The positive sciences of the ancient Hindus
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 Bhāskara, 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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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 Brāhmaṇas and the Upanishads, or in the mythology of the Purāṇas, 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 Sāṅkhya-Pātañjala system accounts for the Universe on principles of cosmic evolution; the Vaiseshika-Nyāya lays down the methodology of science, and elaborates the concepts of
mechanics, physics, and chemistry. The Vedánta, the Púrva-Mímámsá, and in a less degree the Baudhánya, 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 Vyástha-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. Kumárila, Śaṅkara, Śrídha, 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 SÁṆKHYA-PÁTAṆJALI 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 Sáṅkhya 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 (प्राण), 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—परिख्यत्तत्त्व). The very nature of Energy is to do work, to overcome resistance (रज्ज्वलयुक्तत्त्व), to produce motion. All Energy is therefore ultimately kinetic; even potential Energy (चन्द्रशिवक्षिण) 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 (समस्तसत्त्वाम). 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 (ततः गुरु चरघरान).

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. (चन्द्रमयामात्र चहुँचारायौऽल्लामौपूणजने राजसाह्नूः सहवारी अभितः। होकारायेन-तत्रतत्त्व-चित्तवर्यः।)

The Gunas are always uniting, separating, uniting again. (ज्ञोञ्यामिनुनाः: सह्यो नैपायनतिसमप्रयोगो विप्रेत। यथात्योऽयुः।) 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. (सने गुर्भा: परस्परोपरविभागाः: संयोगविभागमाधवः।)
But though cooperating 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. (परस्माराक्रिक्रोधिकिर्मि चर्मिन्निष्टक्क्रियान्तिकिर्मि—वांसाधर्म्। शनवेदयानासान्तिक्क्रियान्तिकिर्मि दुर्ध्रेप्रयासाः
कस्त्वातीत त्रियागाः: रजसश्रेष्ठ स्वतिःतिमुद्गलसमस्तर्व—विज्ञानिक्षु, येताःस्वास्थ्यः on वांसाधर्म्, ibid.। नेत्रत्वे न्यायः संबोध्यये—पापस्वातीतिक्रियानासान्तिकिर्मि, तवश्वास्थ्यः on वांसाधर्म्, 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. (प्रधानवेदयान्तिकिर्मि उपस्वातीतिक्रियानासान्तिकिर्मि य जाप्यासान्तिकिर्मि
प्रधानान्तिकिर्मि—वांसाधर्म्।)
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 (परिवाह) is under arrest. (सत्तरकलम्बक साम्यवस्त्र प्रकृति:—Pravachana, Sutra 61, Chap. I. साम्यवस्त्र चन्द्रानानन्दिरक्तास्या चन्द्रानानन्दिरक्तास्या चक्षुहास्या चक्षुहास्या हि निम्नोऽस्ति:—विज्ञानभिषु, 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. (सत्तरकलम्बक साम्यवस्त्रेऽस्य: चन्द्रानानन्दिरक्तास्या चन्द्रानानन्दिरक्तास्या हि निम्नोऽस्ति:—Sutra 66, Chap. I., प्रचन्नभाष्य:—विज्ञानभिषु। पुष्पसिद्धान्तो युग्मसिद्धान्तो सत्तरकलम्बकार्यं यथाप्रयत्नं रक्षति। सत्तरकलम्बान् ब्रह्मासारदेवि न तुस्तः ibid., Sutra 128, Chap. I.)

Formation of Wholes or Systems—Collocation of Reals.—Creative transformation accompanied with
evolution of motion (परिपक्व) and work done by Energy (शक्ति) cannot take place without a peculiar collocation of the Reals (Gunas). To form wholes or systems (वस्त्र) 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 (गुणावृत्ति, बुनावर्धनपञ्च-)—in other words, without unequal forces or stresses coming into play in different parts of the system. (शक्तिविनाहे—चारणमति। यही सत्त्वे परिपक्वमदन्तः ... समुद्रः समवादः। तस्मां गुणन्तर पुनःविनाहमभाष्मरेष न सम्भवति। न गुणप्रमाण- भाषो वैस्थल सिल। न च वैस्थलसुपनसृवैवर्धवभाष्यते।—चारणमति, चौमुदरी on Kārikā 16.)

The Formula of Evolution—Differentiation in Integration.—Evolution (परिपक्व) in its formal aspect is defined as differentiation in the integrated (समृद्धिविचित्र). In other words, the process of Evolution consists in the development of the differentiated (विभक्त) within the undifferentiated (सम्यक्षेत्र), of the determinate (विशेष) within the indeterminate (प्रक्रिया), of the coherent (संपन्न) within the incoherent (ब्रह्मातिश्र) The evolutionary series is subject to a definite law which it cannot over-step (परिपक्ववनियम). 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 redintegration, and so on \textit{ad infinitum}, is a fundamental misconception of \textit{the course of material evolution}. That the antithesis stands over against the thesis, and that the synthesis supervenes and imposes unity \textit{ab extra} on these two independent and mutually hostile moments, is the same radical misconception as regards \textit{the dialectical form} of cosmic development. On the Sāṅkhya view, increasing differentiation proceeds \textit{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 (चालक्षण), including Prakriti, 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 (विज्ञान), comprising Mahat, the intelligible Essence of the cosmos, evolved by differentiation and integration within the formless, characterless, inconceivable Prakriti.

(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 (चित्तम), and on the other hand
(though through the mediation of this subjective modification, चकित or Ahaṅkāra) the indeterminate material potencies, the subtile vehicles of potential Energy (तम्भात, रूक्षशून्य), the ultimate subtile constituents of the Object-series (the material world). The previous stadium, the cosmic matter of Experience (उपलब्ध, 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 (विश्रेण) 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 Paramāṇus, the different kinds of atomic constituents of different kinds of gross matter (रूक्षशून्य).

(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. (अयुतसंख्यायमेवदानुगतः स्मृतः दृष्टिनिति पत्तश्चिरः—वासभाष, Sutra 44, Chap. III. सामान्यपिरोक्षशून्याय दृष्टि—वासभाष, ibid. सामान्यपिरोक्षशून्याय अन्यथे धन्यं, ibid. चित्तीम्योंचमेवशयावस्थापरिवर्तम:)
(6) And so the cosmic series moves on in ascending stages of unstable equilibrium (विभूषंपरिवर्तन) until the reverse course of equilibration and dissipation of Energy (सहुष्परिवर्तन 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 ब्राह्मण (Sutra 19, Pada II.) is shown below in a tabular form:

Prakriti, the unmanifested unknowable ground

(गृहयमयनन्यंग)  

Cosmic matter of experience (नात्त, निलह)

Subject Series (चिन्हेव) —> Object Series (सहित) :

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

Individuated but indeterminate matter-stuff (subtile material potencies (तन्माट).
Determinate mind-stuff (सिद्धम्), sensory and motor psychoses, etc. (प्राणिविधियः, जन्तुग्रंथिरीयम् and मनः).

Determinate matter-stuff (सिद्धम्), atomic and molecular constituents of gross matter (परमात्मा—वृजुलभुतः).

Coherent and integrated matter-stuff (चपुत्तिःःक्षाथवयः: सदृशः सहायः दृष्टः).

Individual substances, with generic and specific characters subject to constant change or evolution, e.g. inorganic objects composed of atoms or molecules (परमात्मा), vegetable organisms (पूष्कः), animal organisms (स्त्रीरूः). (चपुत्तिःःक्षाथवयः: सदृशः स्त्रीरूः पूषः परमात्मविनिर्मितिः—वासभाष्य, Sutra 44, Pada III.)

तथ तथं संसूच्यं विविधतां क्षणनिमित्तृतें, तथा बहुविवेषा: रितिःस्थवरे संसूच्यस्ति विविधताम्, परिश्वलक्षणिनिमित्तृतें, तथा तेषु चविभगे भूतमृदुलयती मंदिरानी विविधताम्, न रितिःःःक्षाथवयः परं स्त्रीरूतिः स्त्रीरूतिः स्त्रीरूतिः धम्मेलुष्मासवयापरिश्वलक्षणम् धम्मेलुष्मासवयापरिश्वलक्षणम्। (वासभाष्य, Sutra 19, Pada II.)

