâda) which causes audible sound (नादो वायुगुणः वायुर्वा यदि कल्पेत—Kumârila, Śloka-Vârtika; वायुरेव तास्वादित्यानसंयोगात् शब्दगुणको निश्चयते, शब्दस्यापि वायुगुणत्वं वेदितव्यम् — Pârtha - Sârathi Mîsra, Nyâyaratnâkara).

Others, including the teachers of the Śikṣā (Vedic chanting), hold that the physical basis of sound is a series of air movements (वायुसन्तान, cf. Udyotakara's and Vāchaspati's reports); in other words, the air-particles themselves flow in a current in all directions, being obstructed in their path by the impact of tangible objects (*i.e.* material bodies), and the movement ceases, as in the arrow, when the moving force is thus exhausted (*e.g.* स गच्छन्सर्वतोदिक्षु उद्गामवेगाहितक्रियः झरन् वेगज्ञान्वेष न दूरं गन्तुमर्हति . . . शिखादिदक्षु पवनान्मन्त्रेण शब्दमाचक्षते —Jayanta, Nyāya-Manjarī). But the orthodox Mimāmsā view is that of the Mimāmsā doctor, Śabara Svāmi, who holds that Nāda (the physical basis of sound) is a wave-motion of air, being the transmission of conjunctions and disjunctions in the minute particles of air, the wave originating in the first impact, and being continued by the successive impacts of the minute particles (*e.g.* संयोगविभागानैरन्तर्येण क्रियमाणाः शब्दमभिव्यञ्जन्तो नादशब्दवाच्याः (17-1-1) अभिघातेन हि प्रेरिता वायवः क्षिप्तानि वायव्यकाराणि प्रतिघातानः सर्वतो दिक्षान् संयोगविभागान् उत्पादयन्ति यावद्भेगे अभिप्रतिष्ठन्ते । ते च वायोरप्रत्यक्षत्वात् संयोगविभागा नोपलभ्यन्ते । अनुपरतेषु एव तेषु शब्द उपलभ्यन्ते । नोपरतेषु अतएव च अनुवातं दूरात् उपलभ्यन्ते शब्दः—Śabara-Bhāṣya, Sūtra 13, Pāda 1, Adhyāya 1). In this view, the particles of air (वायव्यवयवाः) are subject to a vibratory motion (a sort of *parispanda*) in the production of sound (परिस्पन्दपरलक्षण —Jayanta, Nyāya-Manjarī). The Vākyapadiya describes articulate sounds (*varnas*), and indeed all sounds (*śabdās*), as only forms of air set in motion, with rarefaction and condensation (घनत्व), and capable of variations of velocity and configuration (लक्षणक्रियः प्रयत्नेन बहुविधानु-

वह्निना स्वानेष्वभिहतो वायुः शब्दत्वं प्रतिपद्यते । तस्य कारकसामर्थ्यात्
वेगप्रचयपरिच्छिन्नः संनिपातात् विभज्यन्ते सारवतोऽपि सूक्ष्मैः । Vākya-
padiya, Kāṇḍa 1, Śloka 109).

Nyāya-Vaiśeṣika.—The early Nyāya writers hold that the sound-wave (शब्दसन्तान) has its substrate in Âkâśa (ether) and not Vāyu (air). Later writers (e.g. Vāchaspati in the Tattvavindu) add that sound itself as a phenomenon is not to be conceived as a mode of motion (*parispanda*), for Âkâśa, the substrate, is, in the Nyāya view, incapable of motion (न तावत् परिस्पन्दस्य सूक्ष्मविभाषिनो द्रव्ये विभुनि विभुगुणे वा शब्दे सूक्ष्मभावेनासंभवात्—Tattvavindu). At the same time the propagation of sound must be conceived on the analogy of waves in water (वीचितरङ्गन्याय). Udyotakara in the Vārtika, Vāchaspati in the Tâtparyyatîkā, and Jayanta in the Nyāya-Manjarî controvert the three views current in the Mimāmsâ school—(1) that Nâda, the physical basis of audible sound, is a specific quality of Vāyu (air), (2) that sound, in its physical aspect, is constituted by a series of air movements of the nature of a current (वायुसन्तान), and (3) that it is not air-currents but air-waves, series of conjunctions and disjunctions of the air-particles or molecules (वायव्यवाः, वायुपरमाणवः), that constitute the Nâda, the sound physical, to which, in the case of significant sounds, the Mimāmsakas assign the function of manifesting the Sphota, “transcendental” or “intelligible” sound (*logos*, the word). *Vide* Udyotakara Vārtika, Adhyāya 2, Âhnika 2, Sūtra 14 ; also Tâtparyyatîkā, माभूत् वायुसन्तानो मा च भूततद्गुणो नादः शब्दस्य अङ्गकः वायव्यवास्तु संयोगविभागव्यञ्जका भवन्ति इत्यतस्मात्, etc., *loc. cit.* Against these views the early Nyāya doctors

maintain that sound is a specific quality of Âkâśa (ether) and not of Vâyu (air). At the same time they admit that the impact which originates the sound phenomenon (अध्यायवृत्ति अयावद्द्रव्यभावि विशेषगुण) in Âkâśa does so by setting up a vibration in the molecules of the object struck (*e.g.* a bell), and that these vibrating molecules impinge against the air-molecules in contact (वायुपरमाद्यवः, आध्यात्मिकवायुः). In other words, though Âkâśa is the substrate (आद्यव), the efficient cause of sound (निमित्तकारण) is to be found in the mechanical impact (अभिघात) of vibrating molecules of sonorous bodies against contiguous molecules of air. As to the propagation of sound, the early Nyâya-Vaiśeṣika writers content themselves with stating that the first sound thus produced in the substrate Âkâśa by the impact of the vibrating molecules (*e.g.* of a bell) against the contiguous molecules of air, produces a second sound in the contiguous Âkâśa, and the second sound a third, and so on, in the same way as waves are generated in water, until the last sound sets up a vibration in the ear-drum (कर्णशुक्लि). Of course, this propagation of sound-wave in Âkâśa (ether) is effected by means of the air-wave as its vehicle. This is the Nyâya-Vaiśeṣika hypothesis (कल्पना) of an independent sound-wave (शब्द-सम्पान). Âkâśa (ether) is motionless, but the air-wave would not be transmitted if the air-molecules were not interconnected by Âkâśa. Prasastapâda, the Vaiśeṣika doctor, for example, describes the first sound as giving off a second, the second a third, and so on, expanding in Âkâśa, in the same way as waves are supposed to propagate themselves in the ocean.

शब्दोष्णरगुः संयोगविभागशब्दजः स्थानवायुसंयोगापेक्षमानात्
 स्थानाकाशसंयोगात् वर्योत्पत्तिः । अथर्वलक्षणोऽपि भेरीदण्डसंयोगापेक्षात्
 भेय्याकाशसंयोगात् उच्यते । वेषुपर्वविभागात् वेद्याकाशविभागाच्च शब्दाच्च
 शब्दाच्च संयोगविभागनिष्पन्नात् वीचिसन्तानवत् शब्दसन्तान इत्येकं सन्तानेन
 श्रोत्रप्रदेशमागतस्य ग्रहणम् । Prasastapâda, यथा जलवीथ्या तदव्यवहिते
 देशे वीच्यननुपजायते ततोऽप्यन्यत् ततोऽप्यन्यदित्यनेन क्रमेण वीचिसन्तानो
 भवति तथा क्रमेण शब्दसन्तानो भवति । नन्वेषा कल्पना कुतः सिद्धतीत्याह
 etc. (Śrīdhara, *ibid.*). On this hypothesis the locus of
 the sound at any moment forms a circle in Âkâśa, and
 the propagation is carried on in the air by means of
 ever-expanding circles, as in the case of waves in water.
 But this analogy is rejected by some (*e.g.* Udyotakara),
 who hold that the first sound gives off not one sound
 in a circle, but an indefinite number of sounds in all
 directions, and each of these again gives off another,
 and so on, so that sound may be said to expand by
 successive concentric spherical layers, even as the
 Kadambakoraka (the so-called bud of the *Nauclea*
Kadamba) expands by successive concentric spherical
 layers of filaments which shoot forth from one another.
 On the first of these two hypotheses, the air-wave
 implied in the transmission of sound is of the nature of
 what we call transverse waves ; on the second, of the
 nature apparently of longitudinal waves. In any case, it
 is clear that the orthodox Mimâmsa view of Śabara Svâmi,
 that the air-wave constituting physical sound means
 a series of mere conjunctions and disjunctions of air-
 particles with rarefaction and condensation (*e.g.*, सर्वतोदिक्कान्-
 संयोगविभागानैरन्वयेण, Śabara, प्रथम, Vâkyapadīya), implies
 longitudinal waves, वीचित्ररङ्गन्यायेन तदुत्पत्तिस्तु कीर्तिता कदम्बकोरक
 न्यायादुत्पत्तिः कस्यचिन्नते (Viśvanâtha, Bhâshâ Parichheda,

Śloka 165); परिश्लेषाच्च सन्तानसिद्धिः । तत्राद्यः शब्दः संयोग-विभाग-हेतुकः । तस्मात् शब्दान्तराद्यि कदम्बगोलकन्यायेन सर्वदिक्कानि । तेभ्यः प्रत्येकमेकैकः शब्दः मन्दतरतमादिभावेनाश्रयाप्रतिबन्धमनुविधीयमानः प्रादुरस्ति । ततोऽन्यस्यातिमान्धात् शब्दान्तरोत्पत्तिः—शक्तिविधातो येन केनचित् प्रतिबन्धात् भवति (Udyotakara, II., 2, 14). As the momentum of the impact series (which constitutes the efficient cause of the sound-wave) grows feebler and feebler in the course of transmission through the air-particles, the sound at last dies away. Gangeśa, in the Chintāmaṇi, holds that the propagation is not from molecule to molecule, but travels in ever-expanding circles as in water-waves, perhaps in spherical layers by compression of masses of air; and these air-waves, the vehicles of sound, are exceedingly swift. This explains the velocity of sound. शब्देन च अक्षयवहितपरमाणुदेशोत्पादक्रमेण न शब्दारम्भो येन मेषजादि शब्दानां भूलोकप्रतिपुंगुगान्तरैरपि न स्यात् । किन्तु मेषाद्यभिहतं सर्वतोऽगामि-महावायोमैहिति देशे संयोग-निमित्तमासाद्य आद्यशब्देन सर्वं दिग्बन्तशब्दः एक एव जन्यते उत्तरोत्तरेणापि अधिकाधिकदेशतः सर्वत्र एकैक एव शब्दः वीचित्ररङ्गवदुपपद्यते वायोश्च नयनवत्, महावेगतया शीघ्रगामित्वेन अग्निशब्दारम्भात् आद्यशब्दानन्तरं अचिरैर्यैव शब्दोपलम्भः । वायोरेव च मन्दतरतमादिक्रमेण मन्दादिशब्दोत्पत्तिः यथा आद्य शब्देन कदम्बगोलकवद् दशदिशि दशशब्दा आरभ्यन्ते तैश्च दशशब्द सन्ताना इति (Gangeśa, Tattva Chintāmaṇi).

But how does the first sound produce the second, the second the third, and so on? At every step the efficient cause, the impact of some vibrating molecule against a contiguous molecule of air, must be posited, and this is equally applicable to a sound produced by a sound (शब्दजशब्द) as to one produced by conjunction and disjunction (संयोगज or विभागज). In other words, the sound-wave (शब्दसन्तान) in Ākāśa necessarily implies an

air-wave. The Mimāmsaka view, then, that explains the propagation of sound by the transmission of the original oscillatory motion through the successive layers of air by means of successive impacts or pressures producing conjunction and disjunction of air-molecules (वायवीयाः संयोगविभागाः—Śabarabhāṣya), or rarefaction and condensation (प्रचय—Vākyapadīya), is also implied in the Nyāya-Vaiśeṣika doctrine of the sound-wave (शब्दसन्तान), the difference being that in the latter the air-wave, which is conceived as a mode of serial motion (गति-सन्तान), is only the vehicle or medium of propagation of a so-called sound-wave in Ākāśa, which is not itself a mode of motion. This is what we find expressly and elaborately formulated in the later Nyāya-Vaiśeṣika (*vide* Gaṅgeśa, Chintāmaṇi, *supra*).

SECTION 2.

ANALYSIS OF VIBRATORY MOTION, *e.g.* OF A BELL (IN AIR).

The molecules of a bell vibrate when the bell is struck. The question is—what is the nature of this vibratory movement? Vātsyāyana and Udyotakara answer that, when the hand strikes the bell, some of the molecules are displaced (from their stable position—*i.e.* there is *karma* in the molecules), and thus a Sanskāra (here a kinetic Sanskāra, momentum) is generated (संस्कार, कर्म्यसन्तानसंस्कार—Vātsyāyana and Vāchaspati), and the molecules swing forward under the action of this Sanskāra until they strike the contiguous molecules of air. This now is a case of mutual impact, which divides

the momentum between the colliding masses, and the bell-molecules begin to swing backward, the motion continuing under the action of the diminished Sanskâra until they come in collision again with other air-molecules; and then the process is repeated, and the bell-molecules begin to swing forward and backward until the original energy which is parted with in some measure at each impact becomes so feeble as to be unable to produce any kinetic disturbance (कर्म). Similarly, the air-molecules themselves are set vibrating by means of these impacts, and the transmission of the motion would form the wave of air, which the later Nyâya-Vaiśeṣika expressly posit as the vehicle of the sound-wave. But Udyotakara never conceived vibration *in vacuo*, nor does it appear if he meant to include the second species of Sanskâra (elasticity, Sthitisthâpaka-sanskâra) as converted from its potential state (अतीन्द्रियता) into kinetic energy, and thus contributing to the momentum (*vega*). He uses the generic term Sanskâra, which comprehends elasticity as well as momentum due to impressed force. His commentator, Vâchaspati, does not go into details, and does not analyse the momentum. Later writers, however, expressly state that elasticity (Sthitisthâpaka-sanskâra) is one of the causes of vibration, and that elasticity resides not only in the element of earth, but also in air, water, and *tejas* (*cf.* Viśvanâtha).

ब्रह्मायामभिहन्यमानायां तारस्वारतरो मन्दी मन्दतर इति क्षुत्तिभेदाज्जाना-
शब्दसन्मानोहि अपिच्छेदेन ज्ञयते (Vâtsyâyana, II., 2, 3, 6) पाथिसंज्ञे-
नपेक्षनायात्कर्मैवः पाथि-ब्रह्मासंज्ञेयात् पाथिगतवेगापेक्षात् ब्रह्मायां कर्म
तत्कर्म पाथ्यभिधातनपेक्षनायं विभागसमकालं संस्कारं करोति । सा
ब्रह्मवाभ्यात्मिकं वायुपगृह्णाति सा च वायुनाभिहता पुनः कर्म करोति ।

ततः कर्मणः संस्कारः संस्कारेण पुनः कर्म पुनर्वायूपग्रह इत्येवमादिन्यायेन संस्कार उत्पद्यते । तत्र जन्यस्यातिमान्छात्पश्यायां महाभूतसोभशक्तेरभावः ततो वायूपग्रहोच्छेदः ततःसंस्कारश्च इति (1) Udyotakara Vārtika, Adhyāya 2, Āhnika 2, Sūtra 36. (पश्यातादवयवसंयुक्ता वायुपरमात्मव एव चाध्यात्मिको वायुः—Vāchaspati, Tātparyyatīkā, *loc. cit.*, also संस्कारं वेगात्वं करोति). But *cf.* Viśvanātha, संस्कारभेदो वेगोऽथ स्थितिस्थापकभावेन । मूर्तेमात्रेण वेगः स्यात् कर्मणो वेगजः क्वचित् । स्थितिस्थापकसंस्कारः क्षिती केचित्तुर्ध्वपि । अतीन्द्रियोऽसौविज्ञेयः क्वचित् स्वन्देऽपि कारयन्—Bhāshā-parichchheda, Ślokas 157–159.

As the air-wave forms the vehicle of the sound-wave, if it does not constitute the sound-wave itself, the favourable or retarding influence of currents of wind is easily explained. The presence or absence of water (and other intervening objects) offering greater or less resistance to the transmission of the wave-motion also easily accounts for the greater or less distance to which the sound is carried.

SECTION 3.

ECHO.

प्रतिध्वनि (Echo) was supposed to be a reflection of sound. Some consider it to be an after-sound, a sound generated by sound. Others suppose it to be due to the reflection of sound in the same way as an image in water or in a mirror (प्रतिचित्रम्) is due to the reflection of light. There is an element of hallucination in either case (बुद्धिपरिहानविज्ञेयः)—the image in water is not a real image, neither is the echo the real sound it is taken to be. (रूपवत्त्वं च न ज्ञानान्यतः प्रतिचित्रम्प्रयोजकं ज्ञत्स्यापि प्रतिध्वनिरूपप्रतिचित्रम्

दर्शनात् । न च शब्दस्य शब्दान्तरमेव प्रतिष्ठातिरिति वाच्यं स्फटिकलोहिता-
देरपि जयासन्निकर्षजन्यतापत्त्या प्रतिष्ठित्विभ्यान्वसिद्धान्त्यतेरिति । प्रतिष्ठित्य
पुञ्जेरेव परिक्रामविशेषो विद्याकारो जलादिगत इति मनस्यम् ।—Vijnāna-
bhikṣu, Pravachana-Bhāṣya, Chap. I., Sutra 87.)

SECTION 4.

PITCH, INTENSITY, AND TIMBRE.

Sounds differ from one another by their pitch (तारमन्दादिभेद), by their intensity (तीव्रमन्दादिभेद), and by their quality or timbre (जलाधारण धर्म). When a bell is struck, an indefinite number of notes (श्रुतिभेद, tones and overtones) are emitted, of varying pitches; and the notes die away, becoming less and less intense. Now, we know that the molecules swing to and fro, and that the Sanskāra (momentum, *vega*) of the vibrations (कम्पसन्तानसंस्कार) grows feebler and feebler. The differences in pitch (tones and overtones) as well as in intensity must be due to variations in the Sanskāras of the vibrations. The distinguishable pitches (called Srutis, श्रुतिभेद) as well as the degrees of intensity (तीव्रमन्दादि) must be ascribed to variations in the *vega* (momentum), and, by implication, the frequency, etc., of the vibrations.

Cf. Vātsyāyana, II., 2, 36—चक्ष्वाख्यं सन्तानवृत्तिसंस्कारधृतं
पदुमन्दमिति वसते तस्यानुवृत्त्या शब्दसन्तानानुवृत्तिः पदुमन्दभावाच्च
तीव्रमन्दा शब्दस्य तत्कृतश्च श्रुतिभेदः Vide also Udyotakara's
analysis of vibration based on Vātsyāyana: चक्ष्वापान-
भिहन्यमानायां तारस्तरतरो मन्दोमन्दतर इति श्रुतिभेदाज्ञानाशब्दसन्तानो हि
अविच्छेदेन श्रुयते । सन्तानवृत्तित्वात् मन्दतरमन्दतरादिभिन्नरूपानुविधायिनं
शब्दनुतपादयन्ति तच्च कारणं संस्कारः—Udyotakara, Vārtika,

Adhyâya 2, Âhnika 2, Sûtra 36. समानवृत्तिना कारणेन वृत्तिभेदोत्पत्तिः—Vâchaspati, Tâtparyyatîkâ, *loc. cit.*

Sounds also differ from one another in volume or massiveness in the case of coalescence (समानजातीयोपचय). A sound both loud and massive is called महान् (large)—एवं शब्दसमान एव तारः महान् इत्युच्यते तथाप्यस्ति समानजातीयोपचयः अस्ति य स्फुटतरत्नम् महानपि स्फुटतरः । अयमपि तथा इति महानित्युच्यते—Vâchaspati, II., 2, 36.

Śabara, the Mimâmsâ doctor, explains massiveness (महत्त्व) as due to नादवृद्धि, the coalescence of different air-waves, which by their simultaneous impact affect a comparatively large tract of the ear-drum (यच्चैतत् बहुभिर्भेरीमाभ्यानग्निः शब्दमुच्चारयन्निर्महान् शब्द उपलभ्यते । न वृद्धौ शब्दः । मृदुरेकेन बहुभिश्चोच्चार्यमाणे तान्येव अक्षराणि कर्णशम्भुलीनकलस्य सर्वा नेमि व्याप्तवृद्धिः संयोगविभागनैरन्त्यर्थेण अनेकज्ञो ग्रहणात् महान् इव अवयववानिव उपलभ्यते । संयोगविभागनैरन्त्यर्थेण क्रियमाणाः शब्दमभिव्यञ्जन्तो नादशब्दवाच्याः । तेन नादस्यैवा वृद्धिः न शब्दस्य—Śabara on Jaimini, Sûtra 17, Adhyâya 1, Pâda 1). The Mimâmsakas, who resolve sounds into air-waves, attribute all differences, whether of pitch, intensity, or massiveness, to differences in the series of conjunctions and disjunctions of air-particles that form the waves (*vide* Vâchaspati's report, शब्दानां तु संयोगविभागयोनीनां युक्तस्तद्भेदेन रूपभेदः ; *cf.* also the later Nyâya-Vaiśeṣika, which accepts air-waves as vehicles of sound-waves: वायोरेव मन्दतरतनादिक्रमेण मन्दादि-शब्दोत्पत्तिः—Gangeśa, Tattva Chintâmaṇi). It may be noted that the terms तीव्र and मन्द are occasionally used in a general sense, and applied to express higher and lower degrees of pitch as well as of intensity.

There are also differences of quality (शब्दस्य असाधारणधर्मः). The same sound *ga* (ग), of the same pitch

and intensity, uttered by men and parrots, can be distinguished; so also the sounds, even the same notes of the scale, given out by a wind instrument like the *venu* and a stringed instrument like the *vina*. Similarly, there are sexual and even individual differences of voice (अस्ति हि शुकसारिकामनुष्यवक्त्रप्रभवेभुक्कारादिषु स्पृष्टतटः रूपभेदप्रत्ययः पुंसाम् । एवं स्त्रीपुंसप्रभवेषु स्त्रीपुंसभेदप्रभवेषु च—Vāchaspati, Tāt-paryyatikā, II., 2, 14. वीणा वाद्यते वेद्युः पूर्व्यते वीणावेद्युश्चन्दोर-साधारणी धर्मेः—Udyotakara, II., 1, 15. वेद्युवीणावृद्धादिप्रभवेषु भेदप्रत्ययः शुकसारिकामनुष्यवक्त्रोत्पादिभेदप्रत्ययः—Gangeśa and Ma-thurānātha). The sounds emitted by impact of the different Bhūtas (echo from Ākāśa, hissing from the wind, puffing from fire, bubbling from water, and splitting or cracking from earth) are characteristic examples of such differences of timbre (*vide* Pan-chadaśī, Bhūtaviveka, Śloka 3).

The Vākya-padīya (Kānda I, Śloka 109), as we have seen, ascribes all differences (whether of pitch, volume, or timbre) to the characteristic forms of the air-waves, which differ from one another by their configuration (सन्निपाताद् विभज्यन्ते मूर्त्तयः), and are capable of variations of velocity (momentum, *vega*) as well as of rarefaction and condensation (कारणसामर्थ्याद् प्रचयधर्मिकः).

There are passing references to the obscuration (अभिभव) of sounds in Vātsyāyana, Udyotakara and Vāchaspati, but the subject is treated more from a psychological than from a physical point of view. (तीव्रभेरीशब्दः मन्दतन्त्रीशब्दमभिभवति न मन्दः । नामाभूतेषु शब्दसमानेषु सानु श्रोत्र-प्रत्यासक्तिभावेन कस्यचित् शब्दस्य तीव्रेण मन्दस्य अभिभवो युक्तः—Vātsyāyana, II., 2, 14; *vide* Udyotakara and Vācha-spāti, *loc. cit.* Here तीव्र = loud, and मन्द = low.)

SECTION 5.

MUSICAL SOUNDS.

Śrutis and Svaras.—We have already seen that the distinguishable pitches are called Śrutis, and they are proportioned to the *vega* (momentum) of the *kampa-santana* (vibration). Now the ratio of a note to its octave (in respect of pitch) is given as 1 : 2; we may therefore conclude that the *vega* of the vibration in the latter case was considered to be twice as great as in the former. An indefinite number of Śrutis could be interposed between a note and its octave (ज्ञानस्य हि श्रुतीनां च सूक्ष्मनि विपश्चितः यथा ध्वनिविज्ञेयाद्याममानं गगनोदरे । संगीतरत्नाकर । cf. संगीतपारिजात । केशवव्यवधानेन बह्व्योर्गपि श्रुतयः स्मृताः—संगीतपारिजात, Śloka 40). Twenty-two such are named and recognised for musical purposes. But a Śruti as such cannot constitute a musical tone (Svara). A Śruti is a simple (unmixed) and fundamental tone of a certain pitch, whereas an ordinary musical tone (Svara) is really composed of a fundamental tone (Śruti) and certain partial tones (harmonics, Anurananas, अनुराजन). The musical tones (Svaras), vocal or instrumental, are therefore of the nature of what we call clangs, because, either accompanying or following the Śrutis or simple fundamental tones (हस्तादिनाच), are always found certain partial tones (अनुराजन). व्यवहारे त्वसौ त्रेधा हृदि मन्द्रोर्गभिधीयते । कच्छे मध्ये सूत्रितारो द्विगुणश्चोन्नरोन्नरः (संगीतरत्नाकर) हृदिमन्द्रोर्गलेमध्ये सूत्रि तार इति क्रमात् । द्विगुणः पूर्वपूर्वेस्मात्—Dāmodara, Sangīta-darpaṇa, Chap. I, Śloka 49. श्रुतनन्तरभावी यः श्लिग्धोऽनुराजनात्मकः । स स्वरः उच्यते—Sangīta-ratnākara. स स्वरो यः श्रुतिस्थाने खनन् हृदयरत्नकः (संगीतदामोदर) त्वाविंशतिविधो मन्द्रोऽध्वनिः सञ्जायते

हृदि । स एव द्विगुणो मध्यः कक्षस्थाने यथाक्रमम् । स एव मस्तके तारःस्यान्वध्यात् द्विगुणक्रमात्—Sangîta Samaya Sâra, 1. नादाच्च श्रुतयो जातास्ततः बह्मनादयः स्वराः । प्रथममन्त्रवशाच्छब्दः श्रूयते ह्रस्वमात्रकः सा श्रुतिः सम्परिज्ञेया स्वरावयवलक्षणा । स्वरूपमान्त्रमन्त्रवशात्सादोऽभ्युत्थनं विना । श्रुतिरित्युच्यते—Dâmodara, Sangîta-darpana, Chap. I., Śloka 51. The relation between a Śruti and a Svara is variously conceived as (1) परिष्कारान् modal change ; (2) व्यञ्जन manifestation ; (3) तादात्म्यम् जातिव्यञ्जेरिव the relation of genus and species ; (4) विवर्तन (मुखं यद्दृग् दर्पणेन विवर्तितं) reflection ; (5) कार्यकारणभाव, the relation of cause and effect ; cf. संगीतपारिजात by Ahobala, श्रुतयस्तु स्वरा भिन्नाः प्रावृत्तत्वेन हेतुना । अहिकुण्डलवत् तत्र भेदोक्तिः शास्त्रसम्भवात् ।—संगीत-पारिजात, Śloka 38.

SECTION 6.

THE NOTES OF THE DIATONIC SCALE: DETERMINATION OF THEIR RELATIVE PITCH.

The pitch of a note is inversely proportional to the length of the wire (तन्वीतनुस्वरो ज्ञेयः तद्द्वैर्ध्वेष्यस्तमानतः—श्रेयलीलावती, quoted by Mr. Devala in his "Hindu Musical Scale").

The pitch of the fundamental note to that of its octave is as 1 : 2 (मध्यस्थानस्यः बह्मः द्विगुणसमः—रागविबोध, quoted by Mr. Devala).

The pitch of the fourth note (F) to that of the fundamental (C) is as 4 : 3 (उभयोः बह्मयोर्ध्वेष्ये मध्यं स्वरमाचरेत्—संगीतपारिजात, quoted by Mr. Devala).

The vibrations of the fifth note (G) to those of the fundamental (C) are as 3 : 2 (त्रिभागात्मकवीणायां पञ्चमः स्यात्तदग्रिमे ।—संगीतपारिजात, quoted by Mr. Devala).

Concord (सम्वादिता) is either perfect or imperfect. The

ratio of perfect concord is 3 : 2; that of imperfect concord, 4 : 3 (स-प-स-न मुह्याः संवादिनः स्वराः एकसंज्ञयाः प्रायः—रागविबोध, quoted by Mr. Devala); e.g. if D be the Vâdî, A would be a Samvâdî; if E be the Vâdî, B would be a Samvâdî: in each case a perfect concord. The pitch of D is determined from that of G, and the pitch of A from that of D, in each case, by the rule of perfect concord.

Determination of the pitches of E and B (after Mr. Devala). This may be done in either of the following ways:—

(1) E may be determined from A, and B from E, by the rule of perfect concord. This would give $303\frac{3}{4}$ as the value of the pitch of E, and $455\frac{5}{8}$ as that of the pitch of B, if the pitch of C be taken as 240; or

(2) E may be determined from C by reduction of the fifth harmonic by two octaves, a sort of imperfect concord; and then B may be determined from E by the rule of perfect concord. This would give 300 for E, and 450 for B, if C be taken as 240.

Mr. Devala, in his investigations with the "Sonic chord," finds that Hindu musicians (and Sanskrit-writers on music) adopted the latter values for E and B, as they tested their notes by harmonics (नेहृगतस्वयम्बुस्वर-पङ्क्तिप्रामाण्येन—रागविबोध, quoted by Mr. Devala). The Hindus therefore followed just intonation.

SECTION 7.

MUSICAL INTERVALS.

Musical tones are related to one another in four ways as Vâdîs, Samvâdîs, Vivâdîs, and Anuvâdîs. The

mediaeval compilations explain these in reference to melody, and harmony is altogether unknown, but the terms might be used to indicate relations of harmony as well. The Vâdî might in that case answer to the key-note (or tonic), and the Samvâdis to the two consonances, the fifth (2 : 3), and the fourth (3 : 4).

The rule given for the determination of a Samvâdî is 12 or 8 Śrutis intervening, the intervals being, therefore, 13 and 9 Śrutis respectively (giving the ratios $\frac{2}{3}$ and $\frac{1}{3}$).

C being the Vâdî, G and F are stated to be the Samvâdis.

In the same way, it is stated that if D be the Vâdî, A would be a Samvâdî. If E be the Vâdî, B is given as a Samvâdî.

On the other hand, a two-Śruti interval (*i.e.* a difference of a semitone) gives a Vivâdî, which would thus answer to a dissonance. This is given as a general rule (विषुवन्नरीखरीविवादिनी Matanga). Other cases are also noticed, *e.g.* E is a Vivâdî to D, and B to A, and *vice versa* (ratio of 9 : 10).

The notes that do not come under these heads are Anuvâdis (*e.g.* the sixth); *cf.* Bharata, Nāṭya-Śāstra, Chap. XXVIII., Śloka 23-24.

Also Sangīta-ratnākara :—

चतुर्विधा स्वरा वादी सम्वादी विवाद्यपि अनुवादीति । वादीतु प्रयोगे बहुलस्वरः अतयो द्वादशाहो वा ययोरन्तरगोचराः विषयः सम्वादिनी तौ स्तो निगावन्विवादिनी । रिषयोरेव वा स्यातां तौ तयोर्वीरिषायपि । ज्ञेयाद्या-मनुवादित्वम् । (स्वराध्याय) ।

CHAPTER IV.

HINDU IDEAS ABOUT PLANTS AND
PLANT-LIFE.

SECTION 1.

CLASSIFICATION OF PLANTS.

Charaka :—Plants according to *Charaka* are divisible into (1) *Vanaspatis*, trees bearing fruit without flowers ; (2) *Vânaspatyas*, trees bearing flowers as well as fruits ; (3) *Auṣadhis*, herbs that wither after fructification ; and (4) *Vîrudhs*, other herbs with spreading stems.