N.B.—The usual order given in the Śaṅkhyā-Pātañjala compendiums is as follows:—Prakṛiti, Mahat, Ahaṅkāra—and then the bifurcation, viz. 11 organs (sensory, motor and common sensori-motor) from Rājasic Ahaṅkāra, and Tanmātras from Tāmasic Ahaṅkāra—and
finally the Paramáñus of the Sthúla Bhútas. This is literally correct, but misses the significance of the doctrine of "differentiation within the integrated," according to which the Tanmátras are all evolved, through the medium of Ahañkára, 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.
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 Sāukhya 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 Gùnas, 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 (जहूलसृजिः) 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 (सहवार्थिः) or efficient cause (विधिवाकारः), the sculptor's chiselling, the pressing, the husking, is a sort of mechanical or instrumental help to this passage or transition. बायेस्य्या-कार्यायं उपादान-कारेर्म्। सा न्यात: बायेस्या चनागतास्वयं रण। स रण विज्ञे: (कर्त्ते: प्राचुः कार्ये विज्ञे:) चसाथि: बायेस्या चनागतास्वयं हस्तुष्ठेते। (विधानविभु-प्रवचनभाय, Sutra 115, Chap. I.) चत्वार्थायं: पर्वेयनागतास्वयं। कार्यायमारणीयं बायेस्या चनागतास्वयं चार्यायमानेव च। यथा बिधानभवास्त्रमतिस्वयं: हैलुक्षणापरेव चत्वार्थायायं चत्वर्वेष्य न निष्क्रियान: धार्मिकसतुतुस्वयं च च। (विधानविभु-प्रवचनभाय, 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 Gunā collocation (the sum of material causes), the liberation following on the action
of the proximate efficient cause, or concomitant condition (नितिनिदेशकार्य).

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 (रक्तत्रूपितर्कश्रेण्या) together with a fresh collocation (गुस्तस्विरपितर्कश्रेण्या). सम्बन्धित गुदामानी सत्तिप्रेमित्विनीतक संप्र तत्तथ निर्देश विशेषान्वेषणसंस्करण सम्प्र न वाच्यनोपजनन। सबीं निर्देश नैतिकिकत्व विस्तेन्नुरूहर्व जुह्न। नायुँघुण्डादयति। (अनुभव, सुत्र 12, पाद IV.).

Describing the production of bodies ("organic vehicles") for individual souls out of matter of Prakṛiti, 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 Vyāsa-Bhāshīya 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.
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 Guna, which constitute subordinate or particular laws of cause and effect (क्रमानप्व परिक्रमानायं हेतु, Patañjali, Sutra 15, Pada III.).

What we call the qualities of things are only modes of Energy acting in those collocations. योग्यताविवेचा विशेष: सत्वरेष मध्ये:—स च प्रकोपसर्वनिमित्तमायम्। (सांस्करण, Sutra 14, Pada III.) ते सत्वरेष मध्ये परिक्रमान व्यक्तित्व:। अतःतत्त्वंगता: बुधक्षमान: रक्तसिद्धे गुलानां साधितानुमतिनिर्माणं परस्परप्रति गुलानां:। (सांस्करण, 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 (सम्म सत्तासमानित), without prejudice to the generic and specific differences of things (मनुष्यवेदन समेत सत्तासमानित). Inorganic matter, vegetable organisms, and animal organisms are essentially and ultimately one (ज्ञातुन्नक्ष रक्तसिद्धमित सत्यार्यु तथा सत्यार्यं ज्ञातुन्नक्ष सत्यार्यु: सत्यार्यु) 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. दे́श्नान्थातारणितिनिद्रासमाज्ञाताः (ibid., Sutra 14, Pada III.) यो यथ स्थमेय समन्वयोर भवें सः तस्य कःः। भिस्म: प्रभुपदे घट दप्त्रायसे इति भामेयत्वाय-भक्तः।। रुपिताविरुध्दायानभक्तः: भलस्य चानागाभाषाः वर्णसानाभाषाः। तथा निमित्त चलान्बायाः चालीभाषाः।। (धार्माक, 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 (देशाविभित्त), (2) position in the Time-series (वाताविभित्त), and (3) position in the Causal-series (निभिविभित्त).

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

तथ भूतसूचपूजून विभिन्नमाकसूचना देशवार्तानिश्चारानभाषाप्रार्थना या समायः या सिवार्था इत्युतः। तथापि रक्षुधिनिद्रामयोऽविद्वभवेदिनिपिनियः भूतसूचपूज्यनाभिः समाभिप्रायायानुयथिहः।। (धार्माक, Sutra 44, Pada I.).

Infinite Time is a non-entity objectively considered, being only a construction of the understanding
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 (परिमाण) 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, ज्याद). 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 (क्रमवातपरिवर्तन) as opposed to change of quality (ध्येयपरिवर्तन) and the change due to duration or lapse of time (वस्तुपरिवर्तन). 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.

खण्डः तद्योनाति वस्तुमार्गार द्रव्य विज्ञानसाधारः मुनसेवारात्तादयः। स तत्त्वं कालः वस्तुमयो विज्ञानमात्यतः अद्वैतानुपाती हीनिरीवानी क्षणिकातः द्विमानो वस्तुव्रत्त इव विभासः। वास्तु वस्तुपरिवातसाधारः। क्षणः क्षणानमात्यतः। ते कालिष्ठः कालः इति चार्यसन योगिनः। न च हि खण्डः सह भवतः। क्षणः न द्रव्यः सहव्यवहस्वहव्यवसाधारः पूर्वक्रमातुर्वाचार्यनो यत्रा नमायें विज्ञानः स क्रमः। तत्वात् वस्तुमान श्रवेदः क्षणः न पूर्ववाचः। सन्नीति तस्मात् अति तस्मिनः। येषु तु भूतभावस्य खण्डः ते परिशासनात्मकः वास्तेयः। त्रेतंस्येन खण्डसन कृतः लोकः परिशासनानुभवतः, तत्त्वात्मकः।
THE ANCIENT HINDUS

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 (गुणपरिवर्तनस्य अवधारणात्). But even this is real only for our empirical (relative) consciousness (सृष्टिसङ्गे), which intuits the relation of antecedence and sequence into the evolving Reals (Gunas), in the stage of “empirical intuition” (विविधारणानि निष्क्षेपमया). The “intellectual intuition” (िन्द्रियारणानि निष्क्षेपमया), 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 (मद्य), regarded as the unit of change in the phenomenal or causal series (परमाशुक्लम्—गुणपरिवर्तनस्य अवधारणात्—योगवाच्यम्, 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 (रेष: विमानार्थः), has an ultimate unit, being analysable into the infinitesimal extensive quantity inherent in the Reals (Gunas) of Prakriti. (युग्मप्रकृते-रसुपरिब्रमणः—योगवाच्चिकः। ततं निवा दिगविव चार्मानाकिशो वायुप्रातः, सामान्यतः दिगम्भः ्राराहाराखावाभवः। पूर्वोद्धारिक्ष दिगुपातिभिरेष सम्भवतः। सामान्यतः बाणिज्यवार्तारिक्ष वायुप्रातः तदुपप्रेषः। कालां दिःपर्य निःप्रेषः येद कालः चालुक राप्रेषः; दिः तु सार्वप्रेष नेपते।)

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 Gunas 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. (साम्यविकार भावानां चालुकि राष्टिनिकः, Sutra 51, Pada III.)

The Dissipation of Energy (and of Mass)—their Dissolution into the Formless Prakriti.—Cosmic Evolution (परिवर्तमा) is a two-fold process, creative as well as destructive, dissimilative as well as assimilative, kata-bolic as well as anabolic (चनुत्तत्तत्तः तथा वित्तत्तत्तः, विंसुन्त्तत्तत्तः तथा सदृष्टिपरिवर्तमा). 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 (तिःप्रभु, रतिःप्रभु, तिःप्रभु, भुजङ्गिताधानपत्रमूर्त, भुजङ्गिताधानपत्रमूर्त) in what is essentially an incoherent indeterminate homogeneous whole (चिरिक्ष).

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 (संस्कारिका), 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 Prakṛiti, 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 तत्त्वंय and चौनुत्री.)

The Evolution of Matter (ताम्मात्मिक प्रृति). — The ultimate constitution of Matter is a question of the profoundest interest in the Sâṁkhya-Pâtañjala 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—तत्त्वसाध्याः); (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 (तत्त्वाः); and (3) the five different classes of atoms, the minutest divisions of which gross matter is capable, but which are themselves complex Tanmátric systems (स्मृतमेतेर्माण्).

The first stadium, Bhútádi, is absolutely homogeneous and absolutely inert, being devoid of all physical and chemical characters (रघुपञ्चक्षणं) except quantum or mass (परिणिर्दशन, परिसाध्य); and this admits neither of addition nor of subtraction, can neither be created nor destroyed. The second stadium, Tanmátra, represents subtile matter, vibratory, impinging, 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). The Tanmátras possess something more than quantum of Mass and Energy; they possess physical characters, some of them penetrability (कपालपान), 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 (विजेत्र) 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 (चतुर्दश but not चतुर्थ). 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 (परिच्छेद), and serve to form the radicle of the ether-atom (चावाच्छष्परमाणु); 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 Paramāṇu); 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.

वर्गिषेधाः तथा ज्ञानप्रमाणे स्वर्गोऽग्निः उपपत्तिः रसतमाशः नम्नतमाशः इत्येकब्रह्मबुद्धिवेश्याचारं वहिष्ठादयः प्रचारिषेधाः। (वासाध्य, Sutra 19, Pada II.) जहाँरक्रमेण ज्ञानप्रमाणे तत्तात्त्वायाश्रयं ज्ञानप्रमाणे ज्ञानोपयुक्तं स्पर्शवार्त्तमयं। तवचन्दनमयं लब्धगुणवत्ता तत्तात्त्वाद्वित स्याचारम्। (प्रत्यभाषा, Sutra 62, Chap. I.).

ज्ञानोपयुक्तं श्वर्यमाणा तापतीयसारं एकं परिखाम्: पृथिवीपरमाणु: तापताचार: एवं। भूतानं च च तेहिष्ठ्वाभावावधिवाल्याशाहार्गाः उपाधाय सामावस्तक वायुविकारार्मः समाप्तिः। (वासाध्य, Sutra 14, Pada IV.) तथा। गन्धतमाशः वर्जयितः चुड़लस्तमाशाः स्वेतज्ञातनानं एकं परिखाम्: चारुपरमाणुः: तेषां स महातमादिः। तर्प गन्धर्सती वर्जयिता व्रतिमणातीयां।
Before explaining the genesis of atoms it is necessary to say something about Ākāsa, which is the link between the infra-atomic particles (Tanmātras) and atoms (Paramānus). Ākāsa corresponds in some respects to the ether of the physicists, and in others to what may be called proto-atom (protyle). In one aspect Ākāsa is all-pervasive (विशुद्ध), and devoid of the property of impenetrability which characterises even the infra-atomic potential units (Tanmātras). In another aspect Ākāsa is described as having originated out of the mass, or inertia, in Prakṛiti (Bhūtādi) when the latter became charged with the first potential (the sound-potential). Vijñāna-bhikṣu, in the Yoga-Vārtika, boldly tackles the difficulty. Ākāsa, he explains, has two forms—original and derivative, non-atomic and atomic. The original Ākāsa is the undifferentiated formless Tamas (mass in Prakṛiti, matter-rudiment—Bhūtādi), which is devoid of all potentials, and is merely the all-pervasive seat or vehicle of the ubiquitous original Energy (Rajas). This Ākāsa must not be confounded with vacuum, which is merely negative (व्याकरणभाव—un-occupiedness), though it must be conceived as all-pervasive, occupying the same space as the various forms of gross matter (समानदेशभन्त—धवन्यामहत्यथा चाकार्योम्योगवान्वित), and therefore devoid of
the property of impenetrability (सम्बन्धस्य तत्त्वम्—
यथावासिक) which characterises atomic matter. But when
the original equilibrium (साम्यवस्था) comes to an end,
unequal aggregations form collocations in different
groups and proportions of the three Gunas (नूतनतिभवेत
मनोयोगविवेषं संहननम्—विज्ञानिन्वेण, प्रचन्नभाष्य and योगवासिक).
The transformation of Energy now begins—working on
a collocation of mass (with Essence) (गुणातिररोपसमुद्र सदृशतः—
विज्ञानिन्वेण, योगवासिक); it first gives rise to the sound-
potential (शब्दनयोगम्यविशेष परिवर्ति—विज्ञानिन्वेन), and the
atomic Ākāsa (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
(चक्राकार) is integrated, limited (परिच्छेद), and as such
cannot occupy the same space with other (subsequently
integrated) atoms. But this proto-atomic integration
of Ākāsa (काल्यानकार) is formed everywhere, and, itself
residing in the ubiquitous non-atomic Ākāsa (काल्यानकार—
चक्राकारसमानाकारः), forms the universal medium in which
air or gas atoms, light-and-heat corpuscles, and other
atoms move and float about.

चायोरावरतः। यदि हि चक्राकारसमान चक्राकारः न स्वातः
तदा गुणरूपेण व्यवस्था दशकार्यादिप्रेषो न स्वातः (विज्ञानिन्वेन, योगवासिक, Sutra
40, Pada III.) चक्राकारः हि चक्राकारवारः व्यवस्था । तत्र चक्राकाराशि
ततोगुणविशेषतः अयथहिन्ते। तदानीम चक्राकाराधिप्तकारसमुद्रविशेषाय—
भानाः। तत्तव गुणातिररोपसमुद्र सदृशतः चारी शब्दनयोगम्यविशेषपरिवर्ति
विज्ञानिन्वेन। ततथ चक्राकाराशि गुणातिररोपसमुद्र सदृशतः चारी शब्दनयोगम्यविशेषपरिवर्ति
चक्राकाराशि चायोरावरतः व्यवस्था (विज्ञानिन्वेन, योगवासिक, Sutra 40,
Pada III.).

*The Genesis of the Infra-Atomic Unit-Potentials (Tanmātras) 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 Puráña, Parásara, Patañjali, and a certain school of Vedántists reported in the तत्त्वज्ञानम्.

I. A famous passage in the Vishnu Puráña 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 Prakriti, under the action of Energy (वेदन्त: परिभाषयन्ति—प्रवचनभाष, Sutra 62, Ch. I.) by a process of disintegration and emanation (विभक्तिर्युक्त:—विभावतुकारस्व—आसभाष, Sutra 14, Pada IV. प्रवर्तकभाष: विभाष्याःभाषा भाषिता इति साधत, योगाध्यासिक on Pátañjali’s Sutra—मनोविवेच्य विच्छेदभाष: etc.) in the menstruum, or surrounding medium of the unindividuated cosmic mass (Mahat, महातृप्त:).

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 (परिस्थित). It is called the sound-potential (शब्दतन्त्र).

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 (भूतपर्याय) 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 Tanmátrás and the Bhúta-Paramánus are worked out below:—

1. The super-subtile inviduated Mass (rudiment-matter, Bhútádi), under the action of the original Energy (रस:) disintegrates and emanates (विद्वृत्ते) in the menstruum or surrounding medium (समापर्य) of Mahat cosmic super-subtile Mass, and evolves a form of subtile matter (तन्मात्र), which becomes charged with the sound-potential (vibration-potential, परिस्पर्थ), and is called the unit of sound-potential (परिस्पर्थ).