Chakrapâni notes in his commentary on *Charaka* : The *Vîrudhs* comprise two classes, (1) *Latâs*, creepers ; (2) *Gulmas*, herbs with succulent (or cactaceous) stems and shrubs. The *Auṣadhis* are sub-divided into (1) annuals or perennials, bearing fruit, and (2) plants that wither away after maturing and without fructification, e.g. grasses like the *Dârvâ* (*Cynodon dactylon*).

Suśruta :—*Suśruta*'s division is identical with *Charaka*'s. *Dalvana*, the commentator, gives some details. The *Plakṣa* (*Ficus infectoria*) and the *Udumvara* (*Ficus glomerata*) are given as instances of trees bearing fruits without flowers (*Vanaspatis*). It appears that plants with naked and incomplete flowers (achlamydeous plants) were considered as flowerless, as also trees whose flowers, like those of the fig, are placed

on the internal walls of a common receptacle. Of the *Brikṣas*, flower- and fruit-bearing trees, the mango-tree, the *Jambu*-tree (*Eugenia jambolana*), etc., are given as examples. The *Virudhs* are of two classes, (1) creepers with stems spreading on the ground (प्रतानवन्तः), and (2) herbs with succulent (or cactaceous) stems (गुल्मिन्यः or क्षत्रिन्यः बहुलुलासन्नतिविशिष्टाः). *Auṣadhis* are those that wither away after fructification, e.g. wheat, barley, etc. (प्रलयाकनिष्ठा गोधूमादयः). Some divide *Auṣadhis* into two classes, (1) those that wither after bearing fruit, e.g. paddy, linseed, pulses, etc., and (2) plants that wither after maturity, and bear neither flowers nor fruits, e.g. the mushroom, etc.

Prāśastapāda :—*Prāśastapāda*, the Vaiśeṣika doctor, classifies plants as follows :—(1) *Triṇas*, grasses ; (2) *Auṣadhis*, herbs that wither after fructification ; (3) *Latās*, spreading and creeping herbs ; (4) *Avatānas*, arboraceous plants and shrubs ; (5) *Brikṣas*, trees bearing flowers and fruits ; and (6) *Vanaspatis*, trees bearing fruits without flowers.

Śrīdhara in the *Kandalī* gives *Ulapa* as an example of a grass, wheat as an example of *Auṣadhi* (annual), the *Ketakī* (*Pandanus odoratissimus*) and the *Vijapura* (*Citrus medica*) as examples of *Avatānas* (*Vitapas*, arboraceous plants), the *Kovidāra* (*Bauhinia*) as an example of flower- and fruit-bearing tree, and the *Udumvara* (*Ficus glomerata*) as an example of a *Vanaspati* (flowerless fruit-bearing tree).

Udayana in the *Kiraṇāvalī* notes the *Kuṣmānda* (a species of *Cucurbita*) as an instance of a creeper (*Latā*), and the palms नल्लद्वयः as modifications of the grasses (*Triṇas*).

Amara :—*Amara*, the lexicographer, in the *Vanauṣa-dhivarga* and the *Vaiśyavarga* (enumeration of wild plants and of food-grains) gives some interesting particulars. (1) The trees (the flowering *Brikṣas* and the flowerless *Vanaspatis*) are fruit-bearing, and possess woody stems काष्ठदारु or trunks (प्रकाष्ठ—प्रकाष्ठः स्तम्भः स्यान्मूलात् ज्ञात्वाविलस्रः). Next come (2) arboraceous plants and shrubs (क्षूप, ह्रस्वशाखाश्लिषः क्षूपः) bearing flowers as well as fruits. (3) The *Latās* are next noticed, flowering plants with herbaceous stems, some of them creeping on the ground (प्रतानिनी), others succulent (गुल्लिनी), others twining or voluble (सुलाक्षासंगता लता, वृक्षगामिनी लता—*Amara*, cf. *Mukuta*, तरुमूलात् प्रभृति वृक्षापयस्येनं गता गुडुष्यादि लतापि अचरोहः—others call this श्लिषा). Cf. *Suśruta*—लताः प्रतानवत्यः गुल्लिन्यश्च. (4) Next come the *Auśadhis* (in the narrower sense), herbaceous plants bearing fruit with or without flowers, and dying or withering away after fructification. Some instances of *Kandaśāka* (tubers, rhizomes, corms) are noticed, e.g. the *Palāndu* (the onion, पलान्दुसु बुकन्दकः), the *Laśuna* (garlic, महाकन्द), etc. But the graminaceae enumerated in the *Vaiśyavarga* are the chief instances of the *Auśadhis*—plants that die after fructification. These are cultivated *Auśadhis*, but their affinities with the next class, the grasses (*Triṇas*), are also noted (e.g. धान्यं व्रीहि सस्यकरी। सस्योगुञ्जस्तृणादीनाम्। तृणधान्यानि नीबाराः। नाद्दीनालं च काञ्चोभ्यः). Next are enumerated (5) the *Triṇas*, grasses, of which the characteristic is the formation of *gulmas* (culms of grasses with annular knots from which leaves spring—सस्यो गुल्मे तृणादीनामकाष्ठद्रुमगुञ्जयोः). It is worthy of note that, in the enumeration of the grasses, the bamboo is considered as a sort of giant grass

(तृणध्वज, grass flag, तृणेषु ध्वज ईव). The reeds (नलादयः) are also placed among the grasses (नलादयस्तृणं गर्भुष्याशाकप्रमुखनिपि । प्रमुखस्यन्दान् नीवारकाः). (6) Finally, the Palmaceæ (including the cocoanut, date, areca, and other palms) are classed as Tree-grasses, probably because, like the grasses, they are endogens characterised by spikes and parallel veins. तृणद्रुमः । (तृणराजाहयस्तालः नारकेलस्तु लाङ्गुली etc., एते च हितालसहितास्त्रयः खर्जूरः केतकी ताली खर्जुरा च तृणद्रुमाः, —cf. also the *Râjanighantu*).

I may add that Amara places parasitical plants among the *Latûs* (वन्दा वृषादनी । वृषरुहा । जीवन्निक्षेपि). They climb trees and feed upon them. These are to be distinguished from climbing plants, like the *Gudûchî* (*Tinospora cordifolia*), which have separate roots of their own. They are also to be distinguished from the adventitious roots descending from the branches of trees, like the *Ficus religiosa*, which are usually termed *avarohâs* (अवरोहाः). The name *siphâ* is ordinarily applied to the rootlets and suckers by which the tendrils of various creepers are attached to the soil. (शाखाशिक्षा अवरोहः स्यात् । वटादेः शाखायाः अवलम्बिनी शिक्षा । मूलाचार्यं गता लता । मूलादूर्ध्वं गता लता स्यात्—Amara with Bhânûji Dikṣita's commentary. But the Mukuta notes :—तन्मूलात् प्रभृति वृक्षाद्यप्यर्धनंगता गुडुच्चादि लताभिप अवरोहः ।) The *Gudûchî* is also called *वत्सादनी*, *विषरुहा* ।

The Hindu *Materia Medica* mentions *Âkâsavallî*, *lit.* sky-creeper, a name which seems to have been originally intended for some orchids ; also *Plava* (*lit.* floating), weeds that float in stagnant ponds, and *Śaivḍla*, mosses and lichens (*e.g.* दूषोक्तवेह्मवशैवालं जलेन क्लिपितं पीतं शुक्रवेहर्द — *Chakrapâṇi - Samgraha*, also *Bhâva-*

Prakâsâ). These are not classified, but like the mushrooms must come under the *Pâkaniṣṭha auṣadhis*, Auṣadhis that die after maturing, without bringing forth flowers or fruits.

SECTION 2.

ELEMENTARY IDEAS OF PLANT PHYSIOLOGY.

Characteristics of Plant-Life.

The *Nyâya-vindu-tîkâ* of Dharmottara, the Buddhist scholiast, notices the phenomenon of sleep (contraction of leaves in the night) in certain plants (स्नापः रात्रौ पत्रसङ्कोचः).

Udayana notices in plants the phenomena of life, death, sleep, waking, disease, drugging, transmission of specific characters by means of ova, movement towards what is favourable and away from what is unfavourable (वृक्षादयः प्रतिनियतभोक्त्वाधिष्ठिताः जीवनमरणास्त्रमागराखरोगभेषजप्रयोग-चोन्नसजातीयानुबन्धानकूलोपगमप्रतिकूलोपगमादिभ्यः प्रसिद्धाशरीरवत् — Udayana, पृथिवीनिरूपणम्). I may add that metaphors drawn from the heliotropic movements of the *Sûryya-mukhî*-flower are among the stock-in-trade of Sanskrit poetry and belles-lettres.

The Jaina writer Guṇaratna, in his commentary on the *Ṣaddarśana-Samuchchaya* (circa 1350 A.D.), enumerates the following characteristics of the plant-life : (1) stages of infancy, youth and age ; (2) regular growth ; (3) various kinds of movement or action connected with sleep, waking, expansion and contraction in response to touch, also movement towards a support or prop ; (4) withering on wound or laceration of

organs ; (5) assimilation of food according to the nature of the soil ; (6) growth or decay by assimilation of suitable or unsuitable food as prescribed in the science of the diseases of plants and their treatment (वृक्षायुर्वेद) ; (7) disease ; (8) recovery from diseases or wounds by the application of drugs ; (9) dryness or the opposite, due to the sap which answers to the chyle (रक्त) in animals ; and (10) special food favourable to impregnation. (विश्विद्वदौहृदादिनखं विश्विद्वस्त्रीशरीरवत् यथा स्त्रीशरीरस्य तथाविधदौहृदपूरणात् पुत्रादिप्रसवर्नं तथा वनस्पतिशरीरस्यापि तत्पूरणात् पुष्पफलादिप्रसवर्नं ।) Even the *Vanaspatis* (flowerless, but fruit-bearing trees) may be made to flower (cf. Vārah-mihira's recipes for the treatment of plants for similar purposes ; cf. Guṇaratna, *Tarkarahasyadīpikā*, *Jainamāta*, Śloka 49).

Śankara Mīśra in the *Upaskāra* notes as an additional characteristic the growth of organs (or tissues) by natural recuperation after wound or laceration (भग्नव्रतसंरोहणे च, *Upaskāra*, Chap. IV., Ahnika 2, Sūtra 5, S. B. H., Vol. VI.).

Guṇaratna gives a list of plants that exhibit the phenomena of sleep and waking (सनीमपुत्रादिविज्ञेयवकासुन्दक-बम्बूलागस्याम्लकीकतिप्रभृतीनां स्वापविबोधतः, *ibid.*). He also notices the sensitiveness to touch of plants like the *Mimosa pudica*, लज्जावती लता, which show a manifest reaction in the form of contraction, लज्जालूमभृतीनां हस्तादिसंस्पर्शात् यत्र सङ्कोचादिका परिष्फुटक्रिया उपलभ्यते (*ibid.*).

Sexuality.

Very vague ideas were entertained as to the sexual characters of plants. The pollen is called *Rajas*, *puspa*,

prasuna—names which are also applied to the female menstruum—and Amara expressly states that for females and flowers these elements (and the terms signifying them) are the same (स्त्रीणां सुमनसां पुष्पं प्रसूनं समम्—Amara, *Vanauṣadhivarga*). Charaka (*Dridhavalā*), indeed, distinguishes between the male and the female *vatsa* (or *kutaja*), considering the variety that bears white flowers and large fruits as male (बृहत्फलश्चेत्पुष्पैः पुमान्, *Holarrhena antidysenterica*), and that which bears red or yellow flowers and small fruits as female (श्यावारुहानुपुष्पी स्त्री—असितकूटम्, *Wrightia tinctoria*; Charaka, *Kalpasthāna*, Chap. V.; but this is hopelessly wrong. Even these vague ideas were afterwards completely lost, and the *Rājanighantu* tells us of a grotesque division of plants into male, female, and hermaphrodite, based on the slender or stout, the soft or hard, the long or short, the simple or mixed character of the stems and flowers! (*Rājanighantu*, अनूपादि प्रथमो वर्गः स्त्रीपुंनपुंसकत्वेन त्रैविध्यं स्यादरेष्वपि, etc.).

Consciousness.

The Hindu Scriptures teach that plants have a sort of dormant or latent consciousness, and are capable of pleasure and pain (अनाःसंज्ञा भवन्त्येते सुखदुःखसमन्विताः). Chakrapāṇi notes in the *Bhānumati* that the consciousness of plants is a sort of stupefied (darkened or comatose) consciousness (बुध्वास्तु चेतनावन्मोर्गपि तमश्चक्षुस्ज्ञानतया शास्त्रोपदेशविषया इव).

Udayana also notes that plants have a dormant unmanifested consciousness which is extremely dull (अतिमन्दानाःसंज्ञितया, etc.).

The *Mahâbhârata* adds that plants are sensitive to heat and cold, to the sound of thunder, etc., as well as to odours both pleasant and unpleasant:—

उष्णतो ज्ञायते पर्यं त्वक् फलं पुष्पमेव च ।
 ज्ञायते शीर्ष्यते चापि स्पर्शस्तेनात्र विद्यते ॥
 वाय्वग्न्यग्नि-निर्घोषैः फलं पुष्पं विशीर्यते ।
 ओत्रेण गृह्यते शब्दस्तस्माच्छृण्वन्ति पादपाः ।
 वह्नी वेद्यते वृक्षं सङ्घतश्चैव गच्छति ।
 नक्षद्रुद्रश्च मार्गोऽस्ति तस्मात् पश्यन्ति पादपाः ॥
 पुष्पापुष्पैस्तथा गन्धैर्धूपञ्च विविधैरपि ।
 अरोगाः पुष्पिताः सन्ति तस्माच्चिप्रमन्ति पादपाः ॥
 पादैः सलिल-पानाच्च व्याधीनाश्चापि दर्शनात् ।
 व्याधिप्रतिक्रियत्वाच्च विद्यते रसनं द्रुमे ॥
 वक्रशेखोत्पलनालेन यथोर्ध्वं जलमाददेत् ।
 तथा पवनसंपुङ्गः पादैः पिबति पादपः ॥
 सुखदुःखयोश्च ग्रहणात् क्षिप्रस्य च विरोहणात् ।
 जीवं पश्यामि वृक्षाद्यानचैतन्वं न विद्यते ॥ शान्तिपर्वे, महाभारतः

CHAPTER V.

HINDU CLASSIFICATION OF ANIMALS.

SECTION 1.

CLASSIFICATION OF ANIMALS.

Charaka.

Charaka mentions four primary divisions :—

(1) *Jarâyuja*, born from the uterus, or, rather, placentalia, viviparous (no a-placental mammals were known), *e.g.* man, the quadrupeds, etc.

(2) *Andaja*, born of an ovum (egg), comprising fishes, reptiles, and birds.

(3) *Svedaja* (or *Uṣmaja*), born of moisture and heat, spontaneously or a-sexually generated, *e.g.* worms, mosquitoes, etc.

(4) *Udvijja*, born of vegetable organisms (भूतानां चतुर्विधा योनिर्भवति जरायवस्त्वदोद्भिदः—*Śârîrasthâna*, Chap. III. शकैका योनिः अपरिसंख्येयभेदा भवन्ति भूतानामाकृतिविज्ञेया परिसंख्येयान् —*Ibid.*).

Praśastapâda.

Praśastapâda begins with two great divisions: (1) *Ayonija*, animals that are a-sexually generated, of small dimensions (सुद्रजन्तु); (2) *Yonija*, sexually generated, *i.e.* from the union of a sperm and a germ element. The latter are subdivided into (a) *Jarâyuja*, lit. placen-

talia, viviparous (no a-placental mammals were known), and (b) *Andaja*, oviparous. Man, the quadrupeds (domesticated and wild), etc., are given as examples of viviparous animals, and birds, *Sarîsripas* (reptiles, etc.) of oviparous animals. Udayana in the *Kiraṇâvalî* notes that *Jarâyû* means the placenta (गर्भवेदनचर्मपुटकं जरायुः, cf. Śrîdhara in the *Kandalî*, जरायुरिति गर्भाशयस्य अभिधानं तेन वेदितं जायते इति जरायुजन्). Udayana adds that the term *Sarîsripa* includes insects and fishes as well as reptiles, these being all oviparous (सरोसृपाः परितः प्रसर्षणशीलाः सर्पकीटमत्स्यादयः—पृषिषीनिरूपणम्).

Patanjali.

The a-sexually generated animals, as we have seen, are also called *Kṣudrajantus* (lit. small animals). Pâtanjali in the *Mahâbhâṣya* gives several alternative definitions (or descriptions) of this class of animals. They are defined (1) as animals without bones, अनस्थिकाः सुद्रजन्तवः; or (2) as animals that do not possess any blood of their own, येषां स्वं श्लोथितं नास्ति ते सुद्रजन्तवः; or (3) as numbering more than a thousand in a palmful, i.e. minute in size; or (4) as not easily crushed; or (5) as comprehending all animals up to the ichneumon (in the animal series), अथवा नकुलपर्यन्ताः सुद्रजन्तवः—*Mahâbhâṣya*, 2-4-1.

Suśruta.

Suśruta mentions four great divisions: (1) *Sansvedaja*, born of moisture and heat: this division is mentioned first, as Dalvana notes, because moisture and heat are essential factors in the generation of all forms of animal life, including the classes that follow;

(2) *Jarâyuja*, viviparous or placental; (3) *Andaja*, oviparous; and (4) *Udviija*, bursting forth (from the ground, or perhaps from some previous unmanifest shape, e.g. frogs, coccidæ, etc.). The second, third, and fourth classes are mentioned in the order of their importance. Subsequently the order of enumeration is changed: (1) *Jarâyuja*, (2) *Andaja*, (3) *Svedaja*, (4) *Udviija*. One reading gives the order: (1) *Svedaja*, (2) *Andaja*, (3) *Udviija*, and (4) *Jarâyuja*. Some commentators point out that the order in the text (whatever that may be) is intended to indicate the order of creation by Brahmâ.

Sûsruta mentions man, *Vyâla* (carnivorous quadrupeds), and *Pasu* (herbivorous quadrupeds) as examples of the viviparous; birds, snakes, and *Sarîsripas* as examples of the oviparous; *Krimis*, *Kîtas*, and *Pipîlikâs* (worms, insects, ants, etc.) as examples of the moisture-born; and frogs and the coccidæ (the coccinella) as examples of the animals that "burst forth" (eruptive or metamorphic?). Dalvana notes that the divisions are really cross-divisions (योनिसेकर), and intended to be such, as the natural divisions of Jiva and species are not all exclusively oviparous or exclusively viviparous. For example, among birds (पक्षिणः, winged animals), bats and *Valâkâs* are viviparous (बलाका जंतुकादयः जरायुजाः); indeed, *Valâkâs* are some of them oviparous and some viviparous (पक्षिषु बलाका जरायुजा अस्त्यन्तः). Among snakes, the *Ahipatâkâs*, a species of non-venomous colubrine snakes, are viviparous (ovo-viviparous?). Among the moisture-born, there are some kinds of ants (पिपीलिकाः) which also lay

eggs or burst forth (from the ground, or perhaps from some previous unmanifest shape) (संस्वेदनेभ्यश्च काश्चित् पिपीलिका चक्षुजा उद्भिज्जाश्च).

The oviparous animals are divided by Suśruta into birds, snakes, *Sarīśripas*, etc. Dalvana notes that the *Sarīśripas* include fishes and *Makaras* (sea-fish with fierce teeth, हिंसदंष्ट्रकाः), and the "et cetera" comprehends tortoises and crocodiles (सरीसृपाः शरीरगामिनः कृष्णसर्पादयो नीननकरादयो वा प्रभृतिग्रहणेन कूर्मेनक्रादीनां ग्रहणम्)! The "moisture-born" are due to the moisture and heat either of the earth or of organisms (संस्वेदनाः भुवः शरीरस्य च संस्वेदात् जन्मयः जाताः). Of these, the *Krimis* (worms) arise from the moisture of the fæces in the bowels (कृमयः कोष्ठपुरीषादिवाय्वसम्भवाः—Dalvana); from putrefying dead bodies (शव—Suśruta; cf. शरीरे कियद् चेतानमरं समुत्पन्नानि कृम्यादीनां कथं चैतन्यम्—Gūṇaratna, *Tarka-rahasya-dīpikā* (*Jainamatam*); from decomposing curd or milk (e.g. वर्षासु च स्वेदादिना जनतिदवीयसैव कालेन दम्भाद्यवयवा एव चलनः पूतनादिकृमिरूपा उपलभ्यन्ते—Jayanta, *Nyāya-Manjarī*, *Āhnika* 7, भूतचैतन्यपत्र).

The second class, *Kītas*, noticed among the moisture-born, include the scorpions, the six-spotted venomous insect *śadvindu*, etc. (क्रीडा वृश्चिकश्चइविन्दु प्रभृतयः—Dalvana). Of these the scorpions arise from cow-dung, excreta of snakes, rotten wood (कथं गोमयाद् वृश्चिकः जायते—Pātanjali, *Mahābhāṣya*, 1-4-3); cf. also Suśruta, *Kalpasthāna*, Chap. VII.

The third class, *Pipīlikās*, ants and the like insects, Dalvana notes, are born of moisture and heat, as well as of eggs, and sometimes burst forth from the ground (भुवमुद्भिज्जा जाता उद्भिज्जा—Dalvana). The gnats and mos-

quitoes (दूग्धनसृजकादयः) are also usually placed among the moisture-born. An *anda* (egg) is described as oval, of the form of a *pesî* (अण्डं यस्याकारवस्तुलं—Dalvana; cf. Śrīdhara, *Kandalî*, अण्डं विन्म तेन वेदितं जायते तत् अण्डजं, पृथिवीनिर्हयत्वं).

Chhândogyā and Śankara.

It may be noted that the *Chhândogyā Upaniṣad* classifies animals on the basis of their *vîja* (ovum or seed) as three-fold :—(1) *Andaja*, born of eggs; (2) *Jîvaja*, viviparous; and (3) *Udvîja*. Śankara explains that the *udvîja* animals arise from vegetable organisms (उद्भिन् स्यावर् ततो जातन् उद्विजन्), which is also Charaka's view, as we have seen; but unlike Charaka, Śankara holds that the *svedaja* animals must be included partly under the oviparous, and partly under the *udvîja* (vegetable-born) class (अण्डजोद्विजयोरेव यथासम्भवमनभौवः—*Chhândogyā*, Prapâthaka 6, part 3).

Evidently the idea is, that though vegetable organisms may pass off into animal, there cannot be generation without *vîja* (seed or ovum), and inorganic matter without *vîja* (seed or ovum) cannot give rise to animal life. Pâtanjali, in the *Mahâbhâṣya* (circa 150 B.C.), mentions the opposed view, which holds that not only animal organisms but also vegetable organisms, e.g. grasses, grow from inorganic matter. The Dûrvâ grass, for example, can grow from deposits of the hair of goats and cows, just as scorpions are seen to develop out of cow-dung. Pâtanjali notes the orthodox Sâṅkhya-Vedânta explanation that these are not cases of growth (or transformation) but merely of coming out (अपक्वान्ति),

कर्यं गोमयाद् वृषिको जायते गोलोमाविलोमेभ्यः दूर्वा जायते इति अथक्रान्ति
ना वस्तुभ्यः—*Mahâbhâsya*, 1-4-3.

The Dietary Animals in Charaka and Suśruta.

In noticing different kinds of meat for dietary purposes, Charaka gives a classification of animals (mammals and birds) which has only a practical (therapeutic) significance.

The dietic value of the flesh of any animal was conceived to depend mainly on its habitat and mode of life. Dietary animals (mammals and birds) were accordingly divided into eight classes (अष्टविधा योनिसेवान्) :—

(1) *Prasaha*, carnivorous as well as non-carnivorous (Chakrapāṇī), comprehending land quadrupeds and birds that fall on their food with force.

(2) *Anâpa*, animals that live in marshy or water-logged lands or graze on river-banks.

(3) *Bhûśaya* or *Vileśaya*, animals that live in underground holes.

(4) *Vârîśaya*, aquatic animals, both fresh-water and oceanic.

(5) *Jalachara*, amphibious animals.

(6) *Jângala*, animals that live in dry and elevated (hilly) jungle lands, mostly species of deer.

(7) *Vişkira*, birds that scatter their food in picking up; and

(8) *Pratuda*, birds that pierce or torment their food (worms and fruits) with the beak.

In the chapter on articles of diet, Suśruta gives a practical classification of (vertebrate) animals for dietary

purposes. Animals that find a place in this dietary are first divided into two classes : (1) *Anûpa*, animals that live in marshy or water-logged land (or in water); (2) *Jângala*, animals that live in dry (hilly) jungle land. The *Jângalas* are divided into five classes, and the *Anûpas* into eight. The thirteen classes are based on real and natural distinctions of food and habitat; they are for dietary purposes arranged under six conventional (or artificial) classes (त्रयोदशभेदा षट्सु एव चकार्युताः । संख्येयम् निर्देशादेव षट्संख्यायां लज्जायां षडग्रहणम् तेन षड्वर्गो इति नियमार्यम्—Dalvana, *Sûtrasthâna*, Chap. XXVII.). These thirteen classes of dietary animals may be enumerated as follows :—

I. *Jângala* animals—*Janghâla*, *Vişkira*, *Pratuda*, *Guhâśaya*, *Prasaha*, *Parṇamriga*, *Vileśaya* and *Grâmya*, and

II. *Anûpa* animals—*Kulechara*, *Plava*, *Kośastha*, *Pâdina*, and *Matsya*.

Of these, the *Matsyas* (fishes) are divided into two groups—fresh-water (*lit.* river-water) and sea-water fishes. Among the sea fishes, the *timi* and the *timingala* (whales? तिमिनहृत्तनो मह्यः तिमिङ्गलस्ततोऽपि महत्तनः—Dalvana) find a place, as also the *makara* (shark, हिंसर्दंष्ट्राकः—Dalvana).

The *Kośastha* (living in shells—mollusca) are distinguished from the *Matsyas* (fishes). In this class are enumerated *śankhas* (Conchifera), *śankhana* (smaller Conchifera), *śukti* (pearl-mussels), *sambuka* (*Helix*) with spiral shell (आवर्त्तकोशः—Dalvana), *valluka* (a species of *Helix*, according to some, अन्य सम्युक्तभेदमाहुः—Dalvana), etc. Dalvana adds *vodîka*, *jalaśukti*, and various species of *Helix* (बोटिकजलसुकुटिसम्युक्तभेदा बहुविधा गुणान्ने).

The *Pâdinas*, aquatic animals having pedal (or long dorsal) appendages, comprise *kurmas* (oval or oblong-shaped tortoises, turtles), the *kumbhîras* (crocodiles, Emydosauria, Reptilia), *karkatas* (white and black crabs, Crustacea), the *śiśumâra* (a species of the Delphinidæ cetacea), muscular, with a sharp protruding snout, breathing with the blow-hole *out of the water*, probably a dolphin, as the long dorsal fin was taken for a sort of pedal appendage (दुदाकारोऽथैवकः बहिर्निष्कारं नुचति सोऽपि द्विविधः बभ्रुलदीर्घभेदेन:—Dalvana). The *Pâdinas* do not represent any natural division.

Of the other *Anûpa* animals (aquatic or amphibious animals), the *plavas* (*lit.* floating on the water) represent a class of birds (the Natatores and the Grallatores) exemplified by geese, ducks, cranes, etc.

The *Kulecharas* are herbivorous quadrupeds that frequent the banks of rivers and ponds, and comprise the elephant, the rhinoceros, the *Gâvaya* (*Bos gavæus*), the buffalo, various species of deer, etc.

Of the land animals (*Jângala*), three of the subdivisions represent birds, and five, mammals. The land birds are: (1) the *Prasaha* birds, birds of prey proper (Raptors), comprising the vulture, kites, hawks, owls, etc. (Charaka's *Prasaha* is a much wider class); (2) the *Viṣkiras*, birds that scatter their food in picking up; and (3) the *Pratudas*, birds that pierce or torment their food (fruits or worms) with the beak. The last two classes comprehend between them the *Passeres* (proper and so-called), the *Scansores*, the *Rasores* and the *Columbæ*.

The remaining five classes of *Jângala* animals are

mammals, with the exception of several species of *Vileśayas*, which are reptiles. The *Parṇamrigas* (arboreal animals) comprise the apes, sloths, squirrels, as also some of the reptiles and carnivora. Among the *Parṇamrigas*, the *Putighasa* is a kind of tree-cat giving out a pungent odour; the *Madgumuṣṭika* and the *Briksaśâyika* are arboreal rodents; and the *Avakuśa* is a species of cow-tailed monkey (*vide* Dalvana). The *Janghâlas* are wild animals, herbivorous quadrupeds that are strong-legged and quick-footed, comprising various species of deer and antelopes.

The *Grâmyas* (*lit.* living in or about villages, domesticated quadrupeds) comprise the horse, the mule, the ass, the camel, the goat, the sheep, etc. They are non-carnivorous, being distinguished from the carnivorous quadrupeds (कृष्याद—Suśruta, नृसाद—Charaka). Some are *Ekaśapha* (animals whose hoofs are not cloven) (ग्राम्यशब्देन च एकशकलशब्देन च ग्राम्याः—शकः क्षुरः—Dalvana).

The *Guhâśayas* are carnivorous quadrupeds (कृष्यादाः) living in natural caves or hollows. They comprise the lion, the tiger, the wolf, the hyena, the bear, the panther, the cat, the jackal, the *mrigavaru*, etc. The *vrika* (wolf) is defined as a dog-like animal, small-sized (in comparison with the lion and the tiger). By the cat, here, wild-cats are meant. The *mrigavaru* is described as a jackal-like animal that kills deer.

Finally come the *Vileśayas*, animals that live in holes or burrows, comprising various species of Rodents and Insectivora, and several species of Reptiles.

Snakes in Sūsruta-Nâgârjuna.

The Snakes (Ophidæ) are especially noticed by Sūsruta-Nâgârjuna in the chapters relating to Toxicology (*Kalpasthâna*, Chap. IV.). Five different genera or families are noticed, of which one is non-venomous and four venomous, including one hybrid and three pure or unmixed families. Of the last, (1) the *Darvîkaras* (कृष्णसर्पे, महाकृष्ण, पद्म, महापद्म, झङ्खपाली—*Naia Tripudians*, *Naia Bungarus*) are hooded, swift in their movements, diurnal in their habits, and bear on their hoods or their bodies the marks of chariot-wheels, ploughs, umbrellas, rhombs or cross-bands, goads, etc. (2) The *Mandalîs* (*Vipera*, *Viperidæ*?) are thick (पृषवः), slow-moving, nocturnal in their habits, and bear circles or rings on the body (आदर्शनकल). Charaka adds that they are without hoods. (3) *Rajimats* also are without hoods, and nocturnal, and bear series of dots or marks, and are often of variegated colours on the upper parts and sides. Twenty-six varieties are named of the first, two of the second, and ten of the third.

Of the *Nirviṣas*, non-venomous snakes, twelve varieties are mentioned, including Boidæ (बज्रगर) and the Colubrine *Dendrophis* (पृषेय). Of the *Vaikaraṅja* (hybrid) snakes, there are ten varieties, of which three are produced by the union of certain venomous species, and seven are secondary derivative forms.

The *Darvîkaras* are most deadly when young, the *Mandalîs* when middle-aged, the *Rajimats* when aged. Their poisons act differently, and an elaborate descrip-

tion is given of the action of the venom of each of the three venomous families.

Snakes in the Purânas.

The *Bhaviṣya Purâna* gives the following additional information. The *Nâgas* (Naiæ) copulate in the month of *Jyaishta* or *Âṣâḍha* (May or June), gestate during the rainy months that follow, and bring forth about two hundred and forty eggs in the month of *Kârtika* (November). Most of these are devoured by the parents, but those that are left break forth from the shell in about two months (or one month, according to the *Agni Purâna*).

Eggs of a golden hue like that of the (red) flowers of the *Calotropis gigantea* (सुवर्णीकैवर्णिनिभ) produce male young ones, those somewhat paler and of an elongated ovoid shape (अर्कोदकसुवर्णीभात् दोषैराजीवसन्निभात्) bring forth female snakes, and those of the hue of the *Siriṣa*-blossom hermaphrodite ones. By the seventh day the young snakes turn dark; in a fortnight (or twenty days, according to another account) the teeth come out. The poison is formed in the fangs (दंहासु) in three weeks, and becomes deadly in the twenty-fifth night. In six months *Nâgas* shed the skin (कचुक).

In moving on the ground, the folds of the skin on the under surface alternately expand and contract, appearing to put out and draw in fine filament-like legs, about two hundred and forty in number. The joints on the skin (scales or scutes—सन्धयः) are two hundred and forty in number (perhaps the sub-caudals were not counted).

Snakes are killed by men, mongooses, peacocks, *Chakor*s (a kind of partridge), scorpions, boars, cats, and the hoofs of oxen. Escaping death from these enemies, a *Nâga* may live for a hundred and twenty years. The term of life of the non-venomous snake is shorter, about seventy-five years (*Bhavisya Purâna*, पञ्चमस्कन्ध).

The *Agni Purâna* gives the total number of teeth (of a *Nâga*) as thirty-two, of which four (two on either side) are venomous, viz. *Kâlarâtri* and *Yamadutikâ*, which appear to be the names of the fangs, and *Karâlî* and *Makarî*, which seem to stand for two hard (maxillary) teeth accompanying the two fangs (*cf.* also Charaka—*Driḍhavaḷa*, *Chikitsâsthâna*, XXIII., विषयिकिकिसिक्तम्).

Umâsvati's Classification of Animals.

A more thorough classification of animals is found in the ancient Jaina work, the *Tattvârthâdhigama* of Umâsvati, which the Jaina chronological lists enable us to assign with great probability to the fourth or fifth decennium after Christ (*circa* 40 A.D.). Umâsvati's classification is a good instance of classification by series, the number of senses possessed by the animal being taken to determine its place in the series. Perhaps only senses actively determining the life-habits were counted.

I. First come animals with two senses, viz. touch (as evidenced by contractility of tissue) and taste (as involved in the selection and rejection of food). This division comprises—

- (a) *Apâdika* (Vermes without lateral appendages, Scolecids).

- (b) *Nūpuraka* (ring-like, with pendants, Vermes with unsegmented lateral appendages, Annelids).
- (c) *Gandūpada* (knotty-legged, Arthropoda, including Crustacea, Myriapoda, etc.).
- (d) Some forms of Mollusca, e.g. *Śankha* (Conchifera, Lamelli - branchiata), *Śuktika* (Pearl - mussel, Lamelli-branchiata), and *Sambuka* (Helix).
- (e) *Jalūkā*, Leeches (Annelids).

II. Next come the animals with three senses, namely smell in addition to the primordial senses of touch and taste involved in the contraction of tissues and the appropriation of food. Here also well-developed and active senses alone were perhaps intended; rudimentary or dormant senses were not reckoned. This division comprises—

- (a) *Pipīlikā*, Ants (Formicidæ, Hymenoptera).
- (b) *Rohinīkā*, Red-ants (Formicidæ, Hymenoptera).
- (c) *Upachikā*, *Kunthu*, *Tuburaka*, Bugs and Fleas (Hemiptera, Hemimetabola).
- (d) *Trapusaviṣa* and *Karpāsāsthikā*, Cucumber- and Cotton-weevils and Lice (Aptera, Ametabola).
- (e) *Śatapadī* and *Utpataka*, Spring-tails (Aptera-Ametabola).
- (f) *Triṇapatra*, Plant-Lice.
- (g) *Kāṣṭha-hāraka*, Termites, White ants (Neuroptera, Hemimetabola).

III. Then come the animals with four well-developed and active senses, i.e. sight, smell, taste, and touch. This division comprises—

- (a) *Bhramara*, *Varaṭa*, and *Sāranga*, Bees, Wasps, and Hornets (Hymenoptera, Holometabola).

- (b) *Makṣikâ*, *Puttikâ*, *Dansâ*, and *Maśaka*, Flies, Gnats, Gad-flies, and Mosquitoes (Diptera, Holometabola).
- (c) *Vriśchika* and *Nandyâvarta*, Scorpions and Spiders (Arachnida, Arthropoda).
- (d) *Kîta*, Butterflies and Moths (Lepidoptera, Holometabola), and
- (e) *Patanga*, Grasshoppers and Locusts (Orthopteral Hemimetabola).

IV. Finally come the animals (man and the Tiryyak-yonis) with five well-developed and active senses. Omitting man, this division comprises—

- (a) *Matsya*, Fishes.
- (b) *Uraga*.
- (c) *Bhujanga*.
- (d) *Pakṣi*, Birds, and
- (e) *Chatuṣpada*, Quadrupeds.

Uraga and *Bhujanga* in popular use mean reptiles; but here evidently *Bhujanga* is taken to mean oviparous limbed animals (limbed reptiles and Batrachians) and not creatures whose movements are crooked or in the form of a bent bow; and *Uraga* stands for apodal reptiles, including snakes (Ophidæ).

It will be seen that the first three divisions fall under the Invertebrata, and the fourth is identical with the Vertebrata.

This last division (the Vertebrata) is sub-divided on a different basis, viz. the mode of reproduction. The sub-divisions are three:—

A.—*Andaja*, oviparous (Pisces, Reptilia, and Batra-

chia), e.g. *Sarpa* (Snakes, Ophidia, Reptilia), *Godha* (Varanidæ Lizards, Reptilia), *Krikalâsa* (Chameleons, Reptilia), *Grihagolika* (Common Lizards, Lacertilia), *Matsya* (Pisces), *Kûrma* (Tortoises, Chelonia, Reptilia), *Nakra* (Crocodiles, Reptilia), *Śisumâra* (Dolphin or Porpoise, Cetacea), and Birds proper with feather wings—the *Lomapakṣa pakṣis*.

Porpoises are erroneously put here, being really viviparous like other Cetacea. Frogs are not mentioned in this list. The omission is strange. Perhaps (as in Suśruta) frogs were believed to be *Udvijja* (eruptive or metamorphic) and not *Andaja* (oviparous). But Suśruta mentions the frogs after the quadrupedal and centipedal Reptilia (*Kanava*, *Godheraka*, *Galagolika*, and *Śatapadî*).

B.—*Jarâyujja*, mammals born with placenta, including all mammals other than the *Potaja* (here *Jarâyujja* is used in a restricted sense): (1) Man, (2) Cow, (3) Buffalo, (4) Goat and Sheep, (5) Horse, (6) Ass, (7) Camel, (8) Deer, (9) Yak (*Chamara*), (10) Hog, (11) Bos *Gavæus* (*Gāvaya*)—Ungulata, (12) Lion, (13) Tiger, (14) Bear, (15) Panther, (16) Dog, (17) Jackal, (18) Cat (Carnivora), etc.

The Apes, though not expressly mentioned, are also to be included.

C.—*Potaja*, a class of placental mammals comprising the Deciduata with the exception of Man, the Apes, and the Carnivora, e.g. *Śallaka* (Porcupine, Rodentia), *Hasti* (Elephant, Proboscidea), *Śvavit* and *Lâpaka* (Hedgehogs and other creatures that lap up, Insectivora), *Śasa* and *Śayika* (Hare, Rabbit, and Squirrel, Rodentia), *Nakula* (Ichneumon, which though carnivorous is

supposed to come under the Deciduata), *Mûsik* (Mice, Rodentia), and the *Charma-pakṣa Pakṣis*, so-called birds with leathern wings (Bats, Chiroptera) e.g. *Valguli* (Flying-Fox), *Pakṣivirâla* (Flying-Cat, Micro-Chiroptera) and *Jalûkâ* (apparently meaning blood-sucking Bats or Vampires, though these are scarcely found in the Old World).

The *Potaja* class thus comprises the following Deciduata: Proboscidea, Rodentia, Insectivora, and Chiroptera.

The term *Potaja* is intended to signify that these animals are born without the placenta which is thrown off as an afterbirth, whereas such of the *Jarâyujas* as are not *Potajas* are born with the placenta attached to the embryo. But it is not easy to explain why Man, the Apes, and the Carnivora should not also be reckoned among the *Potajas*. An explanation is suggested below (p. 200).

कृम्यादीनां पिपीलिकादीनां भ्रमरादीनां मनुष्यादीनां च यथासंख्यनेकेक-
वृद्धानि इन्द्रियाणि भवन्ति । यथाक्रमम् । तद् यथा कृम्यादीनां अपादिक-
नूपुरक-गच्छूपद-झङ्ग-शुक्लिक-झम्बूक-जलूका-प्रभृतीनां स्पर्शनरसनन्द्रिये भवतः ।
पिपीलिका रोहिणिका-उपथिका-कुन्पुतुपुरक-चपुसवीज-कपोसास्थिका-ज्ञत-
पञ्चुत्पतक-तृणपत्र-काहहारक-प्रभृतीनां शीथि स्पर्शनरसनब्राह्मणानि । भ्रमर-
वरट-सारङ्ग-मक्षिकापुष्पिका-दंश-मञ्जक-वृषिक-नन्दावर्ष-कीट-पतङ्गादीनां
चत्वारि स्पर्शनरसनब्राह्मणचर्चूषि । ज्ञेयानां च तिस्र्येग्योनिमानां मत्स्योरगभु-
जङ्गपक्षि-चतुष्पदानां सर्वेषां च नारकमनुष्यदेवानां पञ्चेन्द्रियाणि । (Umâ-
svati, *Tattvarthâdhigāṇa*, Chap. II., Sutra 24).

जरायुजानां मनुष्य-गो-महिषाजाविकाञ्च-सरोद्भू-मृग-चमर-वराह-गवय-
सिंह-व्याघ्रर्ष-ह्यीषि-श्व-मृगाल-माषीरादीनाम् । अक्षुजानां सर्प-गोधा-कृकलास-
गृहगोलिका-मत्स्य-कूर्म-नक्र-शिशुमारदीनाम् । पक्षिणां च लोमपक्षाणां-हंस-
चाप-शुक-गृध्र-श्येन-पारावत-काक-मयूर-मद्गु-चक-बलाकादीनाम् । पोतजानां

शङ्खक-हस्ति-श्राविस्त्रापक-शङ्ख-श्रायिका-नकुल-भूषिकादीनाम् चर्मेपक्षिणां च पञ्चाणां जलुका-बल्लुगुलि-भारुह-पक्षिपिरालादीनां गर्भेजन्त । (Umâsvati, *ibid.*, Chap. II., Sûtra 34).

SECTION 2.

RECAPITULATION.

The ancient Hindu classification of animals, as gathered from the authorities mentioned above, may be briefly summarised thus :—

A.—*Kṣudrajantus*, boneless and without (red) blood. Invertebrata, divided into—

- (a) *Ayonija*, a-sexually generated, e.g. the *Svedaja*, born of moisture and heat, and the *Udviija* (eruptive or metamorphic, e.g. the coccinella); and
- (b) *Yonija*, sexually generated, e.g. the *Andaja*, oviparous.

But some are both a-sexually and sexually generated, being both *Svedajas* and *Andajas*, or *Udviijas* and *Andajas*.

The *Kṣudrajantus* (Invertebrata) comprise—

- (I.) The *Krimis*, Vermes : (a) *Apâdikas* without lateral appendages (*cf.* Scolecids), (b) *Nâpurakas*, Annelids (a section), (c) *Gandûpadas*, Arthropoda (a section).
- (II.) The *Jalûkâs*, Leeches, of which twelve species are described, six venomous and six innocuous (*cf.* Suśruta's careful description, *Sûtrasthâna*, Chap. XIII.).
- (III.) *Kośasthas*, Shelled Animals, some forms of Mollusca, e.g. the *Śankhas* (Conchifera), the

Śuktikas (pearl-mussels), the *Sambukas* (spiral-shelled *Helix*), the *Voḍikas*, etc.

(IV.) Then the Insects, typified by the Ants, comprising—

- (a) *Pipīlikâ*, *Rohiṇikâ* (ants, Hymenoptera).
- (b) *Upachikâ*, *Kunthu*, *Tuburaka* (bugs and flies, Hemiptera).
- (c) Cucumber- and cotton-lice (Aptera).
- (d) *Śatapadî*, *Utpataka* (spring-tails, Aptera).
- (e) *Triṇapatra*, grass- or plant-lice (Aptera).
- (f) *Termites* (Neuroptera).

(V.) Insects typified by the Hexopoda, comprising—

- (a) *Bhramara*, *Varaṭa*, *Sâranga*, bees, wasps, and hornets.
- (b) *Makṣikâ*, *Puttikâ*, *Danśa*, *Maśaka*, flies, gnats, gadflies, and mosquitoes.
- (c) *Vriśchika* and *Nandyâvarta*, scorpions and spiders (Arachnida, Arthropoda).
- (d) *Kîta*, butterflies and moths; and
- (e) *Patanga*, grasshoppers and locusts.

Suśruta-Nâgârjuna names six varieties of ants, six varieties of flies, five of mosquitoes (including one marine and one mountain kind), eight varieties of *Śatapadîs* (centipedes), thirty varieties of scorpions, and sixteen of spiders (*Lutâs*). Of the *Kîtas*, the glow-worm and the *Tailakita* (*lit.* oil-worm) are said to be luminous (phosphorescent, *cf.* *Râjanighantu* राजानिघण्टु).

B.—The *Tiryakyonî* animals, sexually generated animals other than such of the *Ovipara* as are included under the *Kṣudrajantu*, in other words, sexually generated

animals possessing bones and blood—corresponding to the Vertebrata—comprise the following classes :—

I. *Andaja*, oviparous—

- (a) The *Matsyas*, fishes, divided into river-water fishes and sea fishes. Suśruta names eleven species of the latter. The *Timi* (whale?) is reckoned as a sea-fish. The *Makara* (shark) is also mentioned, but the *Kurmas*, *Kumbhîras*, and *Śiśumâras* (tortoises, crocodiles, and dolphins) are excluded from the class, as also the so-called shell-fish, being placed among the *Pâdinas* and the *Kôsthas* respectively.
- (b) The *Uragas*, apodal reptiles, including the *Sarpas* (snakes, Ophidia). Five classes of snakes are mentioned, one non-venomous, three venomous, and one hybrid. Eighty varieties of snakes are named, but the classification is based on superficial characters, e.g. markings on the scales, etc., and do not touch any anatomical peculiarities. The pathological observations regarding the distinct action of the poisons of different orders seem to be good.
- (c) *Bhujangas*, oviparous animals with lateral, pedal appendages, both Reptiles and Batrachians. Many of these are quadrupedal and five-clawed (चतुष्पादाः क्रीटाः पञ्चनखाः—Dalvana).

The *Bhujangas* include :—

1. *Godha*, *Grihagolika* and *Krikalâsa* (*Varantas* lizards, common lizards, and chameleons). Suśruta names four varieties of the

Kanava, a species of chameleon-like lizards (*cf. Lâdyâyana* quoted by Dalvana, *Kalpasthâna*, Chap. VIII.), also six varieties of *Galagolika* (a species of lizards), and five varieties of *Godheraka*, Varanus-like lizards, but smaller in size.

Suśruta mentions the frogs (*Udvijja*, eruptive or metamorphic?) after the quadrupedal and centipedal Reptilia (*Kanava*, *Godheraka*, *Galagolika*, and *Satapadî*). Eight species of frogs are named. The frogs are explained by the mythologist to have arisen from dirty water in the rainy season... प्रावृद्धकाले ततः (*i.e. महेश्वरसुम्नात्*) मण्डोदके जाताः (*cf. Dalvana, Kalpasthâna*, Chap. VIII.).

2. *Kûrmas* and *Nakras*, tortoises and crocodiles (*Chelonia* and *Emydosauria*, Reptilia). Some species of the former are oval, others elongated (बर्तुलदीर्घादिभेदाः).
3. *Śiśumâras*, the Delphinidæ (*Odontocete cetacea*).

Suśruta's *Pâdinas* (aquatic animals having pedal or long dorsal appendages) are a conventional class formed for practical dietary purposes, and include (2) and (3) and also the *Karkatas*, crabs (*Crustacea*). Umâsvati's *Bhujanga* class, being a natural sub-division of Vertebrates, does not include *Crustacea*, which are rightly placed among the Invertebrates.

- (d) *Lomapakṣa pakṣi*, winged animals with feathery wings, birds proper. These are oviparous, while the winged animals with leather wings (चर्मपक्षपक्षिणाः) are placentalia of the Deciduata class (पोतजाः).

The Birds proper are divided into four classes :—

- (1) *Plavas*, aquatic or amphibious birds, comprising the Natatores and the Grallatores. Various species are described.
- (2) *Viṣkiras*, those that scatter their food in picking up.
- (3) *Pratudas*, those that pierce or torment their food (fruits or grains).

The enumeration of the species under (2) and (3) shows that these two classes included the Passeres (veræ and so-called), the Scansores, the Rasores, and the Columbæ.

- (4) *Prasahas*, birds of prey proper (Raptors).

Dalvana's descriptions of deer and birds are precise, turning upon coloration, habits of life, etc., e.g. the descriptions of the Ruru, the Kârandava, and the Kanka, expressly quoted from some (unnamed) hand-books :—

कूलेचरमाह . . . हरुः शरदि शृङ्गत्यागी । तल्लक्ष्यं उच्यते—

“ विकटबहुविधायः शम्बराकारदेहः सलिलतटचरित्वात् सशरेभ्यः विविधः । तजति शरदि शृङ्गं रीति ”—इत्यसौ हरुः स्यात् ।

कारकवः शृङ्गसंभेदोऽस्यः अन्ये करहरमाहुः । उल्लख “ कारकवः काकवक्षो दीर्घाक्षिः कृष्णवर्षभाक् ” इति ।

प्रसहानाह . . . कङ्कः दीर्घचक्षुर्नहाप्रायः । उल्लं च “ कङ्कःस्यात् कङ्कनल्लास्यो वायव्यार्धपक्षकः । लोहपृष्ठो दीर्घपादः पक्षाधः पाकुवर्षभाक् । ” इति ।

The sources from which Dalvana derives detailed information about these varied forms of animal life are now unavailable, but these extracts abundantly testify to the minute Nature study of the Hindus.

The Hindus had of course no idea of an anatomical classification of birds.

The ancient writer Lâdyâyana had a much better idea of zoological description in reference to the *Kîtas* (insects and reptiles, *vide infra*).

II.—*Jarâyujas* (viviparous, *lit.* placentalia) in the usual wider sense, comprising—

(a) *Charmapakṣa pākṣis*, leather-winged animals, which are Decidua (*Potaja*). Charaka calls them *Mrigapakṣiṇa* (mammal birds), and distinguishes them from the birds of prey proper, in his enumeration of the *Prasahas* (*Sutrasthâna*, Chap. XXVII). The Bats mentioned are :—

(1) *Valguli* (flying-fox).

(2) The *Pakṣi Virâla* (flying-cat, micro-Chiroptera).

(3) The *Bharanda* (a species of micro-Chiroptera, the horse-shoe bat?).

(4) The *Jalukâ* (*lit.* aquatic or amphibious, or more probably leech, bat, blood-sucking or vampire bat?). These are placed among carnivorous animals.

(b) The *Vileśaya Jarâyujas*, mammals that live in holes or burrows, including various species of Rodents and Insectivora, which are named.

Eighteen different varieties of mice are specified (Súsruta, *Kalpasthâna*, Chap. VI.).

(c) *Parnamrigas*, arboreal mammals, comprising some Rodents (squirrels, etc.), a wild-cat, the sloths, and the apes (वानर).

(d) Non-carnivorous quadrupeds (अन्नखादाः) :—

(1) *Janghâlas* (*lit.* strong-legged quadrupeds, frequenting hilly and jungly tracts), comprising various species of deer (non-carnivorous wild animals, अन्नखादा).

(2) *Kulechara*, mammals grazing on the banks of rivers, and frequenting marshy places, comprising the elephant, the rhinoceros, the gaveya (*Bos gavæus*), the buffalo, the hog, and also several species of deer (which live in well-watered lands). These are also non-carnivorous (अन्नखादा).

(3) *Grâmyas* (*lit.* living in or near villages), non-carnivorous, domesticated quadrupeds, some with undivided hoof, others with cloven hoof, comprising the horse, the mule, the ass, the camel, the cow, the goat, the sheep, etc. These are all non-carnivorous. The dog and the cat are not mentioned in the list.

(e) Carnivorous quadrupeds, *Guhâsaya* (living in natural caves or hollows, carnivorous *Kravyâda*), comprising the lion, the tiger, the wolf (of the dog class), the hyena, the bear, the panther, the cat, the jackal, etc. The Carnivora were termed

Vyâlas or *Kravyâdas*, and the *Herbivora Pâsus*
(in a wider sense).

(f) Man.

The term *Jarâyuja*, in a wider sense, came to mean "viviparous," and included the above orders of animals. But the Jainas used the term *Jarâyuja* in a narrower sense to mean only those viviparous animals which come out at birth with the placenta (a-deciduata). The Deciduata (including the Proboscidea, the Rodentia, the Insectivora, the Chiroptera, etc.) were termed *Potaja*, *lit.* viviparous animals born without placenta. Man, the apes, and the Carnivora are, however, reckoned with the *Jarâyuja* (viviparous, born with placenta). Perhaps the afterbirth was observed in these cases, whereas the *Potajas* (Deciduata) may have been erroneously conceived to throw off no placenta (गर्भे जन्म, *supra*).

Lâdyâyana appears to have made a special study of the classification of *Kîtas* (Insects and Reptiles), and is quoted by Dalvana as a great authority on the subject.

The various forms (रूप) of *Kîtas* are to be distinguished from one another by peculiarities in the following marks :—

(1) Dottings or markings, (2) wings, (3) pedal appendages, (4) mouth, with antennæ or nippers (मुखाङ्गुली—Dalvana), (5) claws, (6) sharp, pointed hairs or filaments, (7) stings in the tail, (8) hymenopterous character (संज्ञितैः पक्षरोन्मिः), (9) humming or other noise, (10) size, (11) structure of the body, (12) sexual organs (this is how I interpret *linga* here), and (13) poison and its action on bodies.

Cf. ऋदुभिः विन्दुलेखाभिः पद्मैः पादैः मुसैः नसैः
 मूकैः ऋदुकलांगलैः संश्रितैः पद्मरोमभिः ।
 खनैः प्रमाथैः संस्थानैः लिङ्गैश्चापि शरीरजैः
 विषवीर्यैश्च कीटानां रूपज्ञानं विभाव्यते ॥

(Quoted from *Lādyāyana* by Dalvana, *Kalpasthāna*,
 Chap. VIII.)

CHAPTER VI.

HINDU PHYSIOLOGY AND BIOLOGY.

SECTION 1.

METABOLISM.

The food that we eat contains five classes of organic compounds. From their radicles or predominant elements, the substances are named Earth-compounds, Ap-compounds, Tejas-compounds, Vâyu-compounds, and Âkâsa-compounds. The Earth-compounds supply the hard, formed matter of the body, the Tejas-compounds give the animal heat (or the metabolic heat), the Vâyu-compounds are the sources of the motor-force in the organism, the Ap-compounds furnish the watery parts of the organic fluids, and the Âkâsa-compounds contribute to the finer etheric essence which is the vehicle of the conscious life

Roughly speaking, the Earth-compounds answer to the nitrogen compounds in the food, the Tejas-compounds to the hydro-carbons (heating-producing), and the Vâyu-compounds to the carbo-hydrates (dynamic). The Ap-compounds are the watery parts of food and drink. The flesh, for example, is a tissue composed principally of the Earth-compounds; the fat, of the Earth- and Ap-compounds; the bones, of Earth-, Vâyu-, and Tejas-compounds. Different operations of the metabolic

heat (perhaps different digestive fluids are also meant) are required to digest the different substances in the food.

The course of metabolism is described as follows. The entire alimentary canal is called the Mahâsrotas (the great channel).

The food goes down the gullet by the action of the bio-motor force, the *Prâna Vâyu*.

In the stomach (आमशय) the food becomes mixed up, first with a gelatinous mucus (प्लीहास्राव) which has a saccharine taste, and then gets acidulated by the further chemical action of a digestive juice (विदाहादहनी गतः, evidently the gastric juice is meant). Then the bio-motor force, the *Samâna Vâyu*, begins to act, and drives down the chyme, by means of the *Grahaṇi Nâdî*, to the *Pittâśaya* (duodenum, *lit.* bile-receptacle), and thence to the small intestines (the आमपक्वाशय). In these, the bile (or rather the digestive substance in the bile, as opposed to the colouring element) acts on the chyme and converts the latter into chyle (रस), which has at first a *katu* taste (pungency). This chyle contains in a decomposed and metamorphosed condition all the organic compounds, *viz.* tissue-producing Earth-compounds, water-parts or Ap-compounds, heat-producing Tejas-compounds, force-producing Vâyu-compounds, and lastly, finer etheric constituents which serve as the vehicle of consciousness. The essence of chyle (सूक्ष्मभाग) from the small intestines is driven by the bio-motor force, the *Prâna Vâyu*, along a Dhamanî trunk (*cf.* the thoracic duct), first to the heart (which is a great receptacle of chyle), and thence to the liver (and the spleen); and in the liver the colouring substance in

the bile acts on the essence of chyle, especially on the Tejas-substance therein, and imparts to it a red pigment, transforming it into blood; but the grosser part of chyle (स्थूलभाग) proceeds along the Dhamanîs, being driven by the bio-motor force, the *Vyâna Vâyu*, all over the body.

When the blood has been formed, the essence of chyle in the blood, acted on by *Vâyu* (bio-motor force) and *Mâmsâgni* (the flesh-forming metabolic heat), forms the flesh-tissue, the Earth-compound of the food-substance especially contributing to this tissue. Of the flesh-tissue thus formed, the grosser part goes to feed or replenish the flesh-tissue all over the body. The finer essence of flesh in the blood in the chyle, acted on again by *Vâyu* (bio-motor current) and the fat-forming metabolic heat (नेदोऽग्नि) in the menstruum of lymph (कषयं सनाश्रित), receives viscosity and whiteness, and produces the fatty tissue, the Earth-compounds and Ap-compounds of the food specially contributing to the product. This fat in the chyle (or blood), or rather the grosser part of it, replenishes the fatty tissue of the body, but the finer essence of fat in the flesh in the blood in the chyle, acted on by *Vâyu* (bio-motor current) and the marrow-forming metabolic heat, in the menstruum of lymph (श्लेष्मकावृत्त), becomes hard (crystalline) and forms bone, the Earth-, *Vâyu*-, and Tejas-compounds contributing principally to the product. The essence of the fat fills the hollow channels of the bones, and acted on again by bio-motor *Vâyu* and metabolic heat, becomes transformed into marrow. The marrow is similarly transformed into the semen, which is con-

veyed down by means of a pair of *Dhamanîs* or ducts (द्वे शुक्रवाहे), lodged in its receptacles (शुक्रधरा—वृषली), and discharged by means of another pair of ducts (द्वे विसर्गाय). The semen, or rather all the elements in their finer essence, give off *ojas*, which returns to the heart, the receptacle of chyle and blood, and again floods the body and sustains the tissues, thus completing the wheel or self-returning circle of metabolism (परिवृत्तित्तु चक्रवत्, cf. Charaka and Vāgbhata).

It is to be noted that, throughout, the fluid in the chyle or blood acts as the menstruum, though occasionally the lymph, which is itself a derivative from the chyle, is added, as in the case of the fatty tissue and the bones; and that each preceding element or constituent of the body (धातु—शरीरात्मक धातु) takes up the proper organic compounds from the food chyle to form the next element or tissue. Throughout, also, the chemical changes are due to the metabolic heat which breaks up the compounds and recombines, but the operations, and even the vehicles perhaps, of this heat are different. For example, these heat-corpuscles in the biliary ducts produce the bile, but the bile-secretion is supposed to contain two distinct substances: (1) a digestive fluid in the duodenum (पित्ताज्ञय), which acts on the chyme to produce the chyle (अन्नस्य पक्व पाचकाख्यं पित्तं); and (2) a colouring bile-substance in the liver, which adds a red pigment to the chyle and transforms it into blood (रक्तकाख्यं पित्तं). Besides, there are three other biles, of which the aqueous humour in the eye is supposed to be one (आलोककं पित्तं), helping in the formation of visual images (रूपग्राहकं). This is the view of Dhanvantari and

his school, but Âtreya holds there is no evidence that the bile really performs the first (digestive) function, for this can be accounted for by the animal heat arising from the working of the whole bodily machine.

There are three different hypotheses regarding the course of metabolism and the successive transformations of the chyle (खीरदधिन्याय—केदारीकुल्यान्याय—खलेकपोतन्यायेति त्रिधा धातुषोषणक्रमः—Chakrapâni, Bhânumatî, Sûtrasthâna, XIV., 10; also his commentary on Charaka, Sûtrasthâna, XXVIII.), but my account is based on the second hypothesis, which has the preference of Chakrapâni (स्वरसः). It may be added as a curiosity that each element of the body (धातु) under the metabolic heat is supposed to give off a finer essence (सूक्ष्मभाग), which serves as the material of the next succeeding element, and a dross (मल), which forms some of the excreta in the body (including the nails, the hair, etc.), besides retaining its own substance (the gross or main part), which is driven along by the *Vâyas* (bio-motor or vital currents), or by the *Śrotas*, to its destination in the body.

Some idea of *circulation* appears to have been entertained, for the heart which receives, and then sends down the chyle through the *Dhamanîs*, gets it back transformed into blood, and the *ojas* also proceeds from the heart and returns to it along with the chyle and the blood.

(*Cf.* Vâgbhata, ताः दुग्धस्याः शिराः रसात्मकं स्रोतः सन्निवहन्त्यः) । पच्यभूतात्मके देहे आहारः पाच्यभौतिकः । विपक्वः पच्यथा सम्यग् गच्छान् खानभिषङ्गयेत् ।—Suśruta, *Sûtrasthâna*, Ch. XLVI. ; *cf.* also विद्यत्पचनजाताभ्यां वृद्धिमाप्नोति मारुतः । आग्नेयमेव यद्द्रव्यं तेन पिशुमुदीर्यते ।—*Ibid.*, Ch. XLI. भौजाप्याग्नेयवायव्याः पचोष्माद्यः सनाभसाः । पचाहा-

एगुणान् खान् खान् पार्थिवादीन् पचन्त्यनु । यथासं ते च पुष्कानि पक्वा
भूतगुणान् पृथक् । पार्थिवाः पार्थिवानेव शेषाः शेषाञ्च देहगान् । अतिरिक्त्वा
गुणा रक्ते बह्वेमीषे तु पार्थिवाः । मदस्यर्षा भुवश्चास्विन् पृथिव्यनिलतेजसा ।—
Charaka quoted by Dalvana. आदी बह्वरसमयज्ञं मधुरीभूतमीरयेत्,
प्रेणीभूतं कर्षं यातं विदाहादद्गतां गतः । वायुना समानास्थेन ग्रहणीमभिनीयते ।
बहि पित्रधरा नाम या कला परिकीर्तिता । आमपक्वाशयान्तःस्था ग्रहणी
साऽभिधीयते । अग्न्यधिष्ठानमक्षस्य ग्रहणाद् ग्रहणी मता । भुक्तमाणाशये रूक्षा
सा विपाच्य नयत्यधः । बलवत्यबला त्वन्नमानमेव विमुञ्चति । . . . अन्नस्य पक्व
पित्रन्तु पाचकास्यं पुरेरितम् । दोषधातुमलादीनामुष्मेत्याचेयज्ञासनम् । . . .
तेजोरसानां सर्वेषामम्बुजानां यदुच्यते, पित्रोऽप्यथा सरागेण रसो रक्तत्वमृच्छति ।
वाय्वग्नितेजसा युक्तं रक्तं मांसत्वमृच्छति । श्लेष्मास्यं च समान्नाय मांसं वाय्वग्नि-
संयुतम्, स्थिरतां प्राप्य शीकल्यं च मेदो देहेऽभिजायते । पृथिव्यग्न्यनिलादीनां
सङ्घातः श्लेष्मणावृतः, सत्त्वं प्रकरोत्यस्य जायतेऽस्य ततो नृणाम् । करोति तत्र
सौधियेमस्थानां मध्ये समीरणः । मेदसा तानि पूर्वमे ज्ञेहो मञ्जा ततः स्मृतः ।
तस्मान्मज्जश्च यः ज्ञेहः शुक्रं संजायते ततः ।—Charaka-Dridhavalā
Samhitā quoted by Aruṇa in his commentary on
Vāgbhata.)