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 शव धृतारः
शव-तन्मात्रः शव-तरिकाः शव-तस्विन्यः चाकासाः सत्तेः.
तथाच
चहहस्तर्यस्यतन्मात्रेऽः नित्यिन्य चाकासाः सृष्टे—मोक्षार्थिक
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—प्रवाहित, वहनन्तर) in addition to the sound-potential (vibration-potential—परिस्पर) and is called the unit of touch-potential (स्पर्शतत्त्व).

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 (प्रक्ष्लप्त, heat-and-light potential) in addition to the impact-potential and the vibration-potential, and is called the unit of colour-potential (रंजतत्त्व).
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 (विकिरण) 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 (रसत्वण्ण), 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-Vārtika, briefly summarizes the Vishnu Purāṇa process as follows:—

Bhūtādi as radicle in conjunction with Mahat produces the sound-potential, which as radicle in conjunction with Bhūtādi produces Ākāsa, which as radicle in conjunction with Bhūtādi produces the touch-potential, which as radicle in conjunction with Bhūtādi produces Vāyu, which as radicle in conjunction with Bhūtādi produces the colour-potential, which as radicle in conjunction with Bhūtādi produces Tejas, and so on.

In this brief summary he does not bring out the force of विकुञ्जराजः (the disintegrating process) and the distinction between the genesis of subtile and gross matter (Tanmātra and Bhūta).

II. A famous passage in Parásara takes another view of the genesis and structure of the Tanmātras and the Bhūta-Paramānus. Krishnapāda, in the तत्तत्त्वज्ञातिवर्गः, represents the scheme as follows:—

The Tanmātras originate from one another in one
linear series, and each Bhūta originates in a separate line from its own Tanmātra:—

\[ \text{Bhūtādi.} \]

\[ \text{Sound-Tanmātra—as a radicle or centre surrounded or encircled by Bhūtādi generates Ākāsa—} \]

\[ \text{Touch-Tanmātra—as a radicle or centre encircled by sound-Tanmātra with Ākāsa-atom as a help generates Vāyu—} \]

\[ \text{Colour-Tanmātra—as a radicle or centre encircled by touch-Tanmātra with Vāyu-atom as a help generates Tejas—} \]

\[ \text{Taste-Tanmātra—as a radicle or centre encircled by colour-Tanmātra with Tejas-atom as a help generates Ap—} \]

\[ \text{Smell-Tanmātra—as a radicle or centre encircled by taste-Tanmātra with Ap-atom as a help generates Prithivi.} \]

The genesis of a Bhūta-Paramānu (atom) from the subtile matter of a Tanmātra is not here so simple as in the view of the Vishnu Purāna. The latter speaks of condensation and collocation, but in the passage under reference a Tanmātra 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:—

Prakřiti—Mahat

Prakṛiti—Mahat

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):—

Ákása

AN ATOM OF VÁYU.

Sp = Sparśa-Tanmátra (impact-potential).
Sb = Śabda-Tanmátra (vibration-potential).
An atom of Tejas (heat-and-light corpuscle) has the following structure:—

Váyu

\[ \text{Váyu} \]

**AN ATOM OF TEJAS.**

\[ Rp = \text{Rúpa-Tanmátra (light-potential)}. \]
\[ Sp = \text{Sparsa-Tanmátra (impact-potential)}. \]

and so on.

A chemist will be disposed to push his chemical processes into the region of subtle matter. He may translate चावर्ण as a menstruum, and सहाय्य 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 Ákáśa-atoms as a catalytic agent.

चर्चाय अः—साहै: अच्छतमार्ज्ज जायते, अच्छतमार्ज्ज भवति-दिरापूणोति, तत्र साहै जायते, तत्र: नीतान् अच्छतमार्गत्वात् अच्छतमार्ज्ज जायते, अच्छतमार्ज्ज

A slight variation of the above view is ascribed to a certain school of Vedántists in the तत्सांनिरंतर. 
The scheme may be represented as follows:—

A Bhūta-atom is evolved by integration (condensation and collocation, स्नातमार्थ) from the corresponding Tanmātra (subtile matter). This is the same view as that of the Vishnu Purāna.

The Tanmātras 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 Tanmātra first disintegrates and emanates in a surrounding medium (a menstruum) of the Tanmātra just preceding it in the order of genesis, and, with the help of its own Sthūla Bhūta as a sort of catalytic, generates the Tanmātra next in order; e.g., the infra-atomic impact-particles (स्योतंज्ञ) disintegrate or emanate, in a surrounding "atmosphere" of the vibratory subtile matter (शन्तसत्त्व), and then, with the help of their own atomic integration Vāyu, gas, generate the Tanmātra next in order, the subtile matter of radiant light-and-heat (तापः).

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

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

(1) Bhūtādi, the rudiment-matter, original Mass, acted on by Rajas (Energy) produces the sound-potential (vibration-potential), जन्मामयायनं चहह्वाराय संसार्रक्षणं राजसार्हारः सहस्वारोभवति

(2) This subtile vibration-potential, as a radicle, with accretion of rudiment-matter (Bhūtādi), condensing and collocating, and acted on by Rajas, generates the subtile touch-potential
(impact-potential), which is impinging 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 (षणतःत्व) which radiates light and heat, in addition to being impinging 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, impinging, 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, impinging, 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 Ākāsa-atom possesses penetrability, the Vāyu-atom impact or mechanical pressure, the Tejas-atom radiant heat-and-light, the Ap-atom viscous attraction, and the Earth-atom cohesive attraction.

Vijñāna-bhikshu in one passage gives the following scheme of the genesis of the Bhūtas:—


\[
\begin{align*}
\text{of Ākāsa} &= \text{Bh(Sb)} \\
\text{of Vāyu} &= \{ \text{Bh(Sb)} \} (\text{Sp}) \\
\text{of Tejas} &= \{ \text{Bh(Sb)} \} (\text{Sp}) \text{ Rp}
\end{align*}
\]

where Bh = सृष्टिः, Sb = जन्तुत्तमाष, Sp = म्यक्षेत्तमाष, Rp = र्ष्यत्तमाष, and so on.
Bhūtas and Paramāṇus—Cosmo-genesis and its successive stages:

The "five Bhūtas" stand for a classification of substances on the basis of their generic properties, resulting, as the Sāṅkhyaśas 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 Paramāṇu, again, is a type of atoms corresponding to each Bhūta class, and indeed one and the same kind of Paramāṇu 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 (Bhūtādi) appeared Ākāsa (ether), first as a Tanmātra (subtile matter) charged with the potential energy of sound (vibration-potential), and then as an atomic integration of a mono-Tanmātric structure (the Ākāsa-atom—चाबासाथु) also ubiquitous and all-enveloping. In the next stage we find a new kind of Tanmātras, 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 Tanmātras (स्वर्यज्ञात्मावस्थि) combining with the vibration-potentials (Ākāsa-Tanmātra) produced a new kind of atom, the di-Tanmātric Vāyu-atom, which by aggregation formed a gaseous envelope composed of impinging (driving) vibratory particles (Vāyu). Next appeared the third class of Tanmātras, 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 (तन्मात्राणि) 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.
Examples of the different Bhūtas:

1. Ākāsa. This is ubiquitous.

2. Vāyu. Various substances composed of di-Tanmātric atoms—kinds of Vāyu—must have been formed in the gaseous envelope, in the second stage of cosmic evolution, out of the proto-atoms of Ākāsa; but they have either suffered a fresh transformation into substances of a more complex atomic structure, or have dissipated into the mono-Tanmātric Ākāsa, out of which they took their rise. The one familiar example now surviving is atmospheric air. Water-vapour (वायु) is but water (Ap), and smoke, fumes, etc., but earth-particles in gaseous diffusion.

3. Tejas. Various classes of Tejas-corpuscles—substances with tri-Tanmātric atomic structure, i.e. two grades subtler than the ordinary elements of chemistry (which are of a penta-Tanmātric structure)—are even now known (तेजस भौगोलिकदेव पहुँचिए। भौर्भ हिस्से जीविका बाबुररहित, तहसीयभाषा).

First, there is fire, or the light and heat emitted by the burning log of wood or lamp (हरिमि:—दीया:—रीमि तेजस:).
Now it is important to note that the flame of a burning log of wood (स्वच्छ) 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-corpuses, light-and-heat particles which are latent (absorbed) therein, come forth as flame (पावित्रीपहन्ने तदनगात्राते तेजसः: अरिन्देवती—विज्ञानिभिः, प्रवचनमात्र, Sutra 110, Chap. V.). Then there is the light of the sun and the stars (दिस्य सौर चादिमानि) which are flaming masses of molten viscous matters (रथमाने तेजः: दिस्य तथा सूर्यादि—तस्यथायामः, चादिमानि) or of molten earthy matters (सूर्यादिति स्वर्णे तेजाति पावित्रीपहन्ने तेजसति—विज्ञानिभिः, प्रवचनमात्र, 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 (जीवाः). 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 (देशप्रावित्रयेके तेजसादिता मुख्यादिता—विज्ञानिभिः, प्रवचनमात्र, Sutra 19, Chap. III.). Aniruddha, a late Sánkhya 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 (सत्व चचिप (तेजसे ज्योतरे
चचिप) सुहर्षण्ड्रिखावयवसायमभाकरे, ज्यात्मे जानुपभोगारः—चातुर्गृहविष, 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 Guṇas—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 Sáṅkhya-Pátañjala conceives the properties (or energies) of substances to result from the grouping or the quanta of the Tanmátras, or the Guṇas themselves,
and hence any radical differences in substances of the same Bhūta class must characterise their atoms, though in an infra-sensible form. In the Nyāya-Vaiseshika, on the other hand, the atoms of the same Bhūta class are alike in themselves, homogeneous; and the variety of substances comprehended under the same Bhūta is ascribed merely to the different arrangements or groupings of the atoms (षून्ध) 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 Sānkhya-Pātañjala points to the various kinds of fruit acids and juices, all originating from one and the same Bhūta (water) with different accretions of earthy matters (भूविभाग:). In the same way, though we speak of only five classes of Tanmātras and atoms, the infinite variety of the world results from the infinitely varied collocations of the three original Gunas which underlie Tanmātra and atom alike. (सत्यर्जनमवत् चरकवेदवाहक: संवात: परमावृत्रित—मायवासिक, क्षयोतकर, reporting the Sānkhya view. चुवसिन्धायपव: संवात: परमावृत्रित—मायवाय, Sutra 44, Pada III. परशास्व: सामान्यविशेषाल्मा चुवसिन्धायवयवेदानुसार: समुदयः—मायवाय, Sutra 44, Pada IV. योगताविश्वव तमंवेश: शक्तिस्रेव भम:—ibid., Sutra 14, Pada III. यो भलेवु चतुपालो सामान्य-विशेषाल्मा सोन्नयो भम:—ibid., Sutra 14, Pada III.)

स्मार्त:—वर्ष रक्तचालो गुरुनामो चनेवेदया प्रवृत्तः—इत्य चाह परिशमान: सत्त्वेऽपि। रथा चारिस्विभुहूं उदर्भ रक्तचालो चापि तत्त्वविशेषारान् चालक नारिहेत-माही-विल-विन्ध-विन्ध-चालकाणरम-बाधपय-दुरसतया परिशमान: मुराद्वेलघुवतिलकुकुम्भायतया विज्ञात: रथसेवक्सुहायसम्बन्धः
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. 2\( t_1 + t_2 \) 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. 3\( t_1 + 2t_2 + t_3 \) 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. 4\( t_1 + 3t_2 + 2t_3 + t_4 \) units; and the Earth-atom (penta-Tanmátric system) \( t_1 + (t_1 + t_2) + \ldots + (t_1 + t_2 + t_3 + t_4 + t_5) \), i.e. 5\( t_1 + 4t_2 + 3t_3 + 2t_4 + t_5 \) 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 Sánkhya-Pátañjala were
asked to account for differences among Paramánus of the same Bhúta class, he would perhaps suppose $t_i$ to vary from $\alpha_1$ to $\beta_1$, $t_2$ from $\alpha_2$ to $\beta_2$, $t_3$ from $\alpha_3$ to $\beta_3$, $t_4$ from $\alpha_4$ to $\beta_4$, and $t_5$ from $\alpha_5$ to $\beta_5$.

Therefore the mass-units contained in the Váyu-atoms of the different possible Váyu substances would be represented by $2\alpha_1 + t$, $2\alpha_1 + 1 + t$, $2\alpha_1 + 2 + t$, $\ldots \ldots 2\beta_1 + t$, in A. P. with unity as common difference, there being $2(\beta_1 - \alpha_1) + 1$ possible Váyu substances.

The mass-units contained in the Tejás-atoms of the different possible Tejás substances would be represented by the series $3\alpha_2 + 2\alpha_2 + \alpha_3$, $3\alpha_1 + 2\alpha_2 + \alpha_3 + 1$, $\ldots \ldots \ldots 3\beta_1 + 2\beta_2 + \beta_3$, increasing in A. P. by unity as common difference, there being $3(\beta_1 - \alpha_3) + 2(\beta_2 - \alpha_2) + (\beta_3 - \alpha_2) + 1$ Tejás substances possible.

The mass-units contained in the Ap-atoms of the different possible Ap substances would form the series $4\alpha_1 + 3\alpha_2 + 2\alpha_3 + \alpha_4$, $4\alpha_1 + 3\alpha_2 + 2\alpha_3 + \alpha_4 + 1$, $\ldots \ldots \ldots 4\beta_1 + 3\beta_2 + 2\beta_3 + \beta_4$, there being $4(\beta_1 - \alpha_4) + 3(\beta_2 - \alpha_3) + 2(\beta_3 - \alpha_2) + (\beta_4 - \alpha_1) + 1$ Ap substances possible.

The mass-units contained in the Earth-atoms of the different possible Earth substances would form the series in A. P., $5\alpha_1 + 4\alpha_2 + 3\alpha_3 + 2\alpha_4 + \alpha_5$, $5\alpha_1 + 4\alpha_2 + 3\alpha_3 + 2\alpha_4 + \alpha_5 + 1$, $\ldots \ldots \ldots 5\beta_1 + 4\beta_2 + 3\beta_3 + 2\beta_4 + \beta_5$, there being $5(\beta_1 - \alpha_5) + 4(\beta_2 - \alpha_4) + 3(\beta_3 - \alpha_3) + 2(\beta_4 - \alpha_2) + (\beta_5 - \alpha_1) + 1$ Earth substances possible.

Size (परिमाण).—As to size or volume, the Sáñkhya accepts only two kinds—the infinitesimal, which is also without parts (चतुः—निर्वर्जन), and the non-in infinitesimal, which consists of parts (महत्—सावर्जन). The latter varies from the excessively small (the so-called Anus, Tan-
mátras, and Paramánus) to the indefinitely great (परमहस्—विस्तृत्—e.g. Ákásā).

The Gunas alone are infinitesimal, with the exception of those ubiquitous ones that evolve into Ákásā-atoms and Mind-stuff (धातुत्तरच, and चन्दनःवरण); 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 Ákásā and Mind-stuff, must be held to be ubiquitous, and this will suffice for the ubiquity of Prakriti. (न च चलस्फूर्ते गुरुत्समप्रसृते विभूमद्यायगम्यते इति वाच्यम्। चन्दनःकरायाकहुःकुःयानां विभूंवेन तदुपस्ते। संभूक्तानां विभूते सति चार्यपरिशास्त्रसुभोभूमित्त्वं स्यार्थासित्वं—सोमवासिक, Sutra 51, Pada III.)

Chemical Analysis and Synthesis—Elements and Compounds.—What, then, is the equivalent in the Sánkhya-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 (समुहः) 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 (समुहाया: समुहाः), and (2) mechanical
aggregates, or collocations of distinct and independent
parts (समुहाया: समुहाः).