यथा केदारनिवर्तं कुल्याजलं प्रत्यासन्नां केदारीमाप्नावयति । तथा रस एव
प्रथमं रक्तं ज्ञावयति । तत्र रक्तस्थानसम्बन्धात् रक्तसादृश्यं रक्त्यपेक्षञ्च अनु-
भवति । रक्तं च रक्तस्थानेन स्तोत्रेनांशेन अन्नं पोषयति । ततो रक्तमाप्नाप्य
मांसमाप्नावयति, एवमुत्तरोत्तरधातून् रसएव ज्ञावयति । (Chakradatta,
Bhānumati). This passage shows that the “venous
blood” was conceived to be chyle-essence mixed with
blood, and that the circulation of the chyle, so far as it
was held to contribute its quota to the constituent
elements and tissues of the body, was really supposed
to be identical with the circulation of the blood (ततो
रक्तमाप्नाप्य मांसमाप्नावयति). This will be abundantly clear
from the following account of the course of the chyle
and the blood :—

ततः सारभूतस्याहाररसस्य द्वौ भागौ भवतः । स्यूलः सूक्ष्मश्च . . . ततः

सूक्ष्मोभागः प्राणवायुनाप्रेरितो धमनीमार्गेण शरीरारम्भकस्य रक्तस्य स्थानं यकृत्-प्रीहृदयं गत्वा तेन सह मिलितोभवति । ततः प्राक्तनरक्तपातो एव तिष्ठति । . . . ततः सारभूतस्य आहाररसस्य द्वौ भागौ भवतः । स्थूलः सूक्ष्मश्च । स्थूलो भागो रज्ज्कास्थेन पिप्पेन रक्तीकृतः शरीरारम्भकं रक्तं पोषयन् स्थान-वायुना प्रेरितो धमनीभिः सञ्चरन् सकलशरीरगतानि हृथिराणि पुष्पाति । ततः सूक्ष्मोभागः स्थानवायुनाप्रेरितो धमनीभिः शिराभिश्च शरीरारम्भकाणि नांसानि याति । *et seq.*

This finer essence of chyle which nourishes the flesh is also carried in the blood, on the irrigation channel hypothesis (केदारी-कुल्यान्याय).

SECTION 2.

THE CIRCULATORY SYSTEM.

The standing puzzle of Hindu anatomy and physiology is the classification of the *Śirās*, *Dhamanîs*, and *Śrotas*, the channels, passages, and ducts in the body including the arteries, veins, nerves, lymphatic vessels, etc. The difficulty was felt by the ancient observers themselves. Some were of opinion that the *Dhamanîs* and *Śrotas* are only modifications of the *Śirās*, and that the division is artificial. Suśruta, however, contends that they are distinct, because they can be traced to different roots and have different functions; they are apt to be confounded only because they are minute, juxtaposed, and similar in function (Suśruta, *Śârîrasthâna*, Chapter IX.). Charaka also accepts the established division, but points out that the numbers as estimated are conjectural (अनिर्देश्यमतः परं तर्कमेव, *Śârîrasthâna*, Chapter VII.).

The *Śirās*, *Dhamanîs*, and *Śrotas* form networks

(जालानि) of cords, fibres, passages, which in the foetus take their rise from the umbilical cord, and proceed upwards to the heart and head, downwards to the kidneys and rectum, and outwards to the trunk and limbs. These three classes comprise all the vehicles or conductors of the fluids, secretions, and currents in the bodily system.

The *Śrotas* (currents). This is a peculiarity of Hindu physiology. The chyle, the blood, the *Vāyu*, the metabolic fluid (रिक्), the lymph, the fat, the marrow, in every part of the body, is supposed to be connected by means of subtle currents (*Śrotas*) with the same kind of fluid (or tissue) in every other part. Without supposing such special connections, many pathological phenomena cannot be explained.

The *Śirās* are divided into four groups: (1) the arteries for conducting the blood, (2) the lymphatics for conducting the lymph, (3) a class of bile-ducts, and (4) a class of ducts for the *Vāyus*, the currents which work the automatic and reflex machinery of the living organism. In each group there are 10 trunk *Śirās*, which sub-divide into 175 cords, and further ramify minutely all over the body, even as a network of minute fibrils covers the leaf of a tree.

The functions of the different groups of *Śirās* are to conduct or transmit the (arterial) blood, the lymph, the bile, and the (vital) *Vāyu* currents respectively to the different parts of the body. The *Śirās* are compared to the conduits of the flowing water in a pleasure-house (a garden), or the channels of irrigation that flood a field. The conduction (or transmission) of the fluids and

currents is effected by an alternate dilation and contraction of the vessels, the systolic movement differing according to the nature of the fluid propelled :

सप्त शिराश्चतानि भवन्ति याभिरिदं शरीरमाराम इव जलहारिणीभिः
केदारद्वयं च कुल्याभिरुपप्लवसते अनुगृह्यते च आकुञ्चनप्रसारणादिभिर्विशेषैः ।
दुग्धपञ्चशेवनीनामिव तासां प्रतानाः । तासां नाभिमूर्ध्नि ततश्च प्रसरन्मूर्ध्नि च
स्तिर्यक् च । तासां मूलशिराश्चत्वारिंशत् । तासां चातवाहिन्यो दश पिप्पवा-
हिन्यो दश कफवाहिन्यो दश दश रक्तवाहिन्यः—Suśruta, *Sârîrasthâna*,
Chap. VII.

The *Dhamanîs* in the foetus take their rise from the umbilical cord, thus bringing nourishment from the mother. They are divided into three groups: (a) ten trunks or cords going up to the heart, and thence to the head, (b) ten going down to the intestines, kidneys, and rectum, and (c) four branching obliquely or sidewise, and ramifying over the whole body. In a general way, it may be stated that the *Dhamanîs* comprise (1) the veins, (2) the nerves (including the sympathetic system), (3) the chyle-ducts (including the thoracic duct?) as distinguished from the other lymphatics, which are mostly classed as *Sîrîs*, (4) the ducts for urine, sweat, and other secretions, and (5) lastly, certain classes of bile-ducts and conductors of *Vâyu* currents, possibly those connected with the venous system and the chyle-ducts.

The first group of *Dhamanîs*:—Special features: Each of the ten ascending *Dhamanîs*, on reaching the heart, trifurcates, and proceeds to the head. Of these fibres, one pair is engaged in conducting each of the four sensory currents (those of sound, colour, taste, and smell) from the sense-organs, as *Charaka* and *Suśruta*

must have supposed, to the heart, which is for them the seat of consciousness (हृदये विशिष्येण चेतनास्थानम्, Suśruta, Śârîrasthâna, Chap. IV.; हृदये चेतनाधिष्ठानमेकम्, Charaka, Śârîrasthâna, Chap. VIII.). Other *Dhamanîs*, also in pairs, are engaged in conducting automatic (or voluntary) motor currents (e.g. the currents concerned in respiration, yawning, sleeping and waking), or the secretions of the lachrymal and mammary glands.

The second group of *Dhamanîs* :—Special functions : The descending *Dhamanîs* go down to the intestines, kidneys, bladder, and rectum, and their special function is to convey, in pairs as before, urine and other secretions and excreta. They also convey the chyle from the small intestines to the ascending as well as the ramifying *Dhamanîs*. In addition, some of them convey sweat to the ramifying *Dhamanîs*.

The third group :—Special functions : The remaining four *Dhamanîs* ramify obliquely over the body into millions of fibres and fibrillæ, which terminate in the pores of the skin. From all parts of the periphery they conduct the sensory currents of touch to the central organ of the heart (including the internal organic sensations). Being connected with the pores of the skin, they conduct sweat outwards, and the influences of baths, embrocations, and fomentations inwards.

Other *Dhamanîs* serving as chyle-ducts and as (venous) blood-vessels.—Besides the special functions performed by the three groups, there are two characteristic functions common to certain classes of *Dhamanîs* which are found in all the three groups, viz. the conduc-

tion of chyle and of (venous) blood, *i.e.* of impure blood before it gets its red pigment from the liver. It may also be added that the three principal elements of the body—*Vāyu* (vital current), *Pitta* (bile, or rather the fluid animal heat which produces metabolism, पाक, and flows to all the parts of the body by means of connective passages), and *Kapha* (lymph)—make use of the *Dhamanîs* as well as the *Sirâs* and *Śrotas*, *i.e.* of all manner of conductors in the organism (*cf.* Charaka, वातपित्तश्लेष्मणां पुनः सर्वज्ञरीरचराणां सर्वाणि श्रोताणि जयनभूतानि—*Vimānasthāna*, Chapter V.).

The functions of the *Sirâs* may therefore be stated as follows :—

(1) The conduction of blood from the liver and spleen, red blood (what may be called the arterial blood of this system of physiology), to the heart, head, trunk, limbs, etc.

(2) Common functions of all connective passages, *viz.* the conduction of *Vāyu* (vital current), *Pitta* (metabolic fluid), and *Kapha* (lymph).

The different classes of *Dhamanîs*, with their functions, are :—

(1) The nerves : (a) eight sensory (central) nerves for the four special senses other than touch ; (b) twelve motor nerves partly for voluntary and partly for automatic movements ; and (c) the nerves of touch and organic sensation, including the sympathetic nerves.

(2) and (3) The chyle-ducts and the conductors of (venous) blood before it is transformed into blood in the liver (and the spleen).

(4) The classes of *Dhamanîs*, which, in common

with the *Śirâs* and *Śrotas*, conduct *Vâyu*, *Pitta*, and *Kapha*, the prime movers of the organic life.

THE VASCULAR SYSTEM.

The anatomical arrangement of the *Śirâs* and *Dhamanîs* in Charaka and Suśruta is so obscure that only a rough outline of its general features can be attempted. In fact, Charaka contents himself with giving the number of *Śirâ* cords as 700, and of *Dhamanî* cords as 200. He also estimates the ramifications as numbering 3,056,900.

The carriage of the blood and the lymph is accomplished by two sets of vessels, *Śirâs* and *Dhamanîs*, the first standing for "arteries" (with capillaries) and lymphatics (other than chyle-ducts), and the second for "veins" and chyle-ducts (as well as certain passages for sweat, etc.).

The navel in the foetus is taken to be the source and origin of the entire vascular system, whether for the blood or the lymph. Vâgbhata takes the heart to be the origin of the *Śirâs*.

From this central alimentary tract two sets of vessels (*Śirâs* and *Dhamanîs*—*Rasavâhinyah*) issue for the flow of the chyle and other lymph, and two sets (*Śirâs* and *Dhamanîs*, "arteries" and "veins"—*Raktavâhinyah*) for the flow of the blood.

The Lymph (and Chyle): Distribution.—The chyle is conducted by the chyle-bearing *Dhamanîs* (*Rasavâhinyah*), and the lymph (other than chyle) by the lymph-bearing *Śirâs* and *Dhamanîs* (*Kaphavâhinyah*).

The lymph-bearing *Sirâs* comprise 10 branches at the origin, and ramify into 175—viz., 25 in each leg, 25 in each arm, 8 in the pelvic cavity, coccyx, penis, etc., 2 in each side, 6 in the back, 6 in the abdomen, 10 in the breast, 14 in the neck, 2 in the ears, 9 in the tongue, 6 in the nose, and 10 in the eyes.

The chyle is carried by another system of vessels (*Rasavâhinyah Dhamanyah*). The chyle-ducts issue from the *Navî* (possibly the receptaculum chyli in this case). A *Dhamanî* trunk descends to the small intestine, and, taking up the chyle, proceeds upwards towards the heart (thoracic duct?). Two chyle-ducts as well as two lymph-ducts (*Dhamanîs—Rasavâhinyah* and *Kaphavâhinyah*) proceed from the heart, and ramify over the head and trunk. Similarly two chyle-ducts and two lymph-ducts proceed from the intestinal tract and ramify over the pelvic region. Four obliquely branching *Dhamanîs* (bearing chyle, sweat, and internal secretions) also spread from the central tract, and ramify in numberless minute channels over the limbs and the body.

The Blood-vascular System.—There are two classes of blood conductors: (1) *Sirâs*, which break up into capillaries (*Pratân*) and distribute “pure” blood from the liver (and spleen) to the heart, and from the heart to the rest of the body (*asrigvahâscha rohinyah sirâh nâtyuṣṇasâtâlâh*,—*Sûsruta*, *Sârîrasthâna*, Chap. VII.; cf. *Vâgbhata*: *daśa mûlasîrâh kṛitsthâh*, Chap. III., *Sârîrasthâna*), and (2) *Dhamanîs* (*Raktavâhinyah*), which proceed, two from the intestinal tract (portal

vein and inferior vena cava), and two from the heart (superior vena cava and pulmonary artery?).

The "venous" blood (chyle-mixed blood) proceeds from the alimentary tract (gastric and intestinal vessels), along a *Dhamanî* trunk (portal vein?) to the liver (and spleen), where the chyle gets a red pigment and is turned into (pure) blood. From the liver and spleen, *Śirâs* ("arteries") proceed to the heart. The liver (and spleen, a minor blood-vascular gland) and the heart are the centres of origin of the *Śirâs* ("arteries"), and distribute pure blood by their means over the entire body.

Arrangement of the blood-bearing *Śirâs* and *Dhamanîs*. — Two blood-bearing *Dhamanî* trunks ("veins") proceed from the heart (superior vena cava and pulmonary artery?), and two proceed from different regions of the alimentary tract (portal vein and inferior vena cava?). Ten *Śirâs* bearing pure blood proceed from the alimentary tract to the liver and spleen, which are joined on to the heart by means of both *Śirâs* and *Dhamanîs*. The ten *Śirâs* are subdivided into 175 branches, which are distributed over the body in the same way as the lymph-bearing *Śirâs* (*vide supra*).

It is clear that Charaka and Suśruta had no idea of the part played by the lungs in the purification of the blood. The liver converts the "venous" blood in this system into true ("arterial") blood, and along with the spleen serves as a basis of discrimination between a *Śirâ* and a *Dhamanî*, thus illustrating Suśruta's statement that the distinction between these two kinds

of blood-vessels must be accepted as real, inasmuch as they have different sources and different functions.

तासानु नाभिप्रभवानी धमनीनामूर्द्ध्वेगा दश दश चाधोगाभिन्यस्त-
 स्रस्त्रियेगाः ऊर्ध्वेगास्तु हृदयमभिप्रपन्ना पित्ताशय-
 मभिप्रतिपन्नास्तत्रस्थमेवाक्षपानरसं विपञ्चं औष्ण्याद् विरेचयन्तः अभिवहन्तः
 शरीरं तर्पयन्ति चोर्ध्वेगातानां त्रियेगगतानां रसस्थानमभिपूरयन्ति (Suśruta,
 Śārīrasthāna, Chap. IX.) तत्र पाचभीतिकस्य आहारस्य सम्यक्
 परिचातस्य यस्तेजोभूतः सारः परमसूक्ष्मः स रस इष्यते । तस्य च हृदये स्थानम् ।
 स हृदयाच्चतुर्विंशतीः धमनीरनुप्रविश्य ऊर्ध्वेगा दश दश चाधोगाभिन्यस्त-
 स्रस्त्रियेगाः कृत्स्नं शरीरं अहरहस्तर्पयति । तस्य शरीरमनुभावतोऽनुमानाद्
 गतिरूपलक्षयितव्या । स सत्याप्योरसः यकृतमीहानी प्राप्य रागमुपैति । (Ibid.,
 Chap. IV.) रंजितास्तेजसास्त्वापः शरीरस्थेन देहिनां रक्तमित्यभिधीयते ।
 (Ibid., Sutrasthāna, Chap. XIV.) समशिराशतानि भवन्ति ।
 याभिरिदं शरीरम् आराम इव जलहारिणीभिः केदार इव कुल्याभिरुपचिक्षते
 चाकुचनप्रसारणादिभिर्विश्लेषैः । नाभ्यां सङ्घा निषङ्गास्ताः प्रतन्वन्ति समन्ततः ।
 तासां मूलशिराः चत्वारि शृङ्गासां वातवाहिन्यो दश पित्तवाहिन्यो दश कफवा-
 हिन्यो दश दश च रक्तवाहिन्यः । तासानु वातवाहिनीनां वात स्थानगतानां
 पञ्चसप्ततिशतं भवति । रक्तवाहिन्यश्च यकृतपीहोरेव । तत्र वातवाहिन्यः शिराः
 एकस्मिन् सकृदि पञ्चविंशतिः । एतेन इतरसकृदिपाहू च व्यास्याती । विशेषतस्तु
 कोष्ठे पृष्ठे चोदरे वक्षसि जजुषः ऊर्ध्वं । एवं रक्तवहाः कफवहाश्च । धातूनां पूरकं
 वर्यं स्पृशंज्ञानमसंज्ञयम् । स्थाः शिराः सत्त्वरद्रक्तं कुर्व्याचान्यान् गुणानपि
 (Śārīrasthāna, Chap. VIII.) द्वितीया (कला) रक्तधरा नाम ।
 तस्यां श्लोकितां विशेषतस्तु शिरासु यकृतं मीहोश्च भवति (Ibid., Chap. IV.)
 चण्डी (कला) पित्तधरा नाम । चतुर्विधमन्नपानमुपयुक्तमामाशयात् प्रच्युतं पञ्चाश-
 योपस्थितं धारयति । श्रोतस्वद् विज्ञेयं शिराधमनीवर्जितं । ... तानि (श्रोतांसि)
 प्राणान्नोदकरसरक्तमांसनेदोमूत्रपुरीषशुक्रार्णववहानि । तत्र प्राणवहे ह्ये । तयोर्द्वैलं
 हृदये रसवाहिन्यश्च धमन्यः । उदकवहे ह्ये । तयोर्द्वैलं तालु ज्ञोन (Kloma,
 gall-bladder) च । तत्र विद्धस्य पिपासा । अन्नवहे ह्ये । तयोर्द्वैलं आमाशयः
 अन्नवाहिन्यश्च धमन्यः । रसवहे ह्ये । तयोर्द्वैलं हृदये रसवाहिन्यश्च धमन्यः ।
 रक्तवहे ह्ये । तयोर्द्वैलं यकृतमीहानी रक्तवाहिन्यश्च धमन्यः । मांसवहे ह्ये ।
 तयोर्द्वैलं आयुत्वर्षं रक्तवाहिन्यश्च धमन्यः ।

SECTION 3.

THE NERVOUS SYSTEM IN CHARAKA.

The Nerves.—*Dhamanîs* as nerves : The anatomy of the nervous system in Charaka and Suśruta can be more clearly and confidently restored. The *Dhamanîs* that ascend from the heart divide into thirty cords, of which twenty, *i.e.* ten pairs, are cranial nerves, and the other ten, or five pairs, are engaged in conveying vital currents, metabolic fluid, lymph, blood, and chyle.

The cranial nerves are : (1) four pairs of sensory nerves carrying sensory impulses from the sense-organs to the heart, *viz.* the optic, auditory, olfactory, and gustatory nerves, and (2) six pairs of motor (or mixed nerves), *e.g.* three pairs of motor nerves for the eye (*Moteres oculorum*, Pathetic and Abducentes) working the Levator Palpebræ and other muscles of the orbit ; one pair of motor nerves for articulation (the Hypoglossal) ; one pair of motor nerves for the larynx (the Pneumo-gastric), and another pair connected with mammæ and (in the case of the male) the seminal duct. It is further stated that other motor or sensori-motor impulses are carried by some of these cranial nerves, *viz.* those which produce sighs and sobs, yawning, laughter, and hunger. Evidently some of the functions of the pneumogastric and the spinal accessory nerves are intended, as also of the phrenic and other nerves of the cervical plexus.

Of the thirty descending *Dhamanîs*, ten (or five pairs) are conductors of blood, chyle, vital current,

metabolic fluid, and lymph, and the remaining twenty are spinal nerves (specially the nerves of the sacro-coccygeal and sacral plexuses, if not also of the lumbar plexus). The obliquely branching *Dhamanîs*, so far as they are nerves, comprise the brachial and the lumbar plexus, and divide and sub-divide hundred-fold, thousand-fold, till they ramify into fibrillæ round the pores of the skin. They carry to the heart cutaneous sensations, external as well as internal. A fibril (सूक्ष्मनाडी) is said to be as minute as the thousandth part of a hair (ल्लोमः सहस्रभागेन तुत्यासु प्रचरत्ययुः—*Panchadaśī*).

ऊर्ध्वगाः शब्दरूपरसगन्धप्रश्वासोष्वासविजृम्भितक्षुद्धसितकषितरुदितादीन्-
विशेषान् अभिवहन्त्यः शरीरं धारयन्ति । तास्तु हृदयमभिप्रतिपन्नास्त्रिधा जायन्ते
तास्त्रिंशत् । तासानु वातपित्तकफशोणितरसान् द्वे द्वे वहतस्ता दश । शब्द-
रूपरसगन्धान् अष्टाभिर्गृह्णीते । द्वाभ्यां भाषते । द्वाभ्यां चोषं करोति । द्वाभ्यां
स्वपिति । द्वाभ्यां प्रतिबुध्यते । द्वे च अक्षुवाहिन्यौ । द्वे स्नानसंभ्रिते । ते एव
शुक्रं नरस्य स्नानाभ्यां अभिवहन्तः ।

तिथ्यैर्गंगानानु चतसृणां धननीनां एकैका शतधा सहस्रधा चोत्तरोत्तरं
विभज्यन्ते तास्त्वसंस्थेयाः ।

ताभिरिदं शरीरं गवाक्षितं तासां मुखानि रोमकूपप्रतिपद्धानि । येः
स्वेदनभिवहन्ति रसञ्चापि सन्तर्पयन्ति अन्नर्षेहिष्ठ । तैरेव चाभ्यङ्गपरिचेकावगा-
हालेपनवीर्यैश्चि अन्नःशरीरमभिप्रतिपद्धाने । त्वपि विपद्धानि तैरेव स्पृशेसुस-
नसुषं वा गृह्णाति । तास्तु एताश्चतस्रोधनन्यः सर्वैरङ्गताः सविभागा आख्याताः ।
(*Suśruta, Śārīrasthāna, Chap. IX.*)

SECTION 4.

THE NERVOUS SYSTEM AFTER THE TANTRAS— PSYCHO-PHYSIOLOGY.

In Charaka and Suśruta (as in Aristotle) the heart is the central organ and seat of consciousness ; but in

the Tantric writings (as in Galen) the seat of consciousness is transferred to the brain or rather the cerebro-spinal system. The soul (the *Jiva*) has its special seat within the *Brahmarandhra* above the foramen of Monro and the middle commissure, but traverses the whole cerebro-spinal axis, up and down, along the *Suṣumna* (the central passage of the spinal cord). The *Brahma-danda* (vertebral column) contains the *Suṣumna*, the *Brahma Nāḍī*, and the *Manovahâ Nāḍī*. The cerebro-spinal axis with the connected sympathetic system contains a number of ganglionic centres and plexuses (*Chakras*, *Padmas*) from which nerves (*Nāḍīs*, *Śīrās*, and *Dhamanīs*)¹ radiate over the head, trunk, and limbs.

SECTION 5.

GANGLIONIC CENTRES AND PLEXUSES (SYMPATHETIC-SPINAL SYSTEM).

Beginning with the lower extremity, the centres and plexuses of the connected spinal and sympathetic systems may be described as follows:—

(1) The *Adhâra Chakra*, the sacro-coccygeal plexus, with four branches, eleven *angulis* (about nine inches) below the solar plexus (*Kanda*, *Brahmagranthî*); the source of a massive pleasurable æsthesia, voluminous organic sensations of repose. An inch and a half above

¹ The writers of the Yoga and Tantra schools use the term *Nāḍī*, by preference, for nerves. They also mean cranial nerves when they speak of *Śīrās*, never using the latter term for arteries, as in the older medical literature.

it, and the same distance below the membrum virile (*Mehana*), is a minor centre called the *Agni-sikhâ*.

(2) The *Svâdhisthâna Chakra*, the sacral plexus with six branches (षष्ठाङ्गि, दलानि—leaves), concerned in the excitation of sexual feelings with the accompaniments of lassitude, stupor, cruelty, suspicion, contempt.

(3) The *Nâvikanda* (corresponding to the solar plexus, *Bhânubhavanam*), which forms the great junction of the right and left sympathetic chains (*Pingalâ* and *Idâ*) with the cerebro-spinal axis.

Connected with this is the *Mañipuraka*, the lumbar plexus with connected sympathetic nerves, the ten branches of which are concerned in the production of sleep and thirst, and the expressions of passions like jealousy, shame, fear, stupefaction.

(4) The *Anâhata Chakra*, the cardiac plexus of the sympathetic chain, with twelve branches, connected with the heart, the seat of the egoistic sentiments, hope, anxiety, doubt, remorse, conceit, egoism, etc.

(5) The *Bhâratîsthâna*, the junction of the spinal cord with the medulla oblongata, which, by means of nerves like the pneumo-gastric, etc., regulates the larynx and other organs of articulation. This also comprises the laryngeal and pharyngeal plexuses.

(6) The *Lalanâ Chakra*, opposite the uvula, which has twelve leaves (or lobes), supposed to be the tract affected in the production of ego-altruistic sentiments and affections like self-regard, pride, affection, grief, regret, respect, reverence, contentment, etc.

(7) The sensori-motor tract, comprising two Chakras, (a) the *Âjnâ Chakra*, lit. the circle of command (over

movements), with its two lobes, and (b) the *Manaschakra*, the sensorium, with its six lobes (five special sensory for peripherally initiated sensations, and one common sensory for centrally initiated sensations, as in dreams and hallucinations).

The *Ājnāvahā Nāḍīs*, efferent or motor nerves, communicate motor impulses to the periphery from this *Ājnā Chakra*, this centre of command over movements; and the afferent or sensory nerves of the special senses, in pairs, the *Gandhavahā Nāḍī* (olfactory sensory), the *Rupavahā Nāḍī* (optic), the *Śavdāvahā Nāḍī* (auditory), the *Rasavahā Nāḍī* (gustatory), and the *Sparaśavahā Nāḍī* (tactile), come from the periphery (the peripheral organs of the special senses) to this *Manaschakra*, the sensory tract at the base of the brain. The *Manaschakra* also receives the *Manovahā Nāḍī*, a generic name for the channels along which centrally initiated presentations (as in dreaming or hallucination) come to the sixth lobe of the *Manaschakra*.

(8) The *Somachakra*, a sixteen-lobed ganglion, comprising the centres in the middle of the cerebrum, above the sensorium; the seat of the altruistic sentiments and volitional control, e.g. compassion, gentleness, patience, renunciation, meditateness, gravity, earnestness, resolution, determination, magnanimity, etc.; and lastly

(9) The *Sahasrâra Chakra*, thousand-lobed, the upper cerebrum with its lobes and convolutions, the special and highest seat of the *Jiva*, the soul.

गुह्यलिङ्गान्तरे चक्रमाधाराख्यं चतुर्वैलम् । परमः सहजः . . . ज्ञानन्दः . . .
स्यादेशानादिदले फलं । साधिज्ञानं लिङ्गमूले षट्पञ्चं चक्रमस्यच । पूर्वादिपु
दलेषु फलानि यतानि प्रथमः कूर्ता . . . नूर्त्ता . . . अवहा स्यादधिष्ठातः

कामशक्ते रिदं गृहम् । नाभी दशदलं चक्रं त्रिपुरसंज्ञं । सुषुम्निरथ नृश्या
स्यादीर्घा ... लज्जा भयं घृणा मोहः ... क्रमात् पृष्ठादि दलेषु स्यात्
भानुभवनञ्च तत् ।

हृदये अनाहतं चक्रं । दलैर्द्वादशभिर्भुजैः । लील्यं कापठ्यं पितृर्कोऽप्यनुता-
पिता आशा ... चिन्ता ... दम्भोवैकल्यं विवेकोऽङ्कृतिस्तथा फलान्येतानि ।
कश्यपेऽस्ति भारतीस्थानं षोडशचक्रं तत्र प्रणव उद्गीतः सप्त स्वरा षड्मादयः ।
ललनास्थं षष्टिकायां चक्रं द्वादशपत्रकं । दमोमानस्ततः खेहः शोकः खेदश्च
सम्भ्रमश्चोन्मिः अज्ञा तोषोऽपराधिता फलानि ललनाचक्रे । भूमध्ये द्विदलं चक्रं
आशासंज्ञं फलानि च आविर्भावाः सत्त्वरजस्तमसां । तत्र चास्ति मनश्चक्रं
षड्दलं तत्फलानि तु स्वप्ने रसोपयोगश्च त्रायं रूपोपलम्भनं स्वप्नं
शब्दबोधश्च पृष्ठादिषु दलेषु । ततोऽपि षोडशदलं सोमचक्रं । दलेषु षोडश
तस्य कलाः षोडश संस्थिताः । कृपाय मार्त्तवं वैश्वं वैराग्यं धृतिस्मयदौ
हास्यं रोमाञ्चं विनयो ध्यानं सुस्थिरता ततः । गाम्भीर्यं मुखमोऽङ्घोभनीदार्य-
कायहे क्रमात् । फलान्युद्यन्ति जीवस्य पृष्ठादिदलगाभिनः । चक्रं सहस्रपत्रनु
ब्रह्मरन्ध्रे । सुषुम्नया ब्रह्मरन्ध्रमारोहत्यवरोहति । जीवः प्राणसमारूढो रज्ज्वा
कोलाटिको यथा । ब्रह्मरन्ध्रे स्थितो जीवः सुषुम्नया संयुतः । ... आधा-
राद्ब्रह्मकुलादूर्ध्वं मेहनाद्ब्रह्मकुलादधः अग्निशिक्षा (चक्रं) चक्रात् तस्मात्
नवाङ्गुलः देहस्य कन्दोऽस्ति । उत्सेधायामाभ्यां चतुरङ्गुलः ब्रह्मयन्त्रिरिति प्रोक्तः ।
(संगीतरत्नाकर as summarised in Dāmodara's Sangitadarpaṇa ;
vide Sangīta-ratnākara, पिण्डोत्पत्तिप्रकरणं, verses 116-144)
दीर्घास्थिर्बुद्धेः पर्यन्तं ब्रह्मदक्षेति कथ्यते तस्यान्ते सुषुम्नं सूक्ष्मं ब्रह्मनाडीति सूरिभिः
(उत्तरगीता)-तत् कश्चिंकायां विष्वग्भ्यापिशाखासहस्रवत्या मनोबहनाइया मूर्ते
तिष्ठति । तस्या अलाबुलतिकायाश्च ऊर्ध्वेमुखे शकाशाखा सुषुम्ना इति
गीयते । स वैमनोवहा नाडी चित्तस्थानं भवति (विज्ञानभिद्य, योगबार्त्तिक)
सुषुम्ना चोर्ध्वेगाभिनीं ज्ञाननाडी भवेत् (*Jñāna Sankalinî Tantra*).
For functions of *Ājnāvahâ Nâdî* and *Manovahâ Nâdî*,
also see Śankara Mîśra's *Upaskāra*.

The cerebro-spinal axis and the heart : their respective relations to the conscious life.—Vijnāna-
bhikshu, in the passage just quoted, identifies the *Manovahâ Nâdî* (vehicle of consciousness, चित्तस्थान) with

the cerebro-spinal axis and its ramifications, and compares the figure to an inverted gourd with a thousand-branched stem hanging down. The *Suṣumna*, the central passage of the spinal cord, is the stem of this gourd (or a single branch). The writers on the Yoga (including the authors of the various Tantric systems) use the term somewhat differently. On this view, the *Manovahâ Nâdî* is the channel of the communication of the *Jiva* (soul) with the *Manaschakra* (sensorium) at the base of the brain. It has been stated that the sensory currents are brought to the sensory ganglia along afferent nerves of the special senses. But this is not sufficient for them to rise to the level of discriminative consciousness (संविद्यकज्ञानम्). A communication must now be established between the *Jiva* (in the *Sahasrâra Chakra*, upper cerebrum) and the sensory currents received at the sensorium, and this is done by means of the *Manovahâ Nâdî*. When sensations are centrally initiated, as in dreams and hallucinations, a special *Nâdî* (*Svapnavahâ Nâdî*), which appears to be only a branch of the *Manovahâ Nâdî*, serves as the channel of communication from the *Jiva* (soul) to the sensorium. In the same way, the *Âjnâvahâ Nâdî* brings down the messages of the soul from the *Sahasrâra* (upper cerebrum) to the *Âjnâ Chakra* (motor tract at the base of the brain), messages which are thence carried farther down, along efferent nerves, to various parts of the periphery. I may add that the special sensory nerves, together with the *Manovahâ Nâdî*, are sometimes generally termed *Jnânavahâ Nâdî*, *lit.* channel of presentative knowledge. There is no

difficulty so far. The *Manovahâ Nâdî* and the *Âjnâvahâ Nâdî* connect the sensori-motor tract at the base of the brain (*Mânaschakra* and *Âjnâchakra*) with the highest (and special) seat of the soul (*Jiva*) in the upper cerebrum (*Sahasrâra*), the one being the channel for carrying up the sensory, and the other for bringing down the motor messages. But efforts of the will (*Âjnâ*, *Prayatna*) are conscious presentations, and the *Manovahâ Nâdî* must therefore co-operate with the *Âjnâvahâ* in producing the consciousness of effort. Indeed, attention, the characteristic function of *Manas*, by which it raises sense-presentations to the level of discriminative consciousness, implies effort (*Prayatna*) on the part of the soul (*Âtman*, *Jiva*), an effort of which we are conscious through the channel of the *Manovahâ Nâdî*. But how to explain the presentation of effort in the motor nerves? Śankara Mîśra, the author of the *Upaskâra* on *Kanâda's Sûtras*, argues that the *Nâdîs* (even the volitional or motor nerves) are themselves sensitive, and their affections are conveyed to the sensorium by means of the nerves of the (inner) sense of touch (which are interspersed in minute fibrillæ among them). The consciousness of effort, then, in any motor nerve, whether *Âjnâvahâ* (volitional-motor) or *Prânavahâ* (automatic-motor), depends on the tactile nerves (or nerves of organic sensation) mixed up with it. Thus the assimilation of food and drink by the automatic activity of the *Prâṇas* implies an (automatic) effort (जीवनयोनिप्रयत्न) accompanied by a vague organic consciousness, which is due to the fact that minute fibres of the inner touch-sense are interspersed with the

machinery of the automatic nerves (the *Prâṇavahâ Nâdîs*).

यद्यपीन्द्रियं मनो न साक्षात् प्रयात्प्रविचयः तथापि मनोवहनाडीगोचरेण प्रयात्नेन मनसि कर्म्म द्रष्टव्यं । नाड्यास्तु त्वगिन्द्रियसाक्षत्वमङ्गीकर्त्तव्यं । अन्त्या प्रायवहनाडीगोचरेण प्रयात्नेन अक्षितपीताम्बुवहरव्यमपि न सम्भवेत् । तत्र-दिन्द्रियप्रदेशेन मनःसंयोगमन्तरेण सुखदुःखे न स्यातामेव । यदि मनसि कर्म्म न भवेत् न भवेच्च पादे न सुखं शिरसि न वेदना इत्याद्याकारोऽनुभवः । (Śankara Mîśra's *Upaskâra*, on Sûtras 14, 15, Âhnika 2, Chap. V.).

The Heart. The heart in the older schools is considered to be the seat of waking consciousness ; for the heart expands during waking life and contracts during sleep.

Sleep (स्वाप) again is of two kinds, (1) dreaming sleep (*swapna, supti*), when the external senses are withdrawn into the heart, but the representative-presentative faculty (मनः, चित्त) wakes, and (2) dreamless sleep (*susupti*), when this last faculty is likewise merged in the mere automatic activity of life.

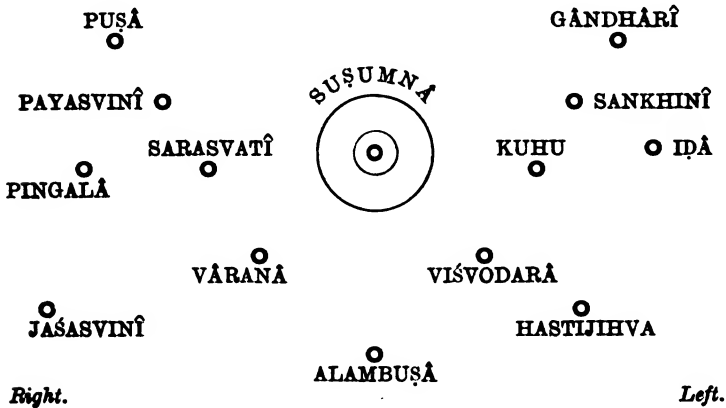
हृदयं पंकजाकृति । सुषिरं स्यादधोपकर्षं रतञ्च चेतनास्थानं । निमीलति स्वपित्वात्मा जागर्त्ति विकल्पमपि । ज्ञेया स्वप्नसुषुप्तिभ्यां स्वापः । वाक्चेन्द्रियाणि चेत् लीयन्ते हृदि जागर्त्ति चित्तं सुषुप्तदोष्यते । मनश्चेत् लीयते प्राये सुषुप्तिः स्यात्तदात्मनः—(*Sangîta-ratnâkara*).

SECTION 6.

NERVE-CORDS AND FIBRES (SYMPATHETIC-SPINAL SYSTEM).

Nerve-cords and fibres—Cranial and spinal nerves, and the connected sympathetic nerves.—With the writers on the Yoga, all the *Śirâs*, and such of the *Dhamanîs* as are not vehicles of vital current, metabolic

fluid, lymph, chyle or blood, are cranial nerves, and proceed from the heart through the spinal cord to the cranium. These cranial nerves include pairs for the larynx and the tongue, for the understanding and use of speech, for the raising and lowering of the eyelids, for weeping, for the sensations of the special senses, etc.— a confused and unintelligent reproduction of Suśruta's classification. But the enumeration of the spinal nerves with the connected sympathetic chain and ganglia, is a distinct improvement on the old anatomists. The following plan attempts to give a rough idea of the relative position of the principal nerves of the sympathetic-spinal system.



The *Suśumnā* is the central cord in the vertebral column (ब्रह्मदेह, मेरु). The two chains of sympathetic ganglia on the left and the right are named *Idā* and *Pingalā* respectively. The sympathetic nerves have their main connection with *Suśumnā* at the solar plexus (भानुभवन, नाभिकन्द in the कन्द, नाभिकन्द or ब्रह्मयन्त्रि). Of the seven hundred nerve-cords of the sympathetic-spinal

system (सङ्गीतः Sangīta-ratnākara), the fourteen most important are :—

(1) *Suṣumnâ*, in the central channel of the spinal cord.

(2) *Idâ*, the left sympathetic chain stretching from under the left nostril to below the left kidney, in the form of a bent bow.

(3) *Pingalâ*, the corresponding chain on the right.

(4) *Kuhu*, the pudic nerve of the sacral plexus, to the left of the spinal cord.

(5) *Gândhârî*, to the back of the left sympathetic chain, supposed to stretch from below the corner of the left eye to the left leg. It was evidently supposed that some nerves of the cervical plexus came down through the spinal cord and joined on to the great sciatic nerve of the sacral plexus.

(6) *Hastijihvâ*, to the front of the left sympathetic chain, stretching from below the corner of the left eye to the great toe of the left foot, on the same supposition as before. Pathological facts were believed to point to a special nerve connection between the eyes and the toes.

(7) *Sarasvatî*, to the right of *Suṣumnâ*, stretching up to the tongue (the hypo-glossal nerves of the cervical plexus).

(8) *Puṣâ*, to the back of the right sympathetic chain, stretching from below the corner of the right eye to the abdomen (a connected chain of cervical and lumbar nerves).

(9) *Paṃasvinî*, between *Puṣâ* and *Sarasvatî*, auricular branch of the cervical plexus on the right.

(10) *Sankhinî*, between Gândhârî and Sarasvatî, auricular branch of the cervical plexus on the left.

(11) *Jasâsvinî*, to the front of the right sympathetic chain, stretching from the right thumb to the right leg (the radial nerve of the brachial plexus continued on to certain branches of the great sciatic).

(12) *Vâranâ*, the nerves of the sacral plexus, between Kuhu and Jasaśvinî, ramifying over the lower trunk and limbs.

(13) *Viśvodarâ*, the nerves of the lumbar plexus, between Kuhu and Hastijihvâ, ramifying over the lower trunk and limbs.

(14) *Alambuṣâ*, the coccygeal nerves, proceeding from the sacral vertebræ to the urino-genitary organs.

(*Vide* Sangîta-ratnâkara, खराभाष्य, पित्तदोषप्रतिप्रकारणम्—Śloka 144–156. Also, the Yogârṇava.)

SECTION 7.

AUTOMATIC AND REFLEX ACTIVITY OF THE ORGANISM—THE FORTY-NINE VÂYUS.

Charaka describes *Vâyu* as that which keeps the machine of the body at work, the prime-mover, the impelling force which sets in motion the organs (including the senses and the mind), which arranges the cells and tissues, and which unfolds or develops the foetal structure out of the fertilised ovum. Charaka and Suśruta notice the five chief *Vâyus* with their functions in the maintenance of the animal life. Suśruta mentions *Prâṇa* as having its course in the mouth, and

concerned in deglutition, hiccough, respiration, etc., *Udâna* as concerned in articulation and singing, *Samâna* as digesting the food in the stomach in conjunction with the animal heat, *Vyâna* as coursing all over the body, driving the chyle and causing the flow of blood and sweat, and *Apâna* as having its seat in the intestinal region, and sending down the urino-genital secretions. (Suśruta—*Nidânasthâna*, Chapter I.)

In the mediæval physiology the number of *Vâyus* is given as 49. As in Charaka and Suśruta, the *Vâyus* are regarded as the moving or impelling forces that work the organism and all its automatic and reflex machinery. The *Âjñâvahâ Nâḍîs* (efferent nerves) are only channels for the conduction of commands of the self or the will (आत्मप्रयत्न); the *Vâyus*, on the other hand, are forces (or currents) that maintain the automatic, reflex, or instinctive activities of the organism. The ten chief *Vâyus* with their functions are enumerated thus :—

(1) *Prâṇa*, which works the ideo-motor verbal mechanism and vocal apparatus, the respiratory system, the muscles engaged in coughing, sighing, etc.

(2) *Apâna*, which ejects the excretions and wastes, the urine, the fæces, the sperm and germ-cells, etc.

(3) *Vyâna*, whose work is extension, contraction, and flexion of the muscles, tendons, and ligaments; the stored-up energy of the muscles.

(4) *Samâna*, the force which, in conjunction with animal heat, works the machinery of metabolism, in the maintenance of the organic life. It drives or propels

the chyle, blood, and every other current (*Śrota*) or circulating fluid in the body.

(5) *Udâna*, concerned in maintaining the erect posture of the body.

(6) *Nâga*, which is concerned in involuntary retching, vomiting.

(7) *Kûrma*, which works the automatic movement of the eyelids, winking, etc.

(8) *Krikara*, concerned with the appetites of hunger and thirst.

(9) *Devadatta*, which brings about yawning, dozing, etc.

(10) *Dhananjaya*, which is concerned with coma, swooning, trance.

वायुः तन्मयन्तधरः प्रवर्तकः चेष्टानी, प्रखेता मनसः, सर्वेन्द्रियाणां उद्योतकः, सर्वशरीरधातुसूहकरः, सम्पानकरः शरीरस्य, प्रवर्तको वाचः, हर्षोत्साहयोयोनिः, श्रेया वह्निमैलानी, कर्ता गर्भकृतीनां । प्राणपानोदानसमानव्यानात्मा (चरक सूचस्थान, Chap. XII.) तेषां मुख्यतमः प्राणः शब्दोच्चारणनिःश्वासोच्छ्वास-काशादिकारणं, अपानः . . . अस्य मूत्रपुरीषादिविसर्गः कर्म्म क्रीर्णितं । व्यानः . . . प्राणपानभृतित्यागग्रहणाद्यस्य कर्म्म च । समानोऽपि अखिलं व्याप्य शरीरं वह्निना सह । द्विसप्तति सहस्रेषु नाडीरंध्रेषु संचरन् भुक्तपीत्ररसान् सम्यगानयन् देहपुष्टिकृत् । उदानः कर्म्मस्य देहोन्नयनोत्क्रमणादि प्रक्रीर्णितं । त्वगादिधातूना-श्लेष पंचनागादयःस्थिताः उज्जारादि निमेषादि क्षुत्पिपासादिकं क्रमात् । तन्द्रामभृति मोहादि तेषां कर्म्म प्रक्रीर्णितं । (संगीतरत्नाकर ।)

Cf. the summary in Raja Sourindra Mohan Tagore's edition of the *Sangîta-darpana*.

शब्दोच्चारणं (वाक्निष्पत्तिकारणं) निश्वासः उच्छ्वासः (अन्नमैलम्यासः) तन्द्रादीनां कारणं (साधनं) प्राणवायुः । विद्यमूत्रशुक्रादिवहन्मपानस्य कर्म्म । आकुचनप्रसारणादि व्यानस्य कर्म्म हेयं । अज्ञितपीतादीनां समतानयनद्वारा शरीरस्य पोषणं समानस्य कर्म्म । उदानवायुः ऊर्ध्वनयनमेव अस्य कर्म्म नागादयः नागकर्म्मकृत्कारदेवदत्तधनञ्जयरूपाः पञ्च वायवः । एतेषां कर्म्माणि

च यथाक्रमं उद्गारोन्मीलनसुधाजननविनृम्भनमोहरूपाणि । (*Sangīta-darpaṇa*, Chap. I., Śloka 43-48). Cf. the extract in Śankara.

प्राणः प्राग्वृत्तिरुच्चासादिकर्मो । अपानः अवाग्वृत्तिरुत्सर्गादिकर्मो । व्यानः तयोः सन्धी वर्तमानः वीर्यवत्कर्महेतुः । उदानः ऊर्ध्ववृत्तिः उत्क्रान्त्यादि हेतुः । समानः सर्वं सर्वेषु अङ्गेषु यः अक्षरसान् नयति । इति । (*Śārīraka Bhāṣya*, Chap. II., Pada 4, Sūtra 2).

SECTION 8.

FETAL DEVELOPMENT (AFTER SUSRUTA).¹

The ovum fertilised by the sperm-cell and developing under the influence of animal heat forms successive layers and tissues, even as layers of cells and fibres are formed in wood. First are formed seven layers, epithelial and dermal (*Saptatwachah*), then follow the several tissues (*Kalâh*), the flesh, the vascular tissue, the fat and marrow, the lymphatic and (glandular) tissue, the intestinal tissues, the biliary and the seminal vessels. These tissues are regarded by some as modifications of the original dermal layers of the ovum (cf. the layers of the blastoderm and their relation to the tissues in Embryology). The tissues are supposed to be developed successively, one out of another, by chemical action or metabolism (*pâka*), e.g. chyle is transformed into blood, blood into flesh, flesh into fat, fat into bone, bone (in reality, fat in the bones) into marrow, marrow into sperm-cell. The organs are next formed out of the tissues. The liver, gall-bladder (*kloma*), spleen, and

¹ Reproduced from my monograph in Dr. Ray's "Hindu Chemistry," Vol. II.

lungs are referred to the blood ; the intestines to the blood, lymph, and bile ; the kidneys to the blood and fat ; the testicles to the blood, lymph, and fat ; the heart to the blood and lymph ; and the tongue to the lymph, blood, and flesh. *Vāyu*, with the accompaniment of animal heat, impels the "currents" (*śrotāmsi*) in the system ; *Vāyu* acting on the flesh gives rise to the muscles ; and it is *Vāyu*, again, which, with the essence of fat (or marrow), produces the nerves, arteries, and tendons (Suśruta, *Śārīrasthāna*, Chap. IV., and *Sūtrasthāna*, Chap. XIV.).

The following parts (tissues and organs) in the foetus are in a special sense modifications of the four organic substances (compounds) contributed by the sperm-cell of the male parent : hair, nails, teeth, bones, nerves, veins and arteries, tendons and ligaments, and the sperm-cell ; the following are modifications of the four organic substances derived from the mother : skin, blood, flesh, fat, the heart, liver and spleen, kidneys, stomach, intestines, etc. (Charaka, *Śārīrasthāna*, Chap. III.).

The rudiments of the head and the limbs begin to appear in the third month, and are developed in the fourth ; the bones, ligaments, nails, hair, etc., become distinct in the sixth. In the second month the sexual character is indicated by the shape of the foetus, the shape of a round joint (?) indicating the male sex, and an elongated shape, as of a muscle (?), the female sex. (Cf. Charaka, *Śārīrasthāna*, Chap. IV.—द्वितीयेमासि घनः सम्यङ्गते पित्तः पेश्यपुद्गवा । तत्र घनः पित्तः पुरुषः स्त्री पेशी अर्जुदं नपुंसकः Chakrapāni notes घनः कठिनः । पित्तो सन्ध्याकारः । पेशी दीर्घनासपेश्याकारा । अर्जुदं बर्तलोच्चत *loc. cit.*)

SECTION 9.

HEREDITY.

Transmission of specific characters—what parental characters are transmitted to offspring.—The question is raised in Charaka (and earlier still in the *Brâhmanas*) how specific characters are transmitted—why the offspring is of the same species as the parental organism, say, the human or bovine species, the equine species (Charaka), or the Asvattha species, *Ficus religiosa* (Śankara, *Brihadâranyaka-bhâṣya*). Species (योन्वः) may be compared to so many moulds, as it were, into which the ovum is cast, even as molten metals are cast in moulds. This is of course only an illustrative analogy; the cause has to be investigated.

Now Charaka and Suśruta, following Dhanvantari, hold that the foetus, or rather the fertilised ovum, develops by palingenesis (instead of epigenesis); in other words, all the organs are potentially present therein at the same time, and unfold in a certain order. As the sprouting bamboo-seed contains in miniature the entire structure of the bamboo, as the mango-blossom contains the stone, the pulp, the fibres, which appear separated and distinct in the ripe fruit, though from their excessive minuteness they are undistinguishable in the blossom, even such is the case with the fertilised ovum.

गर्भस्य हि सम्भवतः . . . सर्वोद्गमप्रवृत्तानि युगपत् सम्भवन्ति इत्याह धन्वन्तरिः । गर्भस्य सूक्ष्मत्वात् नोपलभ्यन्ते वंशाङ्कुरवत् चूतफलवच्च तद्यथा चूतफले परिपक्वे केसरादीनां सास्त्रियमञ्जानः पृथक् दृश्यन्ते कालप्रकर्षात् । तान्येव तद्वत् नोपलभ्यन्ते सूक्ष्मत्वात् । तेषां केसरादीनां कालः प्रत्यक्ता करोति एतेनैव वंशाङ्कुरोर्गप व्याख्यातः । एवं गर्भस्य तद्वत् सर्वेषु उद्गमप्रवृत्तेषु समु लीक्याद-

नृपलम्भिः तान्येव फलप्रकर्षात् प्रत्यक्तानि भवन्ति । (Suśruta, *Śārīra sthāna*, Chap. III.).

The inheritance of specific characters is explained in accordance with this view. Charaka assumes that the sperm-cell of the male parent contains minute elements derived from each of its organs and tissues. (Cf. Darwin's gemmule and Spencer's "ids.") Śankara similarly states that the sperm-cell (or the seed in the case of a plant) represents in miniature every organ of the parent organism, and contains *in potentia* the whole organism that is developed out of it (शरीरोपात्तात्मा शुक्रभूतः चक्रादङ्गान् सम्भवति । Charaka, *Śārīrasthāna*, Chap. IV. ; cf. Śankara on *Bṛihadāraṇyaka*).

But if this is so, why are not congenital deformities of the parent, or constitutional diseases contracted in later life, invariably inherited? Congenital blindness, deafness, dumbness, stammering, lameness, or deformity of the spinal column or of the bony framework, or dwarfish stature, or constitutional diseases like madness, leprosy, or skin diseases in the parent, do not necessarily produce corresponding deformities or infirmities in the offspring. It cannot therefore be that the fertilised ovum represents in miniature every organ and tissue of the parental organisms. The solution of this difficulty Charaka ascribes to Âtreya. The fertilised ovum, it is true, is composed of elements which arise from the whole parental organism (समुदायात्मात्मा, समुदायप्रभव), but it is not the developed organs of the parents, with their idiosyncracies or acquired characters, that determine or contribute the elements of the sperm-cell (or seed). The parental Vija (seed, germ-plasm) contains the whole

parental organism in miniature (or *in potentia*), but it is independent of the parents' developed organs, and is not necessarily affected by their idiosyncracies or deformities. In fact, the parental Vija (seed, germ-plasm) is an organic whole independent of the developed parental body and its organs. In the parental Vija an element representing a particular organ or tissue may happen (for this is accidental, दैव) to be defective or undeveloped, or otherwise abnormally characterised, and in this case the corresponding organ or tissue of the offspring will be similarly characterised. When constitutional diseases, acquired in later life, are found to be inherited, Âtreya would suppose that the Vija of the parent has been affected, and this would explain the fact of the inheritance. In the case of leprosy, for example, it is transmitted to the offspring only when the germ-plasm (the Vija or the fertilised ovum) is infected with the virus of the disease by reason of the leprosy of the parent (*vide* Charaka's report of Âtreya's theory, *Sârîrasthâna*).

एवमयं नानाविधानां एषां गर्भकराणां भावानां समुदायादभिनिवर्त्तते गर्भः । यद्यमेव नानाविधानां गर्भकराणां भावानां समुदायादभिनिवर्त्तते गर्भः कथमयं सन्वीयते । यदि चापि सन्वीयते कस्मात् समुदायप्रभवः सन् गर्भो मनुष्यविग्रहेण जायते मनुष्यश्च मनुष्यप्रभवः । उच्यते । . . . तत्र चेत् इहमेतत्प्रस्तात् मनुष्यो मनुष्यप्रभवः तस्मादेव मनुष्यविग्रहेण जायते यथा गौर्गोप्रभवः यथा चाम्भः अश्वप्रभवः इत्येवं यदुक्तं अग्रे समुदायात्मक इति तदुक्तं । यदि च मनुष्यः मनुष्यप्रभवः कस्मात् जडाप्यकुक्षमूकवामनमिन्मयप्यङ्गोन्मत्तकुष्ठकिल्हावेभ्यो जाताः पितृसदृशा न भवन्ति *et seq.* यद्योक्तं यदि च मनुष्यो मनुष्यप्रभवः कस्मात् जडादिभ्यो जाताः पितृसदृशरूपा न भवन्तीति तत्रोच्यते यस्य यस्यहि अङ्गावयवस्य बीजे बीजभाव उपपत्तो भवति तस्य तस्य अङ्गावयवस्य विकृतिः उपजायते । नोपजायते च अनुपपत्तायात् तस्मात् उभयोपपत्तिरप्यत्र । सर्वस्य च आत्मजानीन्द्र-

यादि तेषां भावाभावेतुः दैर्घं । तस्मात्सैकान्तो जडादिभ्यो जाताः पितृसदृशरूपा भवन्ति । (चरक, ज्ञारीरस्थान, तृतीयपरिच्छेद) दम्पत्योः कुड्बानुत्पादुहशोणित-शुक्रयोः । यदप्यं तयोर्जातं ज्ञेयं तदपि कुड्बितं ।

N.B.—The seventh tissue (the *Sukradharâ kalâ*, sperm-bearing or reproductive) contains the parental *Vija*, which is a minute organism (समुदायात्मक) deriving its elements from the parental organs, but distinct from the latter, and independent of their peculiarities, and it is the combination and characters of these constituent elements of the parental *Vija* in the reproductive tissue that determine the physiological characters and predispositions of the offspring. We may call this *Âtreya's germ-plasm* theory, for it is an advance on the conception of gemmules and of ids, but in *Âtreya's* version the “germ-plasm” is not only representative of the “somatic” tissues, but also generates and is generated by the latter. This mutual interaction of the “germ-plasm” and “somatic tissues” is a distinctive feature of *Âtreya's* hypothesis, the value of which will be differently estimated by different schools of biologists.

I may also add that the continued identity of the germ-plasm (बीज) from generation to generation, though it follows as a corollary from this doctrine of a distinct reproductive tissue, even when conceived to be affected by somatic processes, as *Âtreya* and *Charaka* conceive it to be, is nowhere expressly deduced. On the other hand, *Âtreya* and *Charaka* emphasise the influence of abundant or defective nutrition, and of the constituents of the food, etc., on the characters of the *Vija* in the reproductive tissue, especially as regards the sexual character, the stature, and the colour-pigment

(बन्ध) of the offspring. But though the influence of nutrition on the Vija is thus freely admitted in a general way, it is expressly stated that the peculiar characters or idiosyncracies of the elements that combine to form the Vija must be regarded as a matter of chance (दिव), in other words, the truly congenital variations are accidental.

SECTION 10.

THE SEX QUESTION.

Influence of nutrition on the ovum, especially as regards the sex, stature, and colour-pigment of the resulting offspring.—In a general way, ghee and milk for the male, and oil and beans for the female parent, are favourable to the Vija. The sexual character of the offspring depends in part on a periodicity to which the life-history of the ovum in the female parent is conceived to be subject—a law of alternate rhythmic change (not unlike what we now know to regulate the development of several orders of bacteria or unicellular organisms), a law under which the fertilisation of the ovum on the fourth day after the menstrual discharge, or on the alternate days succeeding, is favourable to the foetus developing the male sexual character, and on the fifth, seventh, and alternate following days to the foetus assuming the female sex. The *Prayogachintâmani* states that the latter occurs on even days, and the former on odd days. Another factor is the relative predominance of the sperm and the germ cells in the fertilised ovum. Excess of the sperm-cell produces the male, that of the germ-cell the female. For male

offspring of tall stature, fair complexion, and energetic temperament, wheat-pulp with honey, ghee (clarified butter), and milk should be taken by the female parent. Generally speaking, the adoption of the food, clothing, habits of people of any particular clime are supposed to be favourable to the production of their characteristic stature and complexion. As to sex, the foetus for a time remains indeterminate, and then takes on a definite male or female character, but before this stage is reached the development of the sex can be modified to some extent by food and drugs (पुंसवनमीषधं). As for the colour-pigment, it is the animal heat (तेजोधातु) which is its source; but where the *Ākâśa* and *Ap* particles predominate (in the food) the animal heat (of the metabolic processes) produces a fair complexion; where Earth and *Vāyu* particles predominate in the food, blackness is the result; and where the different *Bhutas* are combined in nearly equal proportion in the food, the metabolic heat produces a dark pigment. In the later literature, ghee (clarified butter) habitually taken by the female during gestation is supposed to produce a fair complexion, and rice (or wheat) and salads a dark complexion. Charaka also holds that mental impressions of the parent are powerful factors in the determination of the characters of the offspring.

यथाहि बीजननुपगतं उन्नं स्त्री स्त्री प्रकृतिं अनुविधीयते त्रीहिषो त्रीहित्वं यथोवा यवत्वं तथा स्त्रीपुरुषी अपि यथोक्तं हेतुविभागं अनुविधीयते । . . . तस्मादापन्नगर्भो स्त्रियमभिसमीक्ष्य प्राग् व्यक्तीभावात् गर्भस्य पुंसवनमीषधनस्यै दद्यात् । . . . जानात् प्रभृति युग्मेषु अहःसु संगमेतो पुंसकानी ती अयुग्मेषु दुहितृकानी । . . . उपाचरेच्च नपुरीषधसंस्कृताभ्यां वृतस्त्रीराभ्यां पुरुषं स्त्रियनु तैलमावाभ्यां । साचेत् एवमाज्ञासीत् बृहन्नमवदात् इत्यर्थं अोजस्विनं शुधिं

सहस्रसम्पन्नं पुत्रनिच्छेयमिति । शुश्रूषानात् प्रभृति अस्यै मधुसर्पिर्भी संमृज्य
 श्वेतायाः गोः स्वरूपवत्सायाः पयसा आलभ्य राजते कास्ये वा पात्रे काले काले
 सप्ताहं सततं प्रयच्छेत् पानाय । . . . या येषां जनपदानां मनुष्याणां अनुरूपं
 पुत्रमाज्ञासीत् सा तेषां जनपदानां मनुष्याणां आहारविहारोपचारपरिच्छदान्
 अनुविधीयस्व इति वाच्या स्यात् ।

न खलु केवलमेतदेव कर्म वर्षीणां वैशेष्यकरं अपितु तेजोधातुरपि उद-
 कान्तरीक्षधातुः प्रायः अवदातवर्षीकरो भवति । पृथिवीवायुधातुः प्रायः कृष्ण-
 वर्षीकरः । समसर्वधातुः प्रायः श्यामवर्षीकरः । आधिक्ये रेतसः पुत्रः,
 कन्या स्यात् आर्त्तवेगधिक्ये ।

SECTION 11.

LIFE.

These activities maintain the life of the organism, but what is this life itself?

The *Chârvâkas* (materialists and sensationalists) answer that life (as well as consciousness) is a result of peculiar chemical combinations of dead matter (or the four elements) in organic forms, even as the intoxicating property of spirituous liquors results from the fermentation of unintoxicating rice and molasses. Similarly, the instinctive movements and expressions of new-born babes (sucking, joy, grief, fear, etc.) can be explained mechanically as due to external stimuli as much as the opening and closing of the lotus and other flowers at different hours of the day (or night), or the movement of iron under the influence of the loadstone. In the same way, the spontaneous generation of living organisms is frequently observed, *e.g.* the case of animalcules which develop in moisture or infusions, especially under the influence of gentle warmth (खेदज, उष्णज, दीप्तमशकादयः), or of the maggots or other worms which in the rainy season,

by reason of the atmospheric moisture, are developed in the constituent particles of curds and the like, which begin to live and move in so short a time.

Gotama, in his *Sûtras*, reports the Chârvâka explanation of instinctive emotional expressions in babes: पद्मादिषु प्रबोधसम्पत्तिरनघत् तद्विकारः—Sûtra 20, Âhnika 1, Chapter III.; cf. the explanation of the movement preparatory to sucking: अयसो ह्यस्मान्नाभिगमनघत् तदुपसर्षेष्ठी—Sûtra 23, *ibid.* Jayanta, in the *Nyâya-manjarî*, reports the Chârvâka explanation of consciousness (and life).