A substance is an aggregate of the former kind, and
may be divided into two classes: (1) the Bhūtas and
their "isomeric" modifications (शृंख्ल, शृंखलेद, and शृंखलमन्त्र),
and (2) chemical compounds (चित्रितुप्रथं, विस्तारस्त्रोत्संपर्क). Chemical compounds, again, may be subdivided into
two classes: (1) those composed of atoms of the same
Bhūta class, i.e. of different isomeric modifications of
the same Bhūta, and (2) those composed of atoms of
different Bhūta classes. In the first case, there
is contact between "isomeric" atoms (समातीय-संयोग),
in the second case between heterogeneous atoms
(विषातीय-संयोग). The first contact leads to intimate union
(संयोग: या संयोगायिणेऽः तेनेव दृष्टान्तो विश्वेत्—
विष्णुनिष्ठु: प्रश्रव्यिन्न) : the isomeric atoms by a peculiar
liberation of Energy (समातीयोपन्थ—the action of similars
on similars) are attracted towards one another, and
being riveted, as it were, form the so-called material
cause (उपलब्धार्थ) of the compound product. The
second kind of contact (that between unlike atoms
of heterogeneous Bhūtas) begins with a liberation of
Energy (उपलब्ध), which breaks up each of the Bhūtas;
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 Bhūta, that which serves to furnish the
radicles, not necessarily that which is numerically or
quantitatively predominant, gets the name of material

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cause (उपादानकारक), and the others, which by their collocation cause the liberation of Energy (उत्पन्न, चरणम, or रुपम), are called efficient causes (नितिनिदार्शन)—(देववेदान्तात्मात्मात् प्राणान्वयं चालिस चरणान्वयः परिशास्नेत्रान् प्रयंसात्—वाप्स्यात्, श्रीमुद्री on करिका 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 Bhūtas. (यथा पाराशाश्वेतस्य सार्नात्मा नानावृत्ता संख्येत्—सीतपाद on करिका 17. तद्व चैत (तेजसे शारीरे चैति) चकुरप्राप्तिविवायया वाचस्ता, चलने च चयुप्योगात्—विनास on सूत्र 112, Chap. V. वाजितामुक्त्यो च भाषान्वन्तिदेवम् सावयोलम्बवस्थाने चरनेिविरूपे इत्यतः: तदा एकादशुसंबोध्याने पाथर्म नालित।—विज्ञानभिषु, प्रश्चन्नाय ।)

Aniruddha goes so far as to hold that both “isomeric” and “heterogenic” combinations are real cases of constitutive contact. (चारसतासृय, e.g. भौतिकबृहोन्महासां—प्रकरण on सूत्र 113, Chap. V.). But in the later Sāṅkhya-Pātañjala the current teaching denied this—चेतुसार्यायिकायां (Sutra 102, Chap. V.), where विज्ञानभिषु notes—सूत्रानि भविष्यवातीतानि प्राप्तानि न दृष्टब्धि समात्ियेकोपादानम्।

ितराि एकादशुसंप्रमाणम् ।

But besides these transformations of substance (द्रव्यार्थार्थाविवायित) 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. (भौतिकबृहोन्महासांपरिशास्त्रात: न द्वारावतः—यथा रक्त रेतर ज्ञितायेन ज्ञितायेन द्वारावतः, द्वारावतायेन, यथा चैतकार्यक चो ज्ञितायेन द्विहितम् च खसा िविद्यमानो गुणां विद्यमाणश्वयम्—सालभाय, 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 Paramánuś or by larger masses (or lumps)? Now a Paramánuś 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-

¹ This conclusively proves that the decimal notation was familiar to the Hindus when the Vyása-Bhāshya was written, i.e. centuries before the first appearance of the notation in the writings of the Arabs or the Greco-Syrian intermediaries. Váchaspati, who comments on the Vyása-Bhāshya, composed his Nyáya-Súchí-Nibandha in Samvat 898 or 842 A.D. This cannot be Śaka 898, for apart from the decisive use of वस्त्र, which by this time had come to signify the Samvat era, Váchaspati's commentator, Udayana, wrote the Lakshanasávali in Śaka 906—

लक्षणसावली

and Udayana, who wrote the Parisuddhi on the Tátparyastíka of Váchaspati, 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. Váchaspati, then, preceded Udayana by 142 years, and must have been himself preceded by the author of the Vyása-Bhāshya by a longer interval still, for Váchaspati ascribes the Bhāshya to Veda-Vyása himself (वेदव्यासेन भाष्यते भाष्य विषयमात्रे). 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, Várshaganyā, and the Shashti-Tantra-Sástra, without a single reference to Ísvara-Krísha—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 Bhūta or its isomeric modification, the Paramānu, the smallest homogeneous component particle, is unmixed, and therefore corresponds to the atom of modern chemistry. In a mixed substance (मिलितमूल, संहारभूमिः), whether it be an “isomeric” or a heterogenic compound, the qualities are due to the mixture, and therefore its Paramānu (usually called Arambhaka Paramānu), the smallest homogeneous particle possessing its characteristic qualities, must result from the mixture of the Paramānus (in smaller or larger numbers as the case may be) of the component substances. In the Sāṅkhya view, then, the Paramānu of a mixed substance (Arambhaka Paramānu) corresponds to what we now call molecule. (सयान्वयनेन द्वन्द्व परमायुरुम्—ब्रह्माणि। लोकस्य रत्स्य प्रविष्टमन्तयं वासिकायं च भवः स: सयान्वयनेनपरमायु:—वार्ष्णस्यं, तस्तैःत्वार्थ—सूत्र 52, पाद III. नायुर्णेनात्म न निम्भेनात्म। पृथिवीपरमायुः भवः प्रविष्टमन्तयं द्वन्द्वमयेन वार्ष्णस्यं, सयान्यस्यं, ब्रह्माणि, सूत्र 88, चाप V.) That the Paramānus may form binary molecules (सयुक्तं) in forming substances, is acknowledged by the Sāṅkhya, as will appear from Gaudapāda: तत्त्व अध्यात्मार्थभूमिः सयुक्तनेतृत्वः। (गीर्गीर्ग, on Kārikā 12). Even the Vaiseshikas, with their prejudice against “poly-Bhautic” or “heterogenic” combination, acknowledge that in “poly-Bhautic” compounds the different Bhūta substances unite by their Paramānus (or atoms), though they rigidly insist that in such cases only one atom should be regarded as the “radicle” (उपादान or द्वारास्त्रक कारक) and the others as co-efficient causes (समस्यारथप्रकोष्ठ, e.g. प्रक्षेपण—एवं समस्यारथ्यं जानुजे महासृष्टुः महेश्वरस्याः—
It was only in the mediæval Sáṅkhya-Pátañjala that under the influence of the Nyáya-Vaiśeṣika 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 (संग्रह), in the latter case only a grouping of comparatively free or loosely attached atoms round a radicle atom (चूल्ल), with liberation of Energy (उपहर, चरहर, or विहर) and the setting up of unequal stress and strain (गुलाब्यस्यावमि—ईष्टाक्ष). At the same time it was of course admitted that this distinction does not apply to the forms of subtile matter (Tanmátra—सूक्षमपूर्व) which could unite in intimate fusion, whether homogeneous or heterogeneous. For example, the subtile body (सूक्ष्मरूप) which is supposed to be the seat or vehicle of the conscious principle is acknowledged by Vijñána-bhikshu to be penta-Bhaustic (पचधूतालक); in other words, all the five Tanmátras serve as material causes, though the gross body (the animal organism) is stated to be only a "heterogenic" compound with the Earth Bhúta as radicle or base. (चतुष्काल्यां पद्धतिः पचधूतालकं बलात्मकं | तन्मस्तन्त्रं यदृ भूतमयं शिरश्चतुष्काल्यं |—वर्णनमाथ, Sutras 11 and 12, Chap. III. चतुष्काल्यां परीधेनेव चन्द्रानि श्रृवि उपहरावति—ibid., Sutra 19, Chap. III.)
But in the original Sāṅkhya-Pātañjala it appears that the production of a new substance by mixture of unlike Bhūtas (विज्ञातीयसंयोग) 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 Bhūta 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 Vijnāna-bhikshu, who, as one of the latest expounders of the Sāṅkhya-Pātañjala, has been most affected by the Vaiseshika prejudice against "poly-Bhaustic" combination (विज्ञातीयसंयोग), urges that the qualities of a compound substance are not necessarily the result of similar qualities in the component elements. (सत्यार्थ-कारकगुणसौधः काल्पनिकारार्थकता इति ते तेर्वा (तात्विकारण) साधू 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. (सत्यार्थमेवः चक्षुवर्दूषेष्वात्, सामयोगस्मवाने सात्त्विन्यापरि इत्यतः: रक्षदा रक्ष्यवृत्त्यादि सार्वत्नाति—प्रवचनभाष्य, Sutra 32, Chap. II.)