मदशक्तिघत् विज्ञानं । पृथिव्यादीनि भूतानि चत्वारि तत्त्वानि । तेभ्य एव देहाकारपरिच्छतेभ्यः मदशक्तिघत चैतन्यमुपजायते ।

For spontaneous generation, *vide* Jayanta's report :—

वर्षासुषुषु खेदादिना अनतिदधीयसैव कालेन दम्भाद्यवयवा एव चलनः पूतनादिक्रमिरूपा उपलभ्यन्ते ।—*Nyâya-manjarî*, Âhnika 7, भूतचैतन्यपक्षः ।

The Sânkhya view of consciousness—Reply to the materialists :—

The intoxicating power in liquor is a force, *i.e.* a tendency to motion, and this is the resultant of the tendencies (or subtile motions) present in the particles of the fermented rice, molasses, etc. A motion, or a tendency to motion, can in this way be the resultant of several other motions or tendencies. But consciousness (चैतन्य) is not a motion, and cannot be the resultant of (unconscious) natural forces or motions. Neither can the consciousness of the Self, or of the organism as a whole, be supposed to be the resultant of innumerable consciousnesses vested in the innumerable constituent particles of the body. One central abiding intelligence

is a simpler and therefore more legitimate hypothesis than an assemblage of consciousnesses latent in different Bhûtas or particles, *cf.* Vijnâna-bhikṣu's comment on the Sûtra. मदज्ञास्त्रिवचेत् प्रत्येकपरिदुहे साहच्ये तदुद्भवः (Sûtra 22, Chapter III.) ननु यथा मादकताज्ञास्त्रिः प्रत्येकद्रव्यावृत्तिरपि मिलितद्रव्ये वर्तते एवं चैतन्यमपि स्यादिति चेन्न प्रत्येकपरिदुहे सति साहच्ये तदुद्भवः सम्भवेत् । प्रकृते तु प्रत्येकपरिदुहन्त्वं नास्ति ... ननु समुचिते चैतन्यदशनेन प्रत्येकभूते सूक्ष्मचैतन्यज्ञास्त्रिनुमेया इति चेन्न । अनेकभूतेषु अनेकचैतन्यज्ञास्त्रिकल्पनार्था गौरवेण लाघवादेकस्यैव नित्यचित्सरूपस्य कल्पनीयत्वात् । *Cf.* also भूतगतविशेषगुणानां सजातीयकारणगुणजन्यतया कारणे चैतन्यं विना देहे चैतन्यासम्भवात् । (*ibid.*).

मझे मदज्ञास्त्रिर्न गुणः । मद्यारम्भकानां पिष्टगुडमञ्जादीनां यत् यस्य कर्म ते कर्मभिरारम्भं स्वस्वकर्मविरोधिकर्मं यदुच्यते प्रभाव इति । चैतन्यादिकं न कर्म । (Gangâdhara's *Jalpakaḥpataru* (1867, Calcutta), explaining the distinction between property (गुण) and power (प्रभाव), a technical term in medicine, which denotes a form of motion (कर्म) *Sâtrasthâna*, *Jalpakaḥpataru*).

The Sâṅkhya view of Prâṇa (life):—

Life, according to the Sâṅkhya, is not a *Vâyu* (bio-mechanical force) nor any mere mechanical motion resulting from the impulsion of *Vâyu*. The five vital operations, Prâṇa, Apâna, etc., are called *Vâyus*, but this is only a metaphor. Life is in reality a reflex activity, a resultant of the various *concurrent* activities of the *Antahkarana*s, *i.e.* of the sensori-motor (ज्ञानेन्द्रिय कर्मेन्द्रिय), the emotional (मनः) and the apperceptive reactions of the organism (for some add अहङ्कार).

Vijnâna-bhikṣu notes that this explains the disturbing (elevating or depressing) effect on the vitality of pleasurable or painful emotions, like love (काम), which

are activities of *Manas*, one of the *Antahkarana*s concerned in the reactions of the living organism. On the Sâṅkhya view, then, *Prâṇa* or life is not a *Vâyu*, nor is it evolved from the *Bhutas*, inorganic matter. *Prâṇa* is only a complex reflex activity (सम्भूयेका वृत्ति) resulting from the operations of the psycho-physical principles or forces in the organism. Cf. Śankara reporting the Sâṅkhya view—करणानि नियतवृत्तयः सन्तः सम्भूयेका प्राणाख्या वृत्ति प्रतिपद्यन्ते ।—*Śârîraka-bhâṣya*, Chapter II., Pada 4, Sûtra 9. सामान्यकरणवृत्तिः प्राणाद्या वायवः पञ्च ।—*Īśvarakriṣṇa*, Kârikâ. Also Sûtra 31, Chapter II., where Vijnâna-bhikṣu notes :—

वायुवत् सञ्चारान् वायवः प्रसिद्धाः । अस्माकं नार्यं नियमः यदिन्द्रियवृत्तिः क्लेशैव भवति नैकदा । जातिसाङ्ख्यस्य अस्माकं अदोषत्वात् । सामग्रीसमवधाने सति अनेकैरपीन्द्रियैः एकदैकवृत्तुत्यादने बाधकं नास्ति ।—*Vijnâna-bhikṣu*, *Pravachana - bhâṣya*, Chapter II., Sûtras 31, 32. मनोधर्मस्य कामादेः प्राणस्योभयतया सामानाधिकरत्येनैव औचित्यात् ।—*ibid.*

The Vedântic View of Prâṇa.

The Vedântists are believers in an independent vital principle. They agree with the Sâṅkhyas in holding that *Prâṇa* is neither a *Vâyu* nor the operation of a *Vâyu*. But neither is life a mere reflex or resultant of concurrent sensori-motor, emotive and apperceptive reactions of the organism. You may put eleven birds in a cage, and if they concurrently and continually strike against the bars of the cage in the same direction, the cage may move on under this conjoint action. But the sensory and motor activities cannot in this way originate the vital activity of the organism. For the deprivation of any one or more of the senses does not

mean a deprivation of life, and above all there is this radical distinction : there is sameness of kind (समजातीयत्व) between the motions of the individual birds and the resultant motion of the cage, but the sensations do not explain life. *Life* (Prāna) must therefore be recognised as a separate principle, just as the *Manas* and the *Antahkarana*s generally are in the Sāṅkhya Philosophy. Life is a sort of subtle rarefied “ether-principle” (अध्यात्मवायु) pervasive of the organism—which is not gross *Vāyu*, but is all the same subtilised matter, like the *Manas* itself, for, in the Vedānta, everything other than the Self (आत्मा) is “material” (जड़).

This Life is prior to the senses, for it regulates the development of the fertilised ovum, which would putrefy if it were not living, and the senses with their apparatus develop subsequently out of the ovum (न वायुक्रिये पृथगुपदेशात्), Chapter II., Pada 4, Sūtra 9; *vide* Śārīraka-Bhāṣya Śankara; also Vāchaspati Miśra, Bhāmātī :—

सिद्धान्तस्तु न समानेन्द्रियवृत्तिः प्रायः । स हि मिलितानां वा वृत्तिर्भवेत् प्रत्येकं वा । न तावत् मिलितानां । एकद्विविचक्षुःसुन्दिरिन्द्रियाभावे तदभावप्रसङ्गात् । न सल्लु पूर्वाहरिद्रासंयोगजन्माश्लक्ष्णसंस्कारयोरन्यतराभावे भवितुमर्हति । न च बहुविधिसार्थं द्विविधोद्बह्वर्णं द्विविधिविधिसार्थं भवति । न च त्वगेकसार्थं । तथा सति सामान्यवृत्तिवानुपपत्तेः । अपि च यत् सम्भूयकारकाणि निष्पादयन्ति तत् प्रधानव्यापारानुगुणावान्तरव्यापारोऽपि । यथा वयसां प्रातिविस्त्रिको व्यापारः पित्तप्रचालनानुगुणः । इह तु अषष्याद्यवान्तरव्यापारोपेतः प्रायान् न सम्भूय प्रास्युरिति युक्तं प्रमाणाभावादत्यन्तविजातीयत्वाच्च अषष्यादिभ्यः प्रायानस्य । . . . तस्मादन्यो वायुक्रियाभ्यां प्रायः । . . वायुरेवायनध्यात्मतावापन्नः मुख्योऽपि प्रायः । —Śankara, *ibid.* Cf. also, ज्येष्ठश्च प्रायः शुक्रनिषेककालादारभ्य तस्य वृत्तिलाभः । नचेत् तस्य तदानीं वृत्तिलाभः स्यात् शुक्रं पूयेत् न सम्भवेद्वा ओषादीनानु कर्ष्यंश्चुल्यादिस्थानविभागनिष्पत्तौ वृत्तिलाभाच्च ज्येष्ठत्वं ।—Śankara, on Sūtra 9, Pada 4, Chapter II.

CHAPTER VII.

ON THE SCIENTIFIC METHOD OF
THE HINDUS.

The Doctrine of Scientific Method.—A study of the Hindu Methodology of Science is absolutely essential to a right understanding of Hindu positive Science, its strength and its weakness, its range and its limitations. Apart from this rigorous scientific method, Hindu Chemistry, for example, would be all practical recipe, or all unverified speculation. This, however, would be a very inadequate and indeed erroneous view of this early achievement of the human mind. That the whole movement was genuinely and *positively* scientific, though arrested at an early stage, will appear from the following brief synopsis of the Hindu Methodology of Science.

Criterion or Test of Truth, after the Buddhists.—The ultimate criterion of Truth is found, not in mere cognitive presentation, but in the correspondence between the cognitive and the practical activity of the Self, which together are supposed to form the circuit of consciousness. That knowledge is valid which prompts an activity ending in fruition. (*Cf.* the distinction between सम्वादिज्ञान and विसम्वादिज्ञान। Also compare प्रमाणातोऽर्थप्रतिपत्तौ प्रवृत्तिसामर्थ्यात् अर्थवत् प्रमाणम्—Vātsyāyana.) Truth, the Buddhists contend, is *not* self-evidence, *not*

the agreement between ideas, *nor* the agreement of the idea with the reality beyond, if any, for this cannot be attained direct, but the harmony of experience (सन्वाद), which is implied when the volitional reaction, that is prompted by a cognition and that completes the circuit of consciousness, meets with fruition, *i.e.* realises its immediate end (with this compare Sriharsha, Khandana Khanda Khádyā, on the relation of प्रमा to लोकव्यवहार). This is the material aspect of Truth. The formal aspect is given in a principle which governs all presentations in consciousness, and which combines the three moments of Identity, non-Contradiction, and Excluded Middle in every individual cognitive operation [तदुक्तं तत् परिच्छिनत्ति (identity) अन्यद् व्यपच्छिनत्ति (non-contradiction) तृतीयप्रकाराभावं च सूचयति (excluded middle) इति एकप्रमाणव्यापारः—Jayanta, Nyáyamañjarī, प्रमावैविध्यसङ्गहान्].

Perception.—The conditions of Perception, and its range and limits, were carefully studied. The minima sensible (*e.g.* the minimum visible, the Trasarenu, the just-perceptible mote in the slanting sunbeam), the infra-sensible (अनुब्रूतरूप, सूक्ष्म, sometimes termed अतीन्द्रिय), the obscured (अभिभूत, *e.g.* a meteor in the mid-day blaze), and the potential (अनुब्रूतवृत्ति), are distinguished; but finer instruments of measurement were wanting, and this was a principal cause of arrested progress. It may be noted that the measurement of the relative pitch of musical tones was remarkably accurate (*vide* my Paper on Hindu Mechanics and Physics).

Observation (दर्शन—Váchaspati and Udayana).—The entire apparatus of scientific method proceeded on the basis of observed instances carefully analysed and

sifted. This was the source of the physico-chemical theories and classifications, but in Anatomy the Hindus went one step farther; they practised dissection on dead bodies for purposes of demonstration. Ingenious directions are given, *e.g.*, the body must be first disembowelled and wrapped round with the *kusa* and other grasses, then kept immersed in still water for seven days, after which the medical student should proceed to remove the layers of the skin with a carefully prepared brush made of the fresh elastic fibres of green bamboos, which will enable the tissues, vessels and ducts to be observed. Post-mortem operations as well as major operations in obstetric surgery (the extraction of the foetus, etc.) were availed of for embryological observations (*e.g.*, it is stated that the rudiments of the head and the limbs begin to appear in the foetus in the third month, and are developed in the fourth; the bones, ligaments, nails, hair, etc., becoming distinct in the sixth), and also embryological theories, *e.g.*, the indication of sexual character in the second month by the shape of the foetus, the shape of a *round* joint indicating the male sex, and an *elongated* shape the female sex (*cf.* Charaka, Sūtrasthāna, Chap. IV.—द्वितीये मासि वनः सम्यङ्घृते पित्तः पेश्यञ्छुद् वा । तत्र वनः पित्तः पुरुषः स्त्री पेशी चञ्छुद् नपुंसकम् । Chakrapāni notes : वनः कठिनः । पित्तो सन्ध्याकारः । पेशी दीर्घनासपेश्याकारात् । चञ्छुद् वस्तुलोचनम् *loc. cit.*). In Phonetics (as in the Prātisākyas, *circa* 600 B.C.), in Descriptive and Analytical Grammar (as in Pānini), and in some important respects in Comparative Grammar (as in Hemachandra's Grammar of the Prākṛita

Dialects), the observation was precise, minute, and thoroughly scientific. This was also the case in *Materia Medica* and in *Therapeutics*, especially the symptomology of diseases. In *Meteorology* the Hindus used the rain-gauge in their weather forecasts for the year, made careful observations of the different kinds of clouds and other atmospheric phenomena (*e.g.*, they estimate the heights of clouds, the distance from which lightning is ordinarily visible or the thunder is heard, the area of disturbance of different earthquakes, the height to which the terrestrial atmosphere extends, etc.; *vide* Varáhamihira, Srípati, and the authorities quoted by Utpala). In *Astronomy* the observation was, generally speaking, very defective, as in the determination of the solar and the planetary elements, and this was probably due to the lack of practical interest, but the determination of the lunar constants entering into the calculation of lunar periods and eclipses, matters in which the Hindus had a practical ceremonial interest, reached a remarkable degree of approximation (much above Græco-Arab computations) to the figures in Laplace's Tables, which can only be explained by the circumstance that in the case of these constants the Hindus carried out for more than a thousand years a systematic process of verification and correction by comparison of the computed with the observed results (like the navigator's correction of the course of the ship at sea), a process which was termed दृग्गणितैक्य. In *Zoology* the enumeration of the species of Vermes, Insecta, Reptilia, Batrachia, Aves, etc., makes a fair beginning, but the classification

proceeds on external characters and habits of life, and not on an anatomical basis. In Botany the observation was mainly in the interests of *Materia Medica*, and the classification was as superficial as possible. (*Vide* my Paper on the Hindu Classification of Plants and Animals.)

Experiments.—Experiments were of course conducted for purposes of chemical operations in relation to the arts and manufactures, *e.g.* Metallurgy, Pharmacy, Dyeing, Perfumery and Cosmetics, Horticulture, the making and polishing of glass (lenses and mirrors of various kinds are mentioned, the spherical and oval *वृत्त* and *बहुल* being well known—Pliny indeed mentions that the best glass ever made was Indian glass). And the results of such experiments were freely drawn upon for building up scientific hypotheses and generalisations. But of experiment as an *independent* method of proof or discovery the instances recorded in books are rare. I may note one interesting example in Udayana's *Kiranávali*, relating to the weight of air. Udayana argues that air must be a distinct and independent *Bhúta*, for if air were a form of the Earth-*Bhúta*, it would have weight, and it has none. To prove the absence of weight, he refers to an experiment. A small bladder made of a thin membrane, filled with air, will not cause a greater descent in the scale than the same bladder weighed empty. Hence the air possesses no weight. Then Udayana makes an interesting statement. It may be objected, he says, by one who accepts the weight of air, that this argument is inconclusive; for a counter-experiment may be suggested. The

balloon filled with smoke (or gas, धूम) rises in the air, whereas the air-filled balloon comes down. This would go to show that air has weight. Udayana replies that this would only show that both smoke (or gas, धूम) and air have no weight. The Hindus appear to have been ignorant of the principle of Archimedes. Vallabhacháryya, in the *Lílávátí*, it is true, speaks of a peculiar resistance to sinking (or gravity) exercised by water, which explains the tendency in certain objects to float or to come up to the surface of the water, but the description does not show that he had any clear ideas on the subject. Mathuránátha, again, states that the determination of the degree of purity (the carat) of gold by rubbing against the assaying-stone and observing the character of the yellowish streak against the black smooth background, is only an indirect means of ascertaining weight (गुरुत्वपेक्षस्य, *lit.* specific gravity)—which seems to suggest that there was a more direct means of arriving at the latter. Probably this refers to the common Indian method of comparing the lengths and weights of wires of uniform thickness that can be formed by drawing different pieces of gold through the same diamond bore. I think it may be regarded as fairly certain that the Hindus were ignorant of Archimedes' discovery, an ignorance which, at any rate, they could not have well borrowed from the Greeks, no more than they could have thus borrowed their knowledge of things unknown to the Greeks themselves.

[*Cf.* Udayana, *Kiranávali* :—वायुनिरूपनम्, किं च (वायो) पृथिवीत्वे गुरुत्वमपि स्यात् । न च पवनानुपूरितस्य चर्मपुटकादेः अपूरणदज्ञातः

अधिकं अवनमनम् । उच्चीयमानस्य धूमापूरितेन इदम् अनैकान्तिकं इति चेत् न । अलं धूमदग्धायां तथापि गरिमविशेषहेतोरवनतिविशेषस्य अप्रतीतिः । —*cf.* Vallabhácháryya, Lílávati—गुरून्विशेषेणैषि पाषाणालावु-प्रभृतिषु मञ्जनोन्मञ्जननियमवत् अदृष्टहेतुकतासाम्येऽपि पतनोत्पतननियमो भविष्यतीति चेत् न । जलाभोगमनं जलेन धारणं पतनप्रतिबन्ध उन्मञ्जनं एतच्च जलस्य योगस्य कस्यचिदेव पतनप्रतिबन्धसामर्थ्यात् । दृष्टहेतुकमेव मञ्जनञ्च उन्मञ्जनञ्च ।] *Cf.* Mathuránátha, सन्निकर्षवाद्ग्रहस्य on Gaṅgesa's Tattvachintámāni—तस्य (निकर्षोपलस्य) न सुवर्ण-पीताभिव्यञ्जकत्वं किन्तु पीतद्वारा गुरून्वैलङ्घ्यस्य व्यञ्जकत्वमेव तस्य ।

Fallacies of Observation.—Mal-observation and Non-observation :—These were carefully studied in relation to errors of observation, and hallucination (भ्रम, अध्यास, आरोप), which were ascribed to three causes : (a) Doshā, दोष, defect of sense organ, as of the eye in jaundice, or of the skin in certain forms of leprosy (leading to tactile insensibility, *cf.* Susruta), or defect of necessary stimulus, *e.g.* too faint light, or undue distance or nearness, in vision ; (b) Samprayoga, सम्प्रयोग, presentation of a part or an aspect instead of the whole ; and (c) Sanskāra, संस्कार, the disturbing influence of mental predisposition, *e.g.* expectation, memory, habit, prejudice, etc.

The Doctrine of Inference.—Anumāna (Inference) is the process of ascertaining, not by perception or direct observation, but through the instrumentality or medium of a mark, that a thing possesses a certain character. Inference is therefore based on the establishment of an invariable concomitance (Vyápti, व्याप्ति) between the mark and the character inferred. The Hindu Inference (Anumāna) is therefore neither merely formal nor merely material, but a combined Formal-

Material Deductive-Inductive process. It is neither the Aristotelian Syllogism (Formal-Deductive process), nor Mill's Induction (Material-Inductive process), but the real Inference which must combine formal validity with material truth, inductive generalisation with deductive particularisation.

An inference admits of a rigorous formal statement—in the shape of five propositions for dialectical purposes (*i.e.* in demonstrating to others)—or of three propositions when the inference is for oneself (स्वार्थानुमान):—

(1) The probandum, the statement of the proposition to be established (प्रतिज्ञा, साध्यनिर्देश), *e.g.* yonder mountain is “fiery”; (2) the reason, the ascription of the mark (हेतु, लिङ्गव्यपदेश), *e.g.* for it smokes; (3) the general proposition, stating the invariable concomitance which is the ground of the inference—clenched by an example, *e.g.* whatever smokes is “fiery,” as an oven (उदाहरण); (4) next, the application, the ascertainment of the existence of the mark in the present case (उपनय), *e.g.* yonder mountain smokes; (5) finally, the conclusion, the probandum proved (निगमन), *e.g.* yonder mountain is “fiery.”

1. Yonder mountain is “fiery.”
2. For it smokes.
3. Whatever smokes is “fiery,” as an oven.
4. Yonder mountain does smoke.
5. Therefore yonder mountain is “fiery.”

For inference for oneself only the first three or the last three propositions are held to be sufficient.

The Hindu Anumāna, it will be seen, anticipates J. S. Mill's analysis of the syllogism as a material inference, but is more comprehensive; for the Hindu Udāharana, the third or general proposition with an example, combines and harmonises Mill's view of the major premise as a brief memorandum of like instances already observed, fortified by a recommendation to extend its application to unobserved cases, with the Aristotelian view of it as a universal proposition which is the formal ground of the inference. This Formal-Material Deductive-Inductive process thus turns on one thing—the establishment of the invariable concomitance (व्यभिचि) between the mark and the character inferred—in other words, an inductive generalisation. The question is—what is our warrant for taking the leap from the observed to unobserved cases? Under what conditions are we justified to assert a Universal Real proposition on the basis of our necessarily limited observation?

The Chārvāka View.—Among the Chārvākas there were two classes, the cruder school of materialists who accepted perception (प्रत्यक्ष) as a valid source of knowledge, as well as the reality of natural law (स्वभाव), and the finer school of sceptics, who impugned all kinds of knowledge, immediate as well as mediate, and all evidence, Perception as well as Inference; *vide* Jayanta's reference in the Nyāyamañjarī to सुशिक्षितवाङ्मौक्तः; also वाङ्मौक्तैस्तु ज्ञातस्तस्य व्यत्यास्याम इति प्रतिज्ञाय प्रमाद्यप्रमेयसंस्थालक्ष्यनियमाशङ्ककरक्षीयत्वमेव व्याख्यातवान्—*Āhnika* 1, Mañjarī.

The Chārvākas hold that the principle of causality

which the Buddhists assume to be a ground of an induction (अपत्ति), is itself an induction (a case of Vyápti), which amounts to reasoning in a circle (वृत्तक); that every inference is based on an unconditional invariable concomitance, which itself must be inferred, as universal propositions cannot be established by our limited perceptions, and thus there is a *regressus ad infinitum* (अनादिपरम्परा), and that the *nexus* between cause and effect, or between the sign and the thing signified (e.g. smoke and fire), is only a mental step or subjective association based on former perception, a mental step which by accident is found justified by the result in a number of cases.

The Buddhists: their Analysis and Vindication of Inference.—The Buddhists, however, take their stand on the principle of the Uniformity of Nature (प्रतिबन्ध, स्वभावप्रतिबन्ध, Nyáya-Vindu). This uniformity, for scientific purposes, has to be divided into two different relations: (1) the uniformity of succession in the relation of cause and effect, e.g. of smoke to fire (कार्य-कारणभाव, तदुत्पत्ति, Nyáya-Vindu); (2) the uniformity of co-existence (in the form of co-inherence in the same substrate) in the relation of genus and species, e.g. the relation of invariable concomitance expressed in the proposition “all Sinsapás are trees,” which is not a relation of causality, but of co-existence or co-inherence in the same substrate (i.e. the co-inherence of the generic qualities of a tree with the specific characters of a Sisu-tree in this particular individual before me, a Sisu-tree), a relation which may be termed essential identity (तादात्म्य, स्वभाव—Nyáya-Vindu). To

these two the Buddhists add a third ground of inference, non-perception of the perceptible (अनुपलब्धि, दृश्यानुपलब्धि), which is employed in inferring the absence (अतिशेष) of a thing from the non-perception of the thing or of something else. In all cases of inference based on the Uniformity of Nature, the relation is that of inseparableness or non-disjunction between the mark and the character inferred. The question is: how is this inseparableness (अविनाभाव) ascertained, and what is the warrant of our belief in it in these cases?

Ascertainment of Inseparableness or Non-disjunction: Buddhist Account.—First take the case of causation. The cause is the invariable antecedent of the effect. What is meant is that (a) a specific cause (or sum of causal conditions) is invariably followed by a specific effect, and (b) a specific effect (with all the distinctive and relevant accompaniments, कार्यविशेष) is invariably preceded by a specific cause (कारणविशेष). It is not that clouds always lead to rain, or that floods in the river-valley always imply rain in the hills higher up. But this particular conjunction of antecedent circumstances (e.g. the appearance of a particular kind of clouds accompanied by flashes of lightning, the roll of thunder and flights of Valákás—driven by the wind from a particular quarter of the horizon, and ascending in black masses, etc.) is as a rule the precursor of a particular assemblage of rain effects (rain with particular accompaniments). Again, this particular kind of flood (overflowing of the river-banks accompanied by muddy discoloration of the water, rapid currents, the bearing

down of tree-trunks, etc.) is always preceded by rain in the hills higher up (though, no doubt, other cases of floods in a river may be due to a breach in an embankment or the melting of the snows). In other words, the Buddhists (and the earlier Nyáya schools) avoid the difficulty arising from the plurality of causes by taking into consideration the accompanying phenomena, which, if properly marked, would always point to a specific cause of a specific effect, and *vice versa*.

I quote Nyáya authorities, but this device to obviate the plurality of causes is common to the early Nyáya and the Buddhistic systems.

पूर्ववत् । यत्र कारखेन कार्यमनुमीयते । उदाहरणम्—

नेषोन्नत्या भविष्यति वृष्टिरिति कारखेन कार्यानुमानम् । कथं पुनरस्य प्रयोगः । वृष्टिमन्तः एते नेशाः गम्भीरध्वनिवस्त्रे सति बहुवलाकावस्त्रे सति अचिरप्रभावस्त्रे सति उन्नतिमस्त्रात् वृष्टिमन्नेषवत् ।

शेषवत् (यत्र कार्येन कारखमनुमीयते)—उदाहरणम्—

उपरिवृष्टिमन्नेषसम्बन्धि नदीस्रोतः शीघ्रत्वे सति पूर्वोक्तलकाशादिवहनवत्वे सति पूर्वोक्त्वात् पूर्वोक्तमदीवदिति । (Udyotakara, Chap. I., Áhnika 1, Súra 5.) Váchaspati puts this clearly :— यद्यपि कारखमात्रं व्यभिचरति कार्योत्पादं तथापि यादृशं न व्यभिचरति तत्र निपुणेन प्रतिपन्ना भवितव्यम् । अन्यथा धूममात्रमपि वह्निसत्ता व्यभिचरतीति न धूमविज्ञेयो गमको भवेत् । In other words, a single condition called a cause is not invariably succeeded by the effect, nor does the effect-phenomenon in general point to any particular cause as antecedent, for there may be a plurality of causes of a general effect. The skilful observer will therefore select the full complement of causal conditions which is invariably succeeded by the effect, and also the specific effect (e.g. धूमविज्ञेय) which points to a specific causal antecedent. Compare also

Jayanta : “ We infer an effect from a specific assemblage of causes ”—न च कारकमात्रस्य हेतुत्वं कुमो येनास्य व्यभिचारः स्यात् । अपि च विशिष्टमेव कारणं हेतुः । न च कारकविज्ञेयो दुरुपगमः । गम्भीर-गच्छितारम्भनिर्भिक्षगिरिगह्वराः रोलम्बगवलव्यालतमालमलिनक्षिपः . . . वृष्टिं व्यभिचरन्तीह नैव प्रायः पयोनृषः । अनभ्युपगमे चैवमनुमानस्य जीवितम् । न स्यान्नृषविज्ञेयाद्यामपि बोधुमशक्तितः । Similarly, we infer a specific cause from a specific assemblage of effects :—ज्ञेयवदिति यत्र काव्येण कारणमनुमीयते यथा नदीपूरेण उपरितने देशे वृष्टिरिति । वृष्टिमत्पुष्टदेशसंसृष्टा ईयं नदी म्नेनिलकलुषत्वादिपिशिष्टपूरो-पेतत्वात् । यन्तु खेनुभङ्गहिमविलयनादिनापि नदीपूरोपपत्तिं दृष्ट्वा इति तत्रापि उच्यते —

प्रमातुरपराशौच्यं विश्लेषं यो न पश्यति ।

नानुमानस्य दोषोऽस्ति प्रमेयाव्यभिचारिणः ॥

(Nyáyamañjarí, Áhniká 2, on Gotama Sútra 5, Áhniká 1, Chap. I.)

A specific assemblage of causes, therefore, has only one specific assemblage of effects, and *vice versa*. Of course, the observer is to find out the essential or relevant features (as distinguished from the irrelevant ones) which, being included, will enable him to specify the particular cause of the particular effect.

Now, this being premised to be the exact meaning of the inseparableness or non-disjunction in the case of cause and effect, we come to the question with which we started—how is this relation to be ascertained or established between two phenomena or assemblages of phenomena? Obviously, mere observation of their agreement in presence (अन्वय) and their agreement in absence (अतिरेक) is no help in the matter. Take a concrete example. The ass is customarily employed to bring the fuel with which fire is lighted. In a hundred

cases you have observed the ass among the antecedents of smoke. In a hundred cases you may have observed that when there is no ass there is no smoke. This is no warrant for concluding a relation of cause and effect between an ass and smoke. It may be that you happen to have never observed smoke without an antecedent ass, or an ass without smoke following. Even this is of no avail. It is not agreement (unbroken and uniform though it be) in presence or in absence, or in both, that can settle the matter. There is one and only one way of ascertaining the causal relation. Suppose *A* with certain accompaniments is found to precede *B* immediately. Now, if *A* disappearing *B* disappears, even though all other antecedents remain and there is no other change in the case, then and then only can the causal relation be ascertained. It is not a mere table of positive instances or negative instances (अदर्शनात् न दर्शनात्); it is this Method, which we may term the Method of Subtraction (the Method of Difference in its negative aspect), that is the only exact and rigorous scientific Method. Such was the statement of the earlier Buddhists (*cf.* Udyotakara's and Váchaspati's report of the Buddhist doctrine of Inference—स हि प्रतिबन्धी न दर्शनाच्चावसेयः).

तस्मात् तादात्म्यतदुत्पत्तिनिबन्धनः एव प्रतिबन्धः । यदाह कार्यकारण-
भावाद्वा स्वभावाद्वा नियामकात् । अविनाभावनियमोऽदर्शनात् न दर्शनात्
—a Buddhist Káriká quoted in Váchaspati, Udayana, Sriharsha, Mádhava, etc.—कार्यकारणभावश्च इदम्—अस्मिन् सति
भवति—सतसु अपि तदन्वेषु अस्मिन्नसति न भवति—एवमाकारः । न
अन्वयव्यतिरेकाभ्यामतिरिच्यते । . . . (एवं तादात्म्यमपि विपर्यये वाचक-
प्रमाद्योपपन्ना निश्चेतव्यम् । . . . तस्मात् तादात्म्यतदुत्पत्तिभ्यामेव प्रतिबन्धो

नाम्यतः ।—Váchaspati, Tátparyyatiká, Chap. I., Áhniká 1, Sutra 5, अनुमानलक्षणम्—व्याभिप्रायः)

But the canon in this form is not sufficiently safeguarded against possible abuse. Two points have to be emphasised : (1) It must be carefully observed that no other condition is changed, (2) that the appearance and disappearance of *A* must immediately precede the appearance and disappearance of *B*. The definition of a cause is based on two fundamental characters : (1) the unconditional invariableness of the antecedence, and (2) the immediateness of the antecedence. The canon of the Method of Difference must therefore be stated in such a form as to emphasise each of these aspects. And one main difficulty in the practical application of the canon is that, along with the introduction or sublation of an antecedent, some other phenomenon may be introduced or sublated unobserved. As a safeguard against this radical vitiation of the Method, the later Buddhists formulated the canon of a modified Method, termed the Pañchakáraní, a Joint Method of Difference, which combines the positive and the negative Methods of Difference (the Method of Addition and the Method of Subtraction) in a series of five steps, and which equally emphasises the unconditionality and the immediateness of the antecedence as essential moments of the causal relation. This is neither agreement in presence nor agreement in presence as well as absence (the foundation of J. S. Mill's Joint Method of Agreement), but the Joint Method of Difference. The Pañchakáraní runs thus :—

The following changes being observed, everything

else remaining constant, the relation of cause and effect is rigorously established :—

First step—The “cause” and the “effect” phenomena are both unperceived.

Second step—Then the “cause” phenomenon is perceived.

Third step—Then, in immediate succession, the “effect” phenomenon is perceived.

Fourth step—Then the “cause” phenomenon is sublated or disappears.

Fifth step—Then, in immediate succession, the “effect” phenomenon disappears.

Throughout, of course, it is assumed that the other circumstances remain the same (at least the relevant or material circumstances).

This Pañchakāraní, the Joint Method of Difference, has some advantages over J. S. Mill's Method of Difference, or, what is identical therewith, the earlier Buddhist Method ; and the form of the canon, bringing out in prominent relief the unconditionality and the immediateness of the antecedence, is as superior from a theoretical point of view to J. S. Mill's canon, and is as much more consonant than the latter to the practice of every experimenter, as the Hindu analysis of Anumāna as a Formal-Material Deductive-Inductive Inference is more comprehensive and more scientific than Aristotle's or Mill's analysis of the Syllogism (or Mediate Inference).

But even the Pañchakāraní is no sufficient answer to the question with which we started. The Pañchakāraní

is only a method ; it shows only how in a particular case the relation of cause and effect is to be established (प्रतिबन्धहोपाय). But we want more than this—we require a warrant for the process. The Buddhists therefore supply the following proof of the Method : Doubt is legitimate, but there is a limit to doubt. When doubt lands you in an unsettlement of a fundamental ground of practice, and would thus annul all practical exercise of the will, the doubt must cease ; else the doubt would be suicidal or sophistical. In this particular case, when the Pañchakāraṇī is satisfied, the antecedent in question must be the cause, for there is no other antecedent to serve as cause ; the proof is indirect but rigid. If this be not the cause, there is no cause of the phenomenon. It was not, and it begins to be, without a cause ; which would be a contradiction of the rational ground of all practice, for all volitional activity proceeds by implication on the principle of causality. If things could happen without a cause, all our motives to action would be baffled. The link between a presentation and the instinctive volitional reaction would snap, and the circuit of consciousness would be left incomplete. In fact, the Buddhists go farther ; they hold causal efficiency (कार्यक्रिया) to be of the essence of empirical (relative) Reality. The proof of the Joint Method of Difference, then, lies in a strict application of the principle of causality in its negative form (viz., there can be no phenomenon without a cause), and the truth of this last is guaranteed by the same ultimate criterion of empirical (relative) Reality as the truth of Perception itself, viz. the

correspondence between the rational and the practical activity of the self.

But invariable concomitance (or non-disjunction), the Buddhists argue, has another form, *e.g.* the relation of the genus to the species. We may have perceived a hundred instances of the association of certain characters with certain others ; we may also have never perceived the former when the latter were absent ; but this would not enable us to generalise and establish invariable and unconditional co-existence. We must be first satisfied that there is identity of essence (तादात्म्य, स्वभाव). It is only when we perceive that the characters of a *Sinsapá* are co-inherent with the generic characters of a tree in the same individual object (a *Sinsapá*-tree before me), and when we further perceive that the characters are held together by the relation of identity of essence, that we can say that all *Sinsapás* are trees. For as there is identity of essence, a *Sinsapá* would not be a *Sinsapá* if it were not a tree ; it would lose its self-identity, which is a contradiction. Hence the relation of identity of essence (तादात्म्य, स्वभाव), as in the relation of the species to the genus, is the sole ground for establishing uniformity of co-existence (प्रतिबन्ध, स्वभावप्रतिबन्ध).

For the Buddhist Method of Induction in its later form, the Pañchakáraní, *vide* Sarvadarsana Saṅgrahá—Buddhist reply to the Chárváka attack on Inference :—

यदभ्यधायि अविनाभावो दुर्बोधि इति तदसाधीयः । तादात्म्यतदुत्पत्तिभ्यामविनाभावस्य सुज्ञानत्वात् । तदुक्तं—कार्यकारणभावात् वा स्वभावात् वा नियामकात् । अविनाभावनियमोद्देशेनात्र न दर्शेनात् । As for the Nyáya view, अन्वयव्यतिरेकी अविनाभावनिश्चायकी इति ।—the

Buddhist objects : ननु पक्षे साध्यसाधनयोरव्यभिचारो दुरवधारकः भवेत् । भूते, भविष्यति, वर्तमाने अनुपलभ्यमाने च व्यभिचारज्ञाया अनिवारकात् ।—the Nyáya retorts : ननु तथाविधस्थले तावत्केऽपि मते व्यभिचारज्ञा दुष्परिहरा इत ।—the Buddhist answers : नैवं बोधः, विनापि कारकं कार्यमुत्पन्नान् इत्येवं विधायाः ज्ञानायाः व्याघातावधिकतया निवृत्तत्वात् । तदेव हि चाज्ञज्ञोत यस्मिन्चाज्ञज्ञमाने व्याघातादयः नावतर्येयुः । तदुक्तं व्याघातावधिराज्ञा इति । तस्मात् तदुत्पत्तिनिश्चयेन अविनाभावो निश्चीयते । तदुत्पत्तिनिश्चयश्च कार्यहेत्वोः प्रत्यक्षोपलम्भानुपलम्भपक्षकनिवन्धनः । कार्यस्य उत्पत्तेः प्रागनुपलम्भः, कारणोपलम्भे सति उपलम्भः, उपलम्भस्य पश्चात् कारकानुपलम्भात् अनुपलम्भः इति पक्षकारस्या धूम-धूमश्च-जयो कार्यकारणभावः निश्चीयते । तथा तादात्म्यनिश्चयेन अपि अविनाभावः निश्चीयते । यदि शिक्षयाः वृक्षत्वम् अतिपतेत् स्वात्माननेव जज्ञात् इति विपक्षे बाधकप्रवृत्तेः । अत्रवृत्ते तु बाधके भूयः सहभावोपलम्भेऽपि व्यभिचारज्ञायाः को निवारयिता । शिक्षयावृक्षयोश्च तादात्म्यनिश्चयः वृक्षोऽर्थे शिक्षया इति सामानाधिकरस्यवलात् उपपद्यते तस्मात् कार्योत्पत्तौ कारकम् चात्मानम् अनुमापयत इति सिद्धम् । Sarvadarśana Saṅgrahá, Bauddha-Darśanam ; vide also Śrīdhara, Kandali.

The Nyáya Doctrine of Inference.—The Nyáya easily demolishes the Buddhist contention about identity of essence. The Nyáya writers, being realists, do not impugn the reality of the genus (जाति) like the nominalists or the nominalistic conceptualists ; but they point out that the inseparableness (or non-disjunction) in such cases can only be established by the experience of unbroken uniformity (अव्यभिचारित्व, i.e. by अनव्यव्यतिरेकी, दर्शनादर्शने). Uniform agreement in presence with uniform agreement in absence—not the mysterious identity of essence irresistibly perceived in any individual case or cases—is the only basis for constituting genera and species in natural classification. Indeed, some of the later Nyáya writers point out that individuals do not

always possess in nature all the characters that go to form the definition of the class to which they are referred.

Similarly, as regards the relation of cause and effect, a *nexus* is sometimes fancied to be perceived, a power in the cause to produce the effect (शक्ति), or an ultimate form (जातिस्वीकृत्य), which is supposed to be present whenever the effect (quality or substance) is produced (*cf.* Bacon's view of the "Forms" of Simple Qualities). All this is neither a matter of observation nor of legitimate hypothesis. There is nothing except the invariable time-relation (antecedence and sequence) between the cause and the effect. But the mere invariableness of an antecedent does not suffice to constitute it the cause of what succeeds; it must be an unconditional antecedent as well (अन्यथासिद्धिभूतस्य नियतपूर्ववर्तिता, being the definition of कार्यकारणभाव). For example, the essential or adventitious accompaniments of an invariable antecedent may also be invariable antecedents; but they are not unconditional, but only collateral and indirect. In other words, their antecedence is conditional on something else (न स्वातन्त्र्येण). The potter's stick is an unconditional invariable antecedent of the jar; but the colour of a stick, or its texture or size or any other accompaniment or accident which does not contribute to the work done (so far as we are considering it), is not an unconditional antecedent, and must not therefore be regarded as a cause. Similarly, the co-effects of the invariable antecedents, or what enters into the production of these co-effects, may themselves be invariable antecedents; but they

are not unconditional, being themselves conditioned by those of the antecedents of which they are effects. For example, the sound produced by the stick or by the potter's wheel invariably precedes the jar, but it is a co-effect, and *Ákása* (ether) as the substrate and *Vayu* (air) as the vehicle of the sound enter into the production of this co-effect; but these are not "unconditional" antecedents, and must therefore be rejected in an enumeration of conditions or causes of the jar. Again, the conditions of the conditions, the invariable antecedents of the invariable antecedents, are not unconditional. The potter's father is an invariable antecedent of the potter who is an invariable antecedent of the jar, but the potter's father does not stand in a causal relation to the potter's handiwork. In fact, the antecedence must not only be unconditionally invariable, but must also be immediate (अव्यवहितपूर्वकालावच्छेदेन कार्यदेशे सम्बन्धम्). Finally, all seemingly invariable antecedents which may be dispensed with or left out are *ipso facto* not unconditional, and cannot therefore be regarded as causal conditions. In short, nothing that is unnecessary is unconditional. For this class, *vide* *Visvanátha* :—नियतावश्यकपूर्वभाविनः अवश्यकूपनियतपूर्ववर्तिन एव कार्यसम्भवे । तद्विद्यम् (अतिरिक्तं) अन्यथासिद्धं—*Visvanátha*, *Siddhánta-Muktávali*, on *Śloka* 20. For example, it is the custom to point to spatial position or direction with the fingers; but finger-pointing, though invariably present, is not causally related to the perception of direction or spatial position, because we can imagine such perception without finger-pointing (अन्यथासिद्धतया अङ्गुल्युत्था निर्देशस्य दिक्प्रत्यक्षत्वेन न साभाविकः सम्बन्धः, *Váchaspati*, *Tátparyyatiká*, Chap. I.,

Áhnika 1, Súra 5. This shows that the doctrine of *अन्यथासिद्धिभूय* was long anterior to Gaṅgesa).

[Visvanátha in the Bhásha-Parichchheda mentions five kinds of *अन्यथासिद्ध*, conditional antecedents—(1) येन सहपूर्वभावः ; (2) यस्य वा कारणादाय (पूर्वभावः) ; (3) अन्यप्रति पूर्वभावे ज्ञाते यत्पूर्वभावविज्ञानम् ; (4) जनकं प्रति पूर्ववर्तिताम् अपरिज्ञाय यस्य (पूर्ववर्तिता) न गृह्यते ; and (5) अथापि यत् नियतावश्यकपूर्वभाविनः अतिरिक्तम् भवेत् (इतेषु पञ्चसु आवश्यकत्वसौ—Ślokas 19 and 20), यस्य खातन्त्र्येण अन्यव्यतिरेकी न स्तः किन्तु साकारणादायेव अन्यव्यतिरेकी गृह्यते तदन्यथासिद्धम्—Siddhānta-Muktāvali, *loc. cit.*—The Dinakarí points out that the first two cases are comprehended under the formula इतरान्वयव्यतिरेकप्रयुक्तान्वयव्यतिरेकज्ञातिवत् । There are several classifications of these irrelevant antecedents (*अन्यथासिद्ध*) ; I quote one of the best known.]

The unconditional (*अन्यथासिद्धिभूय*), as interpreted in this comprehensive sense, is a far more fruitful conception than Mill's, and is well adapted to its work—the elimination of the irrelevant factors in the situation. In the end, the discrimination of what is necessary to complete the sum of causes from what is dependent, collateral, secondary, superfluous, or inert (*i.e.* of the relevant from the irrelevant factors), must depend on the test of expenditure of energy. This test the Nyáya would accept only in the sense of an operation analysable into molar or molecular motion (*परिस्पन्द एव भौतिको व्यापारः करोत्यर्थः—अतीन्द्रियसु व्यापारो नास्ति—Jayanta, Mañjarí, Áhnika 1*), but would emphatically reject if it is advanced in support of the notion of a mysterious causal power or efficiency (*ज्ञप्ति*). With the Nyáya all energy is necessarily kinetic. This is a peculiarity of

the Nyáya—its insisting that the effect is only the sum or resultant of the operations of the different causal conditions—that these operations are kinetic, being of the nature of motion, in other words, holding firmly to the view that causation is a case of expenditure of energy, *i.e.* a re-distribution of motion, but at the same time absolutely repudiating the Sáukhya conception of power or productive efficiency as metaphysical or transcendental (अतीन्द्रिय), and finding nothing in the cause other than an unconditional invariable complement of operative conditions (कारणसामग्री), and nothing in the effect other than the consequent phenomenon which results from the joint operations of the antecedent conditions. (समुदितसकलकारकनिकरपरिस्थन्द एव—Jayanta. सामग्री कार्ये—सामग्रीकार्यत्वे तु कार्यमस्तु किमकारालपरिस्थित्या शक्या—Jayanta, *ibid.*, Áhnika 1, शक्तिनिराकरणम् । It may be noted that the Nyáya, while repudiating transcendental power (Śakti) in the mechanism of Nature and natural causation, does not deny the existence of metaphysical conditions like merit (धर्म), which constitute a system of moral ends that fulfil themselves in and through the mechanical system and order of Nature—*vide* Jayanta, अतीन्द्रियं किमपि कारणं कस्यितनेव धर्मादि—Áhnika 1, शक्तिनिराकरणम् ।)

The causal relation, then, like the relation of genus to species, is a natural relation of concomitance (व्यभिः स्थाभाविकः सम्बन्धः—Váchaspati) which can be ascertained only by the uniform and uninterrupted experience of agreement in presence and agreement in absence, and not by deduction from a certain *a priori* principle like that of Causality or Identity of Essence.

Nyāya objection to the Buddhist Method of Difference as a means of ascertaining Causality.—Take for example the Buddhist deduction of Causality in any particular conjunction by means of the negative Method of Difference, or of the Pañchakāraṇī. The ascertainment of the causal relation by these Methods is open to the following objections: (1) The unconditionality of the antecedent cannot possibly be ascertained. As the Chārvāka rightly points out, the Methods enable you to eliminate irrelevant antecedents that are or can be perceived; but the introduction or sublation of latent or undetected antecedents can be imagined, against which the Method of Difference is powerless. In the case of the production of smoke, for example, by fire—what if I say that an invisible demon intervenes in every case between the fire and the smoke, that this demon (विज्ञान) is the immediate antecedent and real cause of the latter, and that the fire is an accident which in every such case is brought about by its own causal antecedents? In saying this I do not go counter to the principle of causality, and am landed in no contradiction (आघात) such as strikes at the very roots of all practice, or baffles the completed circuit of consciousness, however much I may violate probability.

(2) In the second place, even supposing that the fire in this particular case (which satisfies the Method of Difference rigidly) is ascertained to be the cause of the smoke, how can I know that fire is the cause in other cases, or that there is no other cause? You will perhaps argue that if there were an *indefinite* number of causes of the same specific phenomenal effect, it would

violate the principle that phenomena are all conditioned, *i.e.* exist only under certain conditions (कारणविशेष), which is more comprehensive than the principle of causality, and the contradiction of which equally overthrows all rational practical activity. Yes, I accept the conditionality of phenomena, but this is not violated by supposing that one specific assemblage of phenomena has more than one cause. It is true that if you suppose such plurality of causes you cannot establish the invariableness of the particular conjunction (green-wood fire and smoke) which your Method of Difference fixes upon as a case of cause and effect; in other words, with your special principle of Causality so restricted, and without any general principle of Uniformity of Nature to fall back upon, you cannot ascertain from the present case, or from any number of similar cases that you may have observed, that *all* green-wood fires are followed by smoke, or that in a given case smoke has been preceded by fire—*i.e.*, you are helpless in demonstrating (or ascertaining indubitably) the relation of cause and effect. But this is an objection against your own position, not mine. Why not admit at once that certain phenomena are naturally connected (as invariable concomitants or antecedents) with other phenomena, and take your stand on observed concomitance (uniform and uninterrupted experience of agreement in presence as well as absence) without assuming causality as an *a priori* principle and making deductions therefrom, and without the trouble of ascertaining the relation of cause and effect in every individual case? I am free to admit that theoretical objections of irresistible force

(like those of the Chárváka sceptics) can be urged against this ascertainment of universal invariable and unconditional concomitance (व्याप्तिग्रहोपाय) on the basis of mere observation. Doubts of this kind can no more be laid by my view of the matter than by your canons of causality and essential identity (तदुत्पत्ति and तादात्म्य). Ultimately we all have to fall back on the rational practice of thinking persons (प्रेक्षावन्तः), and such persons are always content to act on practical certitude instead of hankering after an unattainable apodictic certainty in the affairs of life (प्रामाणिकलोकयाचाननुपालयता यथादर्शनं शङ्कनीयम्). This same practical certitude is also the ultimate warrant of the Deductive-Inductive Inference by which we ascertain the characters of things without direct perception and through the medium or instrumentality of a mark.

[To the earlier Buddhist canon of the Method of Subtraction, *i.e.* the negative Method of Difference, Udyotakara and Váchaspati, of the Nyáya school, pertinently and acutely object as follows :—

सत्यं यत् किञ्चित् क्वचित् दृष्टं तस्य यच्च प्रतिबन्धः, तद्विदः तस्य तत् गमकं तच्च इति अनुजानीनः । स एव तु प्रतिबन्धो न तावत् तदुत्पत्त्या सम्भवति । वा पुनरियं तदुत्पत्तिः । धूमस्य किं वह्नयनकारं भावः । स तादृशः अस्ति रासभस्यापि । तत्प्रतिबन्धोऽपि धूमः स्यात् । अथ तदनकारमेव भावः, न च रासभानकारं भवन्नपि तदनकारमेव भवति, तस्मिन् सति अपि अस्ति अग्नौ तद्भावात् । अस्ति अपि तस्मिन् सत्त्वाद्देव्यनवति वह्नी तद्भावात् । अथ यद्यपि धूमस्य वह्निभावानुविधानं तत्रोपलभं, तथापि देशान्तरादिषु तद्भावोऽस्य कुतस्त्यः । तथा हि भूयो भूयो रासभे दृष्टे धूमोदृष्टः, तद्भावे च अदृष्टः, न स तत्कार्यः । तज्जातीयस्यैव धूमस्य रासभं विना सति वह्नी भावात्, एवं सत्यपि अग्नौ पित्रायेन जनितो धूमः, क्वचिद्देशादौ तज्जातीय एव रासभवदवह्नयभावेऽपि पित्राचादेव भविष्यति, इति अवश्यं शङ्क्या भाव्यं नियानक अपश्यताम् । न च

सति भावनायं नियामकं, तस्य रासभादिषु अविज्ञेयात् । तदनन्तरमेव इति च अवधारणस्य शङ्कायामभावात् । अवधारणेन तु शङ्कापनयने परस्परामयप्रसङ्गात् ।

Buddhist reply:—स्यादेतत् । यो यो धूमोद्गः स सर्वज्ञेयात् आद्रेन्धनसहित वह्न्यनन्तरमेव, न पिज्ञाचानन्तरं । स च कादाचित्कतया निमित्तमपेक्षनाथो यदनन्तरमेव गम्यते तदेव अप्रतीतव्यभिचारं निमित्तं करोति, न तु प्रतीतव्यभिचारं रासभादि । नापि सर्वज्ञानुपलब्धिपिज्ञाचादिः । यदि न तन्निमित्तं कस्मात् विनाशपि वह्निं ज्ञप्तिं धूमा न उपलभ्यते । अथ असी (पिज्ञाचः) सर्वज्ञा वह्निसहितः तथा सति आद्रेन्धनवत् कथं वह्निरपि न कारयति । कारयति चेत् कथं तमन्तरेण धूमभावशङ्का । Now the phenomenon that is contingent (कादाचित्क) cannot be uncaused—अकारणस्य हि कार्यस्य नित्यं सर्वं असह्यं वा स्यात्, अनपेक्षत्वात् न कादाचित्कत्वम् । And with the limitation of a specific effect, there must be only one specific cause, for an unrestricted plurality of causes would amount to the denial of uniformity in causality (*i.e.* of the *unconditional invariable* antecedence)—

नापि अनेकं कारयति, अकारणत्वप्रसङ्गादेव । वह्न्यनन्तरमेव भाव इति हि धूमस्य वह्निकार्यत्वम् । स चेत् अवहरेरपि अनन्तरं, न एवकारार्थः स्यात्, इति न वह्नेः कार्यम् । एवम् अन्यस्यापि न कार्यम् । न हि अन्यानन्तरमेव भवति, वह्निरपि अनन्तरं भावात्, ततश्च अहेतुको धूमः स्यात् । तथा च कादाचित्कत्व-व्याहृतिः ।

Nyāya rejoinder:—सत्यम् । यद्यपि विना वह्निं नोपलब्धो धूमः, यद्यपि च पिज्ञाचानन्तरं नोपलभ्यते तेषामनुपलब्धेः, तथापि पिज्ञाचकार्यं एव धूमः । तत्र तत्र वह्निः कुतश्चित् स्वहेतोः उपनिपतितः, रासभ इव, न धूमस्य जनकः । तेन तदभावेऽपि तज्जातीय एव कारणभेदजन्मा कादाचित्क, कादाचित्को धूमः स्यात् । इति अग्निपुत्रिरेव शङ्कायाः । न च दृष्टसम्भवे नादृष्ट कस्यचित्तुं युक्तम् इति शक्यं भवन्निरवृत्तम् । अनुपलब्धिलक्षणप्राप्तस्य अज्ञाननिराकरणत्वात् (*vide Nyāya-Vindu*) । न च अनुपलब्ध्यनराशि अपि तन्निवेधे प्रभवति । तस्मात् अनन्तरमेव इति अवधारणाभावात् नैवं कार्यकारणभावावधारणं युक्तम् । न च यदन्यसहितानन्तरं उपलब्धं तत्, तदन्यरहितात् तस्मात् भवति भिन्नजातीयं भवति । उक्तं हि रामभस्महितात् वह्नेः यादृशो धूमः

तादृश एव तद्दृष्टितात् वहे रिति । तस्मादेवंविधा शङ्कापिशाची स्तनिवारकं तदुत्पत्तिनिश्चयमास्कन्दती न शक्या निवारयितुम् ।

The Nyáya proceeds to point out that what is contingent need not necessarily be produced by a cause. It is enough if there is natural connection with something else, a relation of antecedence and succession (or concomitance), without any element of productive efficiency or causation.

अपि चास्तु तदुत्पत्तिनिश्चयः तथाऽपि कस्मात् कारयमन्तरेण न कार्यं भवति । तथा च सति अनपेक्षतया कादाचित्कत्वविहितः इति चेत् । अस्तु तर्हि सम्बन्धः स्वाभाविकतया अन्यानपेक्षः अव्यभिचारो गमकत्वाङ्गम् । स च यो वा स वा भवतु । कृतं कार्यकारणभावावधारणायामेन । यथा चैतत् तथा अग्रे दर्शयिष्यामः ।—Váchaspati, Tátparyyatiká, Chap. I., Áhnika 1, Sútra 5, व्याप्तियहोपायविचारः ।]

The Nyáya Analysis of the Causal Relation continued: Co-effects.—In the enumeration of different varieties of irrelevant antecedents (अन्यथासिद्ध), we have already noticed that co-effects of the same cause are apt to be confounded as cause and effect. In some cases the co-effects may be simultaneous, e.g. the case of the ascending and the descending scale in a balance, which are co-effects of gravity (*vide* Pártha-sárathi Misra on Kumárilá, Śloka-Vártika—गुलानमनोब्रमनयोस्तु न निधः कार्यकारणत्वम्, उभयोरेककारणत्वात्,—Śloka 157, Śúnya-Váda). In other cases the co-effects may be successive effects of the same cause, and here the risk is great of mistaking the antecedent co-effect to be the cause of the succeeding co-effect, e.g. the case of ants moving in a line to carry their eggs upward, which is observed before the summer rains, where the movement of ants and the rains are not cause and effect, but successive

effects of the same cause, viz. the heat (उष्ण), which disturbs the elements, viz. the earth and the atmosphere (महाभूतक्षोभ); the ants being affected by this heat earlier than the atmospheric movements which bring the clouds and the rain.

(Udyotakara and Váchaspati: न च पिपीलिकास्य सञ्चारं वर्षस्य कारकमनुपलब्धवानर्थान् । असत्यपि तस्मिन् वर्षस्योत्पत्तेः । वर्षमूलकारकस्य तु महाभूतक्षोभस्य पिपीलिकासञ्चारं पूर्वकार्यम् । क्लृप्यमानाः क्लृप्यमानाः क्लृप्यमानाः भूमेनोष्णका खानि चकानि भूमिजानि उपरिहात् नयन्ति —Tátparyyatiká, II., 2, Súra 37.)

Synchronousness of Cause and Effect.—This is resolved into a case of simultaneous co-effects of the same ultimate cause, e.g. the ascent of one scale and the descent of the other in the balance, which are not related as cause and effect, but are simultaneous effects of gravity. In other cases the synchronousness is only apparent, the interval between the antecedent and the consequent being too small (सूक्ष्मकाल) to be apprehended (योगपञ्चाभिनान), e.g. in the case of the needle piercing a hundred soft lotus-petals laid one upon another, where the steps are really successive; or the illumination of the whole room by the light of a lamp, where the succession is unperceived owing to the inconceivable velocity of light (cf. Kumárilá, Śloka-Vártika—हेतुहेतुना सिद्धं योगपञ्चनिदर्शनम्,—यत् प्रदीपप्रभाशुक्लं, सूक्ष्मकालोऽस्ति तत्र नः । दुर्लभस्तु यथा वेधः पद्मपत्रशते तथा । Śunya-váda, Śloka 156-157.—I quote Mimánsá authorities, but the view is common to the Mimánsá and the Nyáya-Vaiseshika).

The Time-relation in a Chain of Causes and Effects.—A careful study of the time-relation in a chain of causes

and effects is a peculiarity of the Vaiseshika system (and the later Nyāya). A moment (ultimate unit of time, *Kṣana*, क्षण) is defined to be the time-interval between the completion of the sum of conditions and the appearance of the effect. The Vaiseshika conceives the unit to be determined by reference to the division of one atom from another (विभागानुत्पाद्यविभाग प्रागभाव-सम्बन्धकर्मोपच्छिन्नः कालः क्षणः—Śapta-Padārthī, Śivāditya—*i.e.* the ultimate unit of time is the time during which motion exists in an atom prior to its division from another atom, in a case of division due to motion). The Sāṅkhya, we have already seen, determines this ultimate unit by reference to the motion of a *Tanmātra*.

The number of such units will determine the time-interval between a given set of physical conditions and a particular effect, for between a so-called sum of causes and a so-called sum of effects there intervenes a series of atomic (or molecular) motions, with conjunctions and disjunctions which form the causal chain. However crude in the practical application, the fundamental idea is, in connection with the principle of work and energy (for which both the Sāṅkhya and the Nyāya-Vaiseshika furnish a rudimentary basis), immensely suggestive of a possible Time Calculus.

Plurality of Causes.—This will be discussed when we consider the relation of *Vyāpti* to the principle of Causality.

The Nyāya Ground of Inference—Vyāpti नियतसाहचर्ये.
—Inference, then, in the Nyāya, depends on the ascertainment, not of the causal relation, nor of

the relation of genus to species, but of a natural relation, between two phenomena, of invariable and unconditional concomitance (उपाधिभिर्भूतः स्वाभाविकः सम्बन्धः च्यातिः—Udyotakara and Váchaspati). Of the two phenomena so connected, one is called the Vyápya or Gamaka (the sign, mark, or indicator), and the other Vyápaka or Gamyá (the thing signified, marked, or indicated). In the relation of fire and smoke, for example, smoke is the Vyápya or Gamaka (sign or mark); and fire, the Vyápaka or Gamyá (the thing signified or marked). Now the relation of Vyápti between *A* and *B* may be either unequal or equipollent (विषमव्याप्ति or समव्याप्ति). When *A* is the sign of *B*, but *B* is not the sign of *A*, the Vyápti is one-sided or unequal, and here a Vyápti is said to exist between *A* and *B*, but not between *B* and *A*. For example, smoke is a sign of fire, but fire is not universally a sign of smoke. When, therefore, the relation of Vyápti is an unequal one, as between smoke and fire, it is expressed in the proposition—Wherever the Vyápya (sign or mark, *e.g.* smoke) exists, the Vyápaka (the thing signified or marked, *e.g.* fire) also exists. From this it follows by necessary implication (a sort of चर्चाव्याप्ति) that whenever the Vyápaka (*e.g.* fire) is absent, the Vyápya (*e.g.* smoke) is also absent (व्यापकाभावे व्याप्याभावः). Again, the Vyápti may be a mutual or equipollent one, *i.e.* *A* and *B* may be signs of each other, *e.g.* green-wood fire and smoke. Here each in turn is Vyápya and Vyápaka, and this is expressed in the two propositions :—(1) Wherever there is smoke there is green-wood fire, and (2) wherever

there is green-wood fire there is smoke. By necessary implication it follows—(1) Where there is no green-wood fire there is no smoke; (2) where there is no smoke there is no green-wood fire. We have seen that a Vyápti exists between smoke and fire, for wherever there is smoke there is fire, but we cannot say that a Vyápti exists between fire and smoke, for we cannot say that wherever there is a fire there is smoke. The combustion of an iron ball (अयोगोलक), for example, is a case of fire without smoke. But it would be correct to say that a Vyápti exists between green-wood fire and smoke, as well as between smoke and green-wood fire. The question, therefore, is: what is the relation between fire and smoke? The relation between fire and smoke is a conditional relation; *i.e.* on condition that the fire is green-wood fire, it would be a sign of smoke. In other words, a Vyápti implies unconditional invariable concomitance, and the relation between fire and smoke is not therefore a Vyápti (natural unconditional concomitance), for fire requires a “condition,” Upádhi, *viz.* green-wood, to be followed by smoke. Smoke, on the other hand, requires no “condition” to indicate fire. For the purposes of Inference, therefore, relations between phenomena may be considered as of two kinds: (1) Contingent conditional relations, holding good on the fulfilment of a certain condition or Upádhi, and (2) Vyápti, or unconditional invariable relation, between a mark and that which it marks, a relation without any Upádhi or determining condition (उपाधिविधुरः सम्बन्धः). It is this latter kind of relation that serves as the ground of inference. If we can ascertain

that a Vyápti exists between *A* and *B*, then *A* is a sign of *B*, and an inference of the presence of *B* from the presence of *A*, and of the absence of *A* from the absence of *B*, would be warranted. The question, therefore, is, how to ascertain the relation of Vyápti between two phenomena.