In the middle of the ninth century we find Vāchaspati instancing some "heterogenic" or "poly-Bhaustic" compositions as typical examples of evolutionary change...
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 accumulations. 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-Bhūta 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. (स्वयं वारिष्ठोपः वद्धते स्वकर्त्तापि सहकृतिधाराः साहास्त्र नारिकेल-गाढि विन्दु-वायुप्न्य-रसायणं परिधानाम् मथुराजयं वायुभाग्रतं वायुपायश्वा विकल्प्यते। इति वक्तुकुपयां सम्भाव्यं प्रथानन्यं वायुस्वाम च प्रथानानुमा: परिधानेदान् प्रवृत्तिष्ठति।—वृद्धमूढः on Kārikā 16.) Vāchaspati 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). (परिधानेदानः वद्धतानि पदं: परिधानः तु:। तद्धयात गवात्स्य-शरस्यात्मध्यानि हस्तानितियानां राक्षसवस्तं मालीष्ठं शं परिधानः, परिधानेदानानां च प्रदीप इति।—तन्त्रेषु परवर्ती on राजस्थान, Pada IV., Sutra 14.)

Earlier still, *i.e.* not later than the sixth century, the Vyāsa-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
In other words, bi-Bhaotic compounds are here placed in the same category as compounds of substances of the same Bhūta class, for here the particles of both the Bhūtas are regarded as forming the matter (material cause—प्रादानकारण) of the smallest homogeneous portions of the compound substances.

N.B.—Vāchaspati naturally interprets this to mean separate modifications of the two Bhūtas.

The view of the earlier Sāṅkhya, that atoms of different Bhūtas may chemically combine to form molecules of compound substances as much as atoms of different modes of the same Bhūta, comes out clearly in Utpala’s brief reference to the Sāṅkhya system in his commentary on Varāhamihira’s Vṛihat Samhitā.

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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 Sāṅkhya teaching with a methodology derived from the Nyāya-Vaiseshika doctrine (cf. Charaka, Śārirasthāna, Chap. I.; Vimānasthāna, Chap. VIII.; also Suśruta, Śārirasthāna, Chap. I.) had founded an elaborate theory of inorganic and organic compounds, which equally admitted iso-Bhaotic and hetero-Bhaotic 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.

**Ákáśa substances:** Imponderable (or light), rarefied, elastic, capable of sound (vibrations).
Charaka points out that the primary qualities or specific physical characters of the five Bhūtas 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 Vāyu, heat for Tejas, and vacuum (non-resistance, penetrability) for Ākāsa.

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

The Mahābhūtas—Mechanical Mixtures.—Susruta notes that each of the gross Bhūtas (Mahābhūtas) is found mixed up with the other Bhūtas—e.g., the Mahābhūta Ākāsa is the receptacle (or vehicle) of air, heat-and-light, and water vapour; the Mahābhūta Vāyu, of water vapour, light-and-heat, and even fine particles of earth held in suspension; the Mahābhūta Tejas, of earth particles in the shape of smoke, and also water vapour. (चन्द्रग्रह योजित प्रविष्ट भावनातिन निधियोग—Susruta, Śārīrasthāna, Chap. I. जन्म युगः; जन्म ज्ञाप ज्ञापये। जन्म भावे
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, Sūtrakāra, Chap. I.; cf. also Susruta, Sūrabhāṣā, Chap. I. पार्शिवाः सुरक्षारणलिनिप्प्रतिपान्तः शिमतायुक्तपालाद्वः। सुभाषिणि इस पार्शिवलिङ्गस्यालीक्रिया गुरुबार्तिथ्याविद्याधिकरिते तिथिमिथि। सुभूते वारोदारात् तोहकम्बलसामसुपारितकान्तरसाध्यमात्रायोऽविभासित।—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 (चोटिंदं पौषुल्लवं यवारां भूभट्टेक्षयम्).

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 (चवस्यति, Chikitsāsthamā, Chap. X.). These metallic salts are therefore mono-Bhautic Earth compounds. Susruta also gives the preparation of mild and caustic alkalis (Sūrabhāṣā, 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—केषिते भयं समाबाट वैचिष्यो माकुहंवतानाम। Utpala notes—कोच्चिंब नामां बालामरेण)
Ap substances, simple and compound:

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

Pure Ap (Mahābhūta) is tasteless, and the six tastes are developed when the Mahābhūta Ap enters into combination, mechanical or chemical, with other Mahābhūtas. 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 Mahābhūta Ap predominating in their composition taste sweet; with Mahābhūtas Earth and Tejas predominating, acid; with Mahābhūtas Ap and Tejas predominating, salt; with Mahābhūtas Vāyu and Tejas predominating, pungent; with Mahābhūtas Vāyu and Ākāsa predominating, bitter; and with Mahābhūtas Vāyu and Earth predominating, astringent. (Charaka, Sūstrasthāna, Chap. XXVI.; cf. Susruta, Sūstrasthāna, 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 Mahā-
bhūtas, and the particular "taste" which is developed depends on the relative proportion of the Mahābhūtas and the predominance of one or more of them in the penta-Bhaustic compound in question.

Qualities of Compounds.—The isomeric modes of each Mahābhūta 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 Mahābhūtas, 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. (रस्मेनेव रसालं पदनुसर्पश्च सुनामिरेभिषेषवात् महाभूतानां। सूतानामिव स्थायरण्मानां नानावशेषुकृतिपेः।)