Ascertainment of Vyápti according to the early Nyáya (आदिग्रहोपाय).—Briefly speaking, the observation of agreement in presence (सन्वय) as well as agreement in absence (अतिरेक) between two phenomena, with the non-observation of the contrary (अभिचारदर्शनेन), is the foundation of our knowledge of Vyápti (दर्शनादर्शने—Váchaspati). This suggests a natural relation (स्वाभाविकसम्बन्ध—Váchaspati) of invariable concomitance (नियतसाहचर्य—Váchaspati) between the phenomena, which is fortified by our non-observation (अदर्शने) of the contrary (अभिचार). But this does not establish the unconditionality of the concomitance (उपाधिविधुरसम्बन्ध), which is essential to a Vyápti. We have therefore to examine the cases carefully to see if there is any determining condition (Upádhi—*i.e.* some hidden or undetected but really operative or indispensable accompaniment) which conditions the relation between the supposed sign or mark (Gamaka) and the supposed signate (thing signified, Gamyá). Now let us consider what constitutes an Upádhi. It is a circumstance which always accompanies, and is always accompanied by, the supposed signate (the thing signified, Gamyá), but does not invariably accompany the supposed sign or mark (Gamaka). If, therefore, in the set of positive instances where both the sign and

the signate are present, nothing else is constantly present, there can be no Upádhi. Or, again, if in the set of negative instances where both the sign and the signate are absent, no other material circumstance is constantly absent, there is no Upádhi. This follows from the very definition of an Upádhi. It is impracticable to fulfil these requirements rigorously. Still, every one of the accompanying circumstances (of course the likely ones) may be taken successively, and it may be shown that the concomitance continues even when the suspected Upádhi (इङ्गितोपाधि) is absent, and therefore it cannot be the Upádhi. And this is to be fortified by the observation of uniform and uninterrupted agreement in absence (Vyatireka) between the two concomitant phenomena. In this way, when we have disproved all suspected Upádhis, we conclude by establishing the Vyápti. It is true that we may still go on doubting; but doubt has a certain limit for the "experimenter" and the thinking person (परोक्षक, प्रेक्षावान्). When doubt overthrows the foundation of all rational practice (प्रानाधिकलोकयात्रा), or leads to a stoppage or arrest of all practical activity (लोकव्यवहार), it stands *ipso facto* condemned, and must be abandoned (व्याघातावधिराङ्गुला—Śrīharsha and Udayana; व्याघात is mentioned by Vāchaspati). Thus it is that Vyápti is ascertained. In this way we observe innumerable instances of Vyápti. Now, by means of repeated observations of this kind (भूयोदर्शनेन) we have established the principle of the Uniformity of Nature (सम्भावप्रतिबन्ध), and also of Causality; and these two principles thus ascertained may be made use of in their turn as the basis of an argumentation or

deduction (Tarka, Úha, तर्क) to confirm a particular Vyápti in a particular case. Tarka or Úha, then, is the verification and vindication of particular inductions by the application of the general principles of Uniformity of Nature and of Causality, principles which are themselves based on repeated observation (भूयोदर्शन) and the ascertainment of innumerable particular inductions of uniformity or causality (भूयोदर्शनजनितसंस्कारसहितम् इन्द्रियमेव साभाविकसम्बन्धग्राहि—Váchaspati). Thus Tarka also helps in dispelling doubt (सन्देह). Śríharsha, however, questions the validity of this verification—*cf.* the well-known couplet ending तर्कः शङ्कावधिः कुतः ।

It will be seen that the process of disproving all suspected Upádhis (उपाधिशङ्कानिरास), in the early Nyáya, answers exactly *as a process* to Mill's Method of Agreement. In fact, the disproof of a suspected Upádhi by pointing to instances of agreement in presence (सन्वय), even in the absence of the Upádhi, fortified as this is by the instances of agreement in absence (व्यतिरेक), virtually amounts to Mill's Joint Method of Agreement. But the fundamental difference is this : Mill's Method of Agreement is formulated in view of the phenomena of causation (including co-effects, etc.), and, as usually enunciated, confessedly breaks down in dealing with cases of Uniformities of Co-existence unconnected with Causation ; the Nyáya Method, based on the disproof of suspected Upádhis, is a more daring and original attempt, and is far more comprehensive in scope, being applicable to all Uniformities of Co-existence and of Causation alike. And this the Nyáya successively accomplished by introducing the mark of unconditionality (उपाधिविधुरता)

into the relation of Vyápti (Concomitance), even as the same mark of unconditionality (अन्यथासिद्धिशून्यता) had been previously introduced into the definition of Causality (कार्यकारणभाव). The difference between the early Nyáya and the Buddhist systems may be briefly put thus:—The former relied on empirical induction based on uniform and uninterrupted agreement in Nature, and accordingly regarded the Method of Agreement as the fundamental Method of Scientific Induction, founding Inference on Vyápti, to which they subordinated Causality in the doctrine of Method; the latter assumed two *a priori* principles, viz. causality and identity of essence, deduced the canon of the Method of Difference by an indirect proof from the principle of Causality, and made this Method the foundation of all scientific Induction of Causality, just as they based all natural classification of genera and species on their *a priori* principle of Identity of Essence.

Texts from the early Nyáya :—

(a) Method of Agreement and the Joint Method without the device of the Upádhi :—

Cf. Jayanta on साहचर्ये—तस्मिन् सत्येव भवने न विना भवन् ततः । अयमेवाविनाभावो नियमः सहचारिता । ‘तस्मिन् सत्येव,’ “only this remaining throughout,” while others change—implying the Method of Agreement. The set of positive instances, in which this antecedent alone is constant, must be supplemented by a set of negative instances (agreement in absence):—अतिरेकनिश्चयमन्तरेण प्रतिबन्धयह्यानुपपत्तेः । नियमश्चायं उच्यते यत् तस्मिन् सति भवन् ततो विना न भवन् इति भूयोदर्शनम् । तच्च तस्मिन् सति भवन् इत्यन्वयमात्रपरिच्छेदात् अगृहीतो नियमः स्यात् । ततो

विना न भवन् इत्यस्य अर्थस्य अपरिच्छेदात् इति—Jayanta, *Áhnika* 2, अतिरेकव्याप्तिनिश्चयावश्यकत्वं ।

(b) Doctrine of the Upádhi: unconditional concomitance distinguished from conditional :—

यो वा स वा असु सम्बन्धः यस्य असी खाभाविको नियतः स एव गमकः, गम्यश्च इतरः सम्बन्धीति युज्यते । तथा हि धूमादीनां वह्न्यादिसम्बन्धः खाभाविकः । ननु वह्न्यादीनां धूमादिभिः । उपलभ्यन्ते ते हि विनापि धूमादिभिः । यदातु आर्द्रेन्वनादिसम्बन्धम् अनुभवन्ति तदा धूमादिभिः सह संबध्यन्ते । तस्मात् वह्न्यादीनाम् आर्द्रेन्वनाद्युपाधिकृतः सम्बन्धो न खाभाविकः । ततो न नियतः । खाभाविकसु धूमादीनां वह्न्यादिसम्बन्ध उपायेः अनुपलभ्यमानात् क्वचित् अभिचारस्य अदर्शनात् अनुपलभ्यमानस्यापि कल्पनानुपपत्तेः । अतो नियतः सम्बन्धः अनुमानाङ्गम् ।

(c) Concomitance sufficient without causal *nexus* :—

The Buddhist objects: In Nature everything is connected with everything else. Hence, if there were no *nexus* of causality between antecedent and consequent, everything might follow from everything else. The Nyáya replies: You admit uniformities (of co-existence, etc.) other than causal; so you confess that a natural fixed order can exist without the causal *nexus*

(d) An Upádhi, how established and how disproved :—

The Nyáya then proceeds to show how an Upádhi is established, or how disproved by observation :—
तत्र वस्त्रेः अनार्द्रेन्वनस्य विना धूमम् अयोगोलकादी दर्शनात् आर्द्रेन्वनोपाधिः अस्य धूमेन सम्बन्धः न तु खाभाविक इति निश्चीयते । धूमविशेषस्य तु विना वह्नित् अनुपलभ्यात्, उपाधिभेदस्य च अदृश्यमानस्य कल्पनायां प्रमाणाभावात्, विशेषवस्तुस्य च संज्ञयस्य अनुपलब्धपूर्वो अनुत्पादात्, उत्पादे च अतिप्रसङ्गात् प्रेक्षावत् प्रयुक्त्येदात्, खाभाविकः सम्बन्धः अवधार्यते ।

(e) General Method of Induction by exhaustion

of the Upádhi, more comprehensive than Mill's Joint Method :—

For the definition of an Upádhi, *vide* Śrīharsha and Udayana : अथाप्रसाधनो यः साध्यसमव्याप्तिः उच्यते स उपाधिरिति । Hence, to avoid an Upádhi (which is साध्यसमव्याप्तिः), the constant presence of anything relevant other than the sign and the signate in the positive instances (of agreement in presence, अन्यथ), and the constant absence of any such thing in the negative instances (of agreement in absence, अतिरेक) must be safeguarded against. This amounts to Mill's Joint Method.

(f) Suspicion of non-perceptible Upádhi—Limits of legitimate doubt :—

न च अदृश्यमानोऽपि दर्शनानर्हता साधकवाधकप्रमाणाभावेन संदिग्धानाम उपाधिः स्थाभाविकत्वं प्रतिवर्त्तति इति साम्प्रतम् । अवश्यं शङ्कया भवितव्यं नियामकाभावादिति दत्तावकाशा खलु ईयम् प्रमाणात्मन्यौदात्तिकमेव शङ्का पिशापी लम्बप्रसारा न क्लिप्तं नास्तीति नेयं क्लिप्तं प्रवर्त्तेत । सर्वत्रैव कस्यचित् कथञ्चित् अनर्थस्य शङ्कास्पदत्वात् । अनर्थशङ्कायाश्च प्रेषावर्त्ता निवृत्तवृत्तत्वात् । अन्यथा किञ्चाक्षयानोपयोगेण अपि मरणादिदर्शनात् । तस्मात् प्रामाणिकलोकवाचान् अनुपालयता यथादर्शने शङ्कनीयम् । . . . तन्मादुपाधिं प्रयत्नेन अन्वियन्तो-ऽनुपलभमाना नास्तीति अवगम्य स्थाभाविकत्वं सम्बन्धस्य निश्चिनुतः ।—

(g) Tarka, Úha : Deductive verification of particular inductions by applying the two fundamental inductions of Uniformity of Nature and Causality :—Doubt finally dispelled :—

Now innumerable particular uniformities of this kind (Vyáptis) are observed, and as a result of this repeated observation a belief in the Uniformity of Nature (स्थावप्रतिबन्ध), as well as in the principle of Causality (कार्यकारणभाव), is generated in the mind, a belief which has evidential value and validity. It is not

intuition (न मानसम्) but a mental pre-disposition based on uniform and uninterrupted experience (भूयोदर्शनमनित-संस्कारसहितम् इन्द्रियमेव स्वाभाविकसम्बन्धग्राहि—यत्र भूयोदर्शनम् असाधारणम् इति प्रमाणाकारं जातम्). Then, armed with these new resources, the belief in uniformity and in causality as general principles, we proceed to fortify our particular inductions (Vyáptis), whether of Uniformity of Nature or of Causality, by indirect deduction from these general principles :—We argue : If, under these observed circumstances, *A* were not the mark of *B*, the principle of Uniformity of Nature would be violated—Nature would not be uniform—or, if under these observed circumstances *A* were not the cause of *B*, the principle of Causality would be violated, the phenomenon *B* would be without a cause ;—and such indirect proof (तर्क, ऊह) gives us the overwhelming probability which we call practical certitude, and on which every reasonable man (every thinking and judging person) proceeds to act in due natural course.—स्वभावतश्च प्रतिबद्धा हेतवः स्वसाधनेन, यदि साध्यमकारेण भवेद्युः, स्वभावादेव प्रत्यवेरन्निति तर्कसहायः अनिरस्तसाध्यव्यतिरेकवृत्तिसंदेहा यत्र दृशाः, तत्र स्वसाध्यम् उपस्थापयन्मेव ।—Váchaspati, I., 1, Sútra 5 ; cf. also I., 1, Sútra 40 : ऊहः कारणस्योपपत्त्या सभवेन ज्ञायते । कारणसम्भवे कार्यस्य असत्त्वात् ।

Instances of Vyápti (uniformity) not comprehended under Causality, or the relation of genus and species :—The Nyáya points out that the relations of cause and effect and of genus and species do not exhaust the grounds of Inference. There are cases of Inference based on Vyápti (*i.e.* on invariable and unconditional concomitance) which come neither under Causality (तदुत्पत्ति) nor under Identity of Essence (तादात्म्य).

Váchaspati notes that to-day's sunrise and yesterday's sunrise, the rise of the moon and the tide in the ocean, the relative positions of the stellar constellations, are instances of Vyápti (invariable concomitance) between phenomena which are neither related as cause and effect nor as genus and species. Jayanta adds the conjunction of sunset with the appearance of the stars; of ants moving in procession (with their eggs) with the approach of the rains; of the rising of the constellation Agastya (Canopus) above the horizon with the drying-up of rivers; of the spring-tide with the full moon; and dismisses as sophistical and far-fetched the Buddhist attempt to explain all these cases by means of causality. We have seen that the Nyáya and the Mimánsá reduce most of these conjunctions to cases of co-effects of the same cause, co-effects which may be either simultaneous or successive.

अपि च अज्ञानस्य सवितुरुदयस्य अस्तनेन सवितुरुदयेन, चन्द्रोदयस्य च समानकालेन समुद्रवृष्टा . . . न कार्यकारणभावः तादात्म्यं वा । अपच दृष्टो-
गम्यगमकभावः ।—Váchaspati, Tátparyyatiká, I., 1, Súra 5 ;
cf. also Jayanta, Nyáyamañjarí : अन्येषामपि हेतूनां भूत्वा जगति
दर्शनात् । सूर्योस्तनयमालोक्य कल्प्यते तारकोदयः । पूर्णचन्द्रोदयाद्दृष्टिरम्बुधेर-
वगम्यते । उदितेनानुमीयन्ते सरितः कुम्भयोगिनः । शुष्यत्पुलिनपथेन-
विश्रान्तस्वर्गपथः । पिपीलिकाश्चरन्तेऽनुमितवृष्टयः । भवन्ति पथिकाः
पर्यकुटीरकरणोद्यताः ।

Vyápti between Cause and Effect—Relation of Causality to Vyápti :—

On the Buddhist (and early Nyáya) view that one specific assemblage of "effect" phenomena has one specific assemblage of causal conditions, there would be two aggregates—the sum of causal conditions (कारणसामग्री)

and the sum of effects (कार्यैकानयो). For example, fire requires green-wood to complete the sum of causal conditions to give rise to smoke with some particular marks (धुनविज्ञेय—बहुलपाकुतादिधर्मे विशिष्ट, Jayanta, II. ; compare Gaṅgeśa, कृष्णागुरुप्रभववह्निमानयं कदुकादुरभियादुरधूमवत्त्वात् । —Chintāmani, Anumana, Viruddha-Siddhānta). Here, between an effect and a single condition (termed a cause) there is a relation of Vyāpti. The effect is Vyāpya or Gamaka (the sign or mark); the cause (or condition) is Vyāpaka or Gamyā (the thing signified). In other words, the presence of the effect indicates the presence of the causal condition, and the absence of the causal condition will by implication indicate the absence of the effect. Smoke of this particular kind is supposed to be an effect of which there is one and only one assemblage of causal conditions (fire and green-wood); hence, where there is smoke there is fire, and when there is no fire there is no smoke.

Now introduce the complication of the plurality of causes :—Fire, for example, is the effect of several assemblages, *e.g.* (1) blowing on heated grass ; (2) focussing rays through a lens on a combustible like paper or straw ; (3) friction with the fire-drill, etc. Here each assemblage is regarded as a sum of causes. But in this case there is no Vyāpti between the effect “fire” and any particular assemblage of causal conditions, say of the lens or the fire-drill ; for the presence of fire does not indicate the presence of the lens or the fire-drill assemblage, nor does the absence of either of the latter in particular indicate the absence of fire. Indeed, in such a case the effect “fire” is not a mark or sign

(Gamaka or Vyápya) of any one in particular of the different possible causal assemblages, though each of these particular assemblages of causal conditions is a mark or sign (Gamaka or Vyápya) of fire.

The plurality of causes requires a further consideration in the light of the definition of the causal relation. A cause is defined to be the unconditional invariable antecedent. From the unconditionality it follows that the entire sum of conditions, and not one single condition, is, properly speaking, the cause. In view of the plurality of causes, an invariable antecedent must be taken to mean that any particular cause (*i.e.* assemblage of causal conditions) is invariably followed by the effect—not that the effect is invariably preceded by any particular cause.

Popularly, a single condition, say the lens or the fire-drill, is said to be a cause of fire ; but, in view of the plurality of causes, this is apt to be misleading, as there is no Vyápti in this case ; the lens or the fire-drill is no more a mark of fire than fire is a mark of the lens or the fire-drill.

The plurality of causes strains the definition of a cause, and undermines the relation of Vyápti between an effect and a cause. Any particular cause (causal aggregate) still indicates the effect, but not *vice versa*. The earlier Nyáya (down to Váchaspati and Jayanta) obviated the plurality, as we have seen, by introducing distinctive marks in the effect such as would indicate a single specific cause (कार्यवैलक्षण्य or कार्यभेद indicating कारकवैलक्षण्य or कारकभेद). Some, indeed, went farther and held that when the antecedent causal assemblages

differ in kind, the effect-phenomena, though apparently the same, do really differ specifically (or in kind)—कारणवैजात्यत् कार्यवैजात्यम् । But the Nyáya discards this hypothesis; the fire is the same, though the possible causes (or causal aggregates) differ, *e.g.* the lens, the drill, etc. But the effect-phenomenon to which we attend is not the only effect; in the case of plurality of causes we must carefully examine the accompaniments of the effect, *i.e.* the sum of effects, and the examination will show some distinctive or specific circumstance or accompaniment which will enable us to definitely determine the particular assemblage of causal conditions that must have preceded in the case under examination. This is the device of the earlier Nyáya as well as of the Buddhists, as we have seen; but the later Nyáya doubts the practicability as well as the theoretical validity of such a step on an unrestricted assumption of the plurality of causes, and feels troubled by the circumstance that no effect for which more than one cause (or causal aggregate) can be assigned, can be regarded as a mark or sign (Gamaka or Vyápya) of any one of the causes in particular. Accordingly, some adherents of the later Nyáya advanced the proposition that when more than one causal aggregate can be supposed for any effect, the latter is a mark or sign (Gamaka or Vyápya) not of any one of the causal aggregates in particular, but of one or other of them; and the absence not of one such cause, but of each and every one of them, alone indicates the absence of the effect. A cause therefore should be defined to mean *one or other* of the possible alternative aggregates

which, being given, the effect follows invariably and unconditionally. If we ask what is the defining mark (or quiddity) of the cause (कारणतावच्छेदक), we are told that it is *one-or-otherness* (अन्यतमत्व), and nothing else; others cut the Gordian knot by assuming that the different possible causes of the same effect possess a common power or efficiency (अतिरिक्तशक्ति), or a common "form" (जातिस्वीकृत्य), which accounts for the production of a common effect. The latter is therefore a sign or mark of this power (शक्ति) or this form (जातिस्वीकृत्या), which is manifested by each of the causal aggregates. This hypothesis (कल्पना), they hold, is simpler and more plausible than the hypothesis of specific differences latent in the apparently identical effect of a plurality of causes (कारणवैजात्यात् कार्यवैजात्यम्).

Cf. Dinakarī on the Siddhānta-Muktavali: केचित्तु वदन्ति प्रति नृशुभकारसंयोगादीनां नृशुभकारसंयोगत्वादिरूपेण कारणतया व्यभिचारेण असम्भवात् अतिरिक्तशक्तिसिद्धिः । न च नृशुभकारयोः अरश्चिनिर्मेन्वोः शशितरश्चिकिरणयोश्च सम्बन्धस्य जन्यतावच्छेदकं बहिर्वृत्ति-वैजात्यत्रयं कल्पयामिति न व्यभिचार इति वाच्यम् । तत्रान्यतावच्छेदकवैजात्यत्रय-कल्पनामपेक्ष्य तत्तत्सम्बन्धानां एकशक्तिमत्त्वेन कारणत्वकल्पनाया एव लघुत्वेन न्याय्यत्वात् इत्याहुः । तत्र । . . अन्यतमत्वेन कारणतासम्भवात् . . . परे तु नृशादिसम्बन्धकालीनवायुसंयोगादीनां एकशक्तिमत्त्वेन हेतुतामादाय विनिगमनाविरहात् न शक्तिसिद्धिः इत्याहुः । Śloka 2; *cf.* also, नृशारश्मिसम्बन्धतमत्वं कारणस्य विनिगमकम् ।

Cf. Udayana, Kusumāñjali, Stavaka 1: कथं तर्हि नृशारश्मिशिष्यो भवन्नाशुशुद्धिरेकजातीयः । एकशक्तिमत्त्वात् इति चेत् न । यदि हि विजातीयेषु अपि एकजातीयकार्यकारण-शक्तिः समवेयात्, न कार्यतात् कारणविशेषं क्लृप्तं अनुमीयेत । कारणव्यावृत्त्या च न तज्जातीयस्यैव कार्यस्य व्यावृत्तिरवसीयेत । . . . एतेन सूक्ष्मजातीयमिति निरस्तम् । अवहरेरपि तत्स्वीकृत्यात् भूभोत्पत्त्यापत्तेः ।

The scientific Methods already noticed—the Joint Method of Difference (the Pañchakāraṇī) and the Joint Method of Agreement (Vpāptigraha with Upādhisānkānirasa and Tarka)—are not the only methods of ascertaining causality or concomitance, or establishing a theory (सिद्धान्त); nor are these Methods always practicable. Very often we reach the explanation of a fact (उपपत्ति) by means of a hypothesis (कल्पना) properly tested and verified (निर्णीत). A legitimate hypothesis must satisfy the following conditions:—(1) the hypothesis must explain the facts (दृढसिद्धि or उपपत्ति); (2) the hypothesis must not be in conflict with any observed facts or established generalisations (दृढसिद्धये हि चदृष्टं कल्प्यते, न दृढविधाताय—Jayanta, Nyāyamañjarī, Áhnika 1); (3) no unobserved agent must be assumed where it is possible to explain the facts satisfactorily by observed agencies (यदि चदृष्टमन्तरेण दृष्टं न सिद्धति कामनदृष्टं कल्प्यतान्, अन्यथाऽपि तदुपपत्तौ किं तदुपकल्पनेन *ibid.*); (4) when two rival hypotheses are in the field, a crucial fact or test (विनिगमक, *ratio sufficiens*) is necessary; the absence of such a test (विनिगमनापिरह) is fatal to the establishment of either; (5) of two rival hypotheses, the simpler, *i.e.* that which assumes less, is to be preferred, *ceteris paribus* (कल्पनाह्लाषव *versus* कल्पनागौरव); (6) of two rival hypotheses, that which is immediate or relevant to the subject-matter is to be preferred to that which is alien or remote (प्रचनोपस्थितत्व); (7) a hypothesis that satisfies the above conditions must be capable of *verification* (निर्णीय) before it can be established as a theory (सिद्धान्त). The process of verification of a hypothesis consists in showing that

it can be deduced as a corollary from (or is involved by implication in) some more general proposition which is already well established (*cf.* Vatsyayana's exposition and illustration of Verification, निर्णय—including both the Deductive Method and Colligation):

This doctrine of Scientific Method, in Hindu Logic, is only a subsidiary discipline, being comprehended under the wider conception of Methodology, which aims at the ascertainment of Truth, whether scientific (Vijñána) or philosophical (Jñána) (मोक्षे श्रीज्ञानं स्यात् विज्ञानं शिष्यशास्त्रयोः, Amara-Kosha); the latter being the ulterior aim. In the investigation of any subject, Hindu Methodology adopts the following procedure: (1) the proposition (or enumeration) of the subject-matter (Uddesa), (2) the ascertainment of the essential characters or marks, by Perception, Inference, the Inductive Methods, etc.—resulting in definitions (by लक्षण) or descriptions (by उपलक्षण); and (3) examination and verification (परीक्षा and निर्णय). Ordinarily the first step, Uddesa, is held to include not mere Enumeration of topics, but Classification or Division proper (विभागः उद्देशरूपानपायानु उद्देश एवासी । सामान्यसंज्ञया कीर्तनमुद्देशः प्रकाशभेदसंज्ञया कीर्तनं विभाग इति—Jayanta, Mañjarí); but a few recognise the latter as a separate procedure coming after Definition or Description. Any truth established by this three-fold (or four-fold) procedure is called a Siddhánta (an established theory). Now the various Pramánas, Proofs, *i.e.* sources of valid knowledge, in Hindu Logic, viz. Perception, Inference, Testimony, Mathematical Reasoning (सम्भव, including Probability in one view), are only operations subsidiary to the

ascertainment of Truth (तत्त्वनिर्णय). And the Scientific Methods are merely ancillary to these Pramánas themselves.

I have explained the principles of the Hindu doctrine of Scientific Method, avoiding the technicalities of Logic as far as possible; and I cannot here enter upon the logical terminology or the logical apparatus and machinery, which would require a separate volume to themselves. For these I would refer the reader to my Paper on Hindu Logic as also for an account of the later Nyáya (न्यायशास्त्र), which, in spite of its arid dialectics, possesses a three-fold significance in the history of thought: (1) logical, in its conceptions of Avachchedaka and Pratiyogi, being an attempt to introduce quantification on a connotative basis, in other words, to introduce quantitative notions of Universal and Particular, in both an affirmative and a negative aspect, into the Hindu theory of Inference and Proposition regarded connotatively as the establishment of relations among attributes or marks; (2) scientific, in its investigation of the varieties of Vyápti and Upádhi (and of अवयवाधिकार), being an elaboration of Scientific Method, in the attempt to eliminate the irrelevant; and (3) ontological and epistemological, in its classification and precise determinations of the various relations of Knowledge and Being, with even greater rigidity and minuteness than in Hegel's Logic of Being and Essence. I will conclude with a few observations on Applied Logic, *i.e.* the logic of the special sciences, which is such a characteristic feature of Hindu scientific investigation. What is characteristic

of the Hindu scientific mind is that, without being content with the general concepts of Science and a general Methodology, it elaborated the fundamental categories and concepts of such of the special sciences as it cultivated with assiduity, and systematically adapted the general principles of Scientific Method to the requirements of the subject-matter in each case. The most signal example of applied logic (or Scientific Method) worked out with systematic carefulness is the Logic of Therapeutics in Charaka, a Logic which adapts the general concepts of cause, effect, energy, operation, etc., and the general methodology of science, to the special problems presented in the study of diseases, their causes, symptoms, and remedies (*vide* Charaka, *Vimánasthána*, Chap. IV.; also *Sutrasthána*; *vide* my Paper on Hindu Logic). Here I will give an illustration of Applied Methodology from the science of Analytical and Descriptive Grammar. Patañjali, in the *Mahábháshya* (*circa* 150 B.C.), is very careful as regards Methodology. I take no note now of the philosophical presuppositions of his philology (*vide* my Paper on the Hindu Science of Language), but will confine myself to his presentation of the Applied Logic of Descriptive and Analytical Grammar. The sentence is the unit of speech, as every Hindu philologist contends, but the first business of Analytical Grammar is to analyse the sentence into its significant parts and their coherent relations to one another. Assuming that articulate sounds are significant, the question is: how is the sentence, which is the unit of articulate speech, broken up into significant words and their mutual

relations? Patañjali answers that this is done by an instinctive use (*cf.* Vāchaspati's भूयोदर्शनजनितसंस्कारम् इन्द्रियम्) of the Joint Method of Difference (combined Addition and Subtraction), fortified by the Joint Method of Agreement (अन्वयव्यतिरेकी). Patañjali starts with a simple case. Take the two sentence-units: Pathati (he reads) and Pachati (he cooks). Suppose you start with the assumption that these sounds are significant, and that *separate elements have separate meanings*. Then you hear Pathati, and, at the same time, a man reading is pointed at. Then the assemblage of sounds Pathati (*i.e.* Path + ati) stands for the assemblage "one reads" (*i.e.* the action reading + an individual agent). Similarly, by finger-pointing or other indication, you find that the assemblage Pachati (*i.e.* Pach + ati) stands for the assemblage "one cooks" (*i.e.* the action cooking + an individual agent, say the same agent as before).

Now look at the groupings:—

Path + ati = reading + one agent.

Pach + ati = cooking + one agent.

From repeated observation of similar groupings, one is led to conclude that Path is the invariable concomitant of the action "reading," because the disappearance of the former (the other element remaining) leads to the disappearance of the latter (a rough Method of Difference by subtraction—हीयते); that Pach is the invariable concomitant of the action "cooking," because the introduction of Pach (with nothing else added) leads to the introduction of the action "cooking" (a rough Method of Difference by addition—उपजायते); and

that Ati, which is the only "common antecedent" (अन्वयी), is the invariable concomitant of "one agent," which is the only common "consequent" (अन्वयी). In fact, the last should come first by the Method of Agreement, then the other two, either by Residue or by Joint Agreement in presence and absence (अन्वयव्यतिरेकी). So far all is plain sailing, though only very simple and very rough applications of the Methods are given. But—and this is the point—throughout the argument it is assumed that one sound is the concomitant of one idea; in other words, there is no plurality of causes to vitiate the application of the Method of Agreement in the above example. And now the objection is advanced that this basal assumption is untrue. The same sound is not the concomitant of the same idea; different words (sounds) may have the same meaning, and the same word (sound) may have different meanings. We cannot therefore by the Joint Method of Agreement (अन्वयव्यतिरेकी) determine the meanings of words or the separate functions of roots (stems) and inflections—at least, not so simply as is pretended above. Patañjali states this difficulty in the way of applying the Scientific Methods to the problems presented by Analytical Grammar, a difficulty arising from the plurality of causes, but does not state the solution. The solution, however, depends on the Method of Subtraction and Addition (Patañjali's हीयते and उपजायते); for it will be found by extensive observation that the number of meanings of which a word (sound) may be capable is limited. So also is the number of words (sounds) expressive of a given meaning. Hence, by

the Method of Difference, etc., the causal relations of words and meanings may be determined. Patañjali thus establishes the doctrine of Prakṛiti and Pratyaya (roots and inflections), with their separate significance, which is of course a necessary postulate in the case of an inflectional language like Sanskrit. Isolating and agglutinative languages offer less difficulty, whereas the difficulties are in some respects enhanced in the case of languages with a polysynthetic or incorporating (incapsulating) morphological structure.

कथं पुनर्ज्ञायते अर्थं प्रकृत्यर्थः अर्थं प्रत्ययार्थे इति । अन्वयव्यतिरेकाभ्याम् । कोऽसौ अन्वयो व्यतिरेको वा । इह पञ्चमीसुक्ते कश्चित् शब्दः झूयते, षष्ठमीसुक्ते कश्चित् शब्दो हीयते (वच्),—कश्चित् उपजायते (यद्,—कश्चित् अन्वयी (अति);—अर्षोऽपि कश्चित् हीयते (विश्लिष्टिः);—कश्चित् उपजायते (पठिक्त्रिवा),—कश्चित् अन्वयी (कर्तृत्वं चैकार्थं) । तेन नन्वानहै वः शब्दो हीयते, तस्य असौ अर्थः योग्यो हीयते । वः शब्द उपजायते तस्य असौ अर्थः योग्यो उपजायते । वः शब्दोऽन्वयी तस्य असौ अर्थः योग्योऽन्वयी ।

विषय उपन्यासः—वहवी हि शब्दा एकार्थी भवन्ति । तदयथा इन्द्रः शक्रः पुरन्दरः । एकैव शब्दो बहुर्थः । तदयथा यज्ञाः पादा नादा इति । अथ किं न साधीयोग्यवत्ता सिद्धा भवति । नापि झूमोऽर्थवत्ता न सिद्ध्यतीति । वक्षिता हि अर्थवत्ता अन्वयव्यतिरेकाभ्यामेव । तत्र कुत एतदर्थं प्रकृत्यर्थः अर्थं प्रत्ययार्थे इति । (Mahābhāṣya, 1-3, 9.)

Patañjali not only applies the Scientific Methods to the foundations of Grammatical Analysis, but also *by their means* establishes and elaborates the fundamental categories and concepts of Grammatical (and Philological) Science, e.g. the concepts of action (क्रिया), agent (कर्ता), instrumental cause (करणं साधकतन्त्रम्), end (निमित्त), origin (हेतु), limit (अवधि), substance (द्रव्य), quality (गुण), and genus (जाति); also of the fundamental relations (at the bottom of all thought and *speech*)—the relations

of time (कालिकसम्बन्ध), of space (दिग्देशसम्बन्ध), of causality (कार्यकारणभाव), of inherence (समवाय), of co-inherence (सामानाधिकरण्य), of substance and attribute (विज्ञेयकविज्ञेयभाव), of the sign and the signate (संज्ञासंज्ञिभाव), of mutual dependence (इतरेतराश्रय)—an entire grammatical (and philological) apparatus, which will serve as a *point d'appui* for generations of philologists and grammarians to come.

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