Susruta ignores Charaka's distinction between Mahābhūta and subtle Bhūta, and views every substance as in reality penta-Bhaustic, and it is only the relative predominance of a particular Bhūta or Bhūtas in any substance that determines its class. (पृथ्विप्रेमेऽवावर्गाक्षानां सत्यसायात् द्रव्यमिरेभिषेषत:। जन्तुक्षेत्रस्य चिन्मयेनामो भवति इदं पारिवर्त इदं जायचं इदं नैववर्त इदं चाययं इदं चाययं चाययं।
—Susruta, Sūtrasthāna, 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 Drīḍhabāla of the genuine Charaka Samhitā, which was
itself a redaction by Charaka of the original work of Agnivesa, the disciple of Átreyaka Punarvasu as distinguished from Krīshṇátreya and Bhikshu Átreyaka, also well-known medical authorities. The extant Susruta is a redaction by Nágárjuna of an original work (Vṛiddha 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, Lohasāstra), and the Buddhist Nágárjuna, author of the Mādhyamika-sūtravṛtti. Charaka and Susruta continued to receive additions after Dridhabala and Nágárjuna, and even after Vāgbhata, but the whole of the extant Charaka is probably much earlier than the commentator Chakrapāni, and the whole of the extant Susruta earlier than Dalvana, the commentator, and Mādhava, the author of Rugvinischaya. The extracts in Vāgbhata make it certain that the passages I have quoted or shall quote from the Sūtrasthāna and Śārīrasthāna 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 (ज्योतिषाज्ञ), 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 mediaeval works on Medicine and Rasāyana which leave no doubt as to its remarkable scientific value. The metallurgist Nāgārjuna advanced the knowledge of chemical compounds by his preparations of mercury. The Harshacharita, in the seventh century, relates a fable concerning this Nāgārjuna, and speaks of him as a friend and contemporary of Sātavāhana. The relative priority of Patañjali and Nāgārjuna is a vexed question in the history of metallurgy. That Nāgārjuna's Lohasāstra was earlier than the final redaction of Patañjali will appear from the following circumstances:—(1) Chakradatta in his summary of Nāgārjuna mentions that the chemical process of testing pure iron must be repeated twice before it can be regarded as decisive, whereas Śivadāsa 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 Nāgārjuna's recipe (cf. Chakradatta, and Patañjali as reported in the Yogaratnākara-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. (प्राचायम्भियोत्वत्वितिद्विविद्याः पुरानबृष्टेण समस्या हालव्यो प्रवेशहायुपद्भावः। Chapter LVI., ibid.) Varáhamihira also alludes to the experts in machinery (वन्याद्वि:, वन्यः;) and the professional experts in the composition of dyes and cosmetics (रागमय्युत्तिपदः: 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 (झोरकमुख्यार) 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 (गुच्छरी महंत्सर सागारभक्षण) and other chemicals (e.g. sulphate of iron) also cow-dung (cf. the "cow-dung substitute," Roscoe); (2) the extraction of the principle of indigo 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 mediaeval 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 Vásavadattá and the Dasakumára Charita in the sixth century allude to the preparation of a mass of fixed or coagulated mercury (पार्वतप्रकृत्व बालुकावृक्षांि— वाञ्चकाल); a chemical powder, the inhalation of which would bring on deep sleep or stupor (योगविलास—दशकुमारापरिश); a chemically prepared stick or wick for producing light without fire (योगविलास—दशकुमारापरिश); and a powder which, like anaesthetic drugs or curare, paralyses sensory and motor organs¹ (सचनम्पमित्व इन्द्रायायन—वाञ्चकाल— प्रभुद्वातमैंक्षरूपाया—Darpana). Vrinda (circa 950 A.D.) notices the preparation of sulphide of mercury (रक्षामृतचावी),

¹ This last interpretation is doubtful; but in any case the familiar use of a technical term of alchemy like Stambhana-churram (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 (समुद्रितात्त्व). Chakrapāni (circa 1050 A.D.) mentions the preparation of the black sulphide of mercury "by taking equal parts of mercury and sulphur."

The Rasārnava (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 Rasārnava regards mercury as a penta-Bhaumatic 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 Sādharana 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 alkanis, mineral earths, and several poisons.

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

¹ From Patañjali's and Nāgārjuna's Lohasāstra (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. (अम्लकरण, पदार्पण, अब्दार्पण, स्देन, स्थान, etc.), e.g. the preparation of perchloride of mercury by taking common salt and mercury (रसक्षुर—पारदक्षण चैत्यनीकारके चिद्राकारः); of sulphide of mercury (हिंजू) by taking sulphur and mercury; of Sindura from lead (बिन्दूर नागसम्भवम्—Amarakosa, sixth century A.D.); of the medicinal compounds Svarnasindura and Rasasindura 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 (हिंजू); of copper from sulphate of copper (गुप्त, सस्पद) by heating this substance with one-fourth of its weight of borax (Rasaratna-samuchchaya,—cf. Bhāvaprakāsa, गुप्ते तावदोपयातु विसिद्ध तावदेन वहरति); of zinc (वहरम्, वहरद) from calamine (रसक); of copper from pyrites (पांजक, विसम्भत), 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 (साधनां, साधनां, and सूतियां)—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 Vīdas 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 Vīdas, 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 (स्वायत्त जूत) 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 (चौक्षिण्यक रसायन जूत). 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 (सप्तर्थेऽ वसा मकरा हेषेऽ दुर्गुपचिक्षु). Salt may be either mineral or vegetable salt.
Susruta divides poisons into two classes—vegetable and animal, but several poisons expressly termed mineral poisons (चारपक्ष) 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 Mahābhūtas.

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 Bhūtas 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. (यह अन्तःस्वाद्योप्रगाढः भार्यार्थानि भूतानि भूताप्तःस्वाद्यावाति भार्यार्थानि भूताप्तःस्वाद्यावाति भूतानि भूताप्तःस्वाद्यावाति वैव et seq.—Charaka, Śārirasthāṇa, Chap. II., vide also Charaka, Śārirasthāṇa, Chap. VII., cf. Gaṅgādhara's
Formation of Molecular Qualities in Chemical Compounds.—The Charaka school, which we have seen was an offshoot of the Sānkhya (cf. Charaka, Vimānaśthāna, Chap. VIII., वचा वादिन: प्राकाः: तथा सांख्यचतुर्भ प्राकाः: नित), supplemented the above account of inorganic and organic compounds with a characteristically Sānkhya 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 (Paramāṇus) themselves. (ष्वयंते रसायनं पद्धमुपपं व्युनाशिरेकविमात्रां महाभूतानं। भूताभिः स्थाय्रस्वस्मानं नानाशोकौक्तिप्रसिद्धं॥—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 Gaṅgādhara Kavirāja Kaviratna in the Jalpakalpataru, a commentary on the Charaka-Samhitā, published at Calcutta in 1869, premising that the Kavirāja’s view is pure and genuine Charaka doctrine. Gaṅgādhara 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 Bhúta 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 (नियंत्रण), 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 Gaṅgādhara does not specify—becomes intensive (नियंत्रण), 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.

(Jalpakalpataru, Sústrasthána of Charaka, pp. 198–200; edition published by Bhubanachandra Basák, Calcutta, Samvádaratnákara 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 Sáukhya 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 evolitional 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" (चिन्तनशक्ति) 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 Vāyu would be smell-less, colourless, and tasteless, and so on. The Nyāya-Vaiseshika does not deny that there may be compounds of different Bhūtas, nor does it deny the causal operation of specific qualities as efficient or energising (dynamic) causes (उपसत्तु, निविष्टवार्ता), but it refuses to place these compounds on the same footing as compounds of isomeric modes of the same Bhūta; and it accepts the "material" causality in such cases of only one of the Bhūtas, regarding the others as co-efficients (निविष्टवार्ता).

The earlier Sāṅkhya schools including the medical schools of ancient India brushed all this aside as a distinction without a difference. The Vedāntists, as we shall presently see, flouted this doctrine of Árambha-váda. The Jainas, in opposing this Vaiseshika 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 Nyāya-vártika, and of Váchaspati Misra in the Tátparyyatíka, 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_qA (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:—

मय्यभिसभ्य: पृथिव्यायपरनाया तावतरे व्युक्तमारम्युः। तयोऽऽपरसम्मुख्येण तदार्थसम्बन्धे सापि गम्भृवस्मालावप्रसंस्कात्। द्वे पाण्डियपायुसमुनेरस्त्र गम्भृय तक्षेत्र चनारसबलात्। नापि पाण्डियपरनायाद्वे द्वषवा पाण्डियपरसायुः। हेतु चावनामारम्यमिव गम्भृवस्मालावप्रसंस्कात्। इति साम्यम्। परमावनो व्युमारम्युः चनारसबलात्। तथादित्वय: परमावण: न जाब्यमारभय!}

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 \(\frac{33}{25}\) of a second, which is nearly the measure of the Paramánu of time as given in the Vishnu Purána (vide Bháskara’s Siddhánta-Śiromani—वाज्ञानावाह).
following table given both in Udayana's Kiranávali and Śrīdhara's Nyáya-Kandali:—

30 Muhúrtas = 1 day (24 hours),
30 Kalás = 1 Muhúrta,
30 Káshthás = 1 Kalá,
18 Nimeshas = 1 Káshthá,

This makes 1 Kshana of the Nyáya-Vaiseshika equal to \( \frac{4}{9} \) 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 \( \frac{4}{9} \) 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" (नामास्तिको 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. Spottis-woode'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 Calcoli 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 Krishnas (Manu, Chap. VIII.; Vishnu, Chap. IV.; and Yájñavalkya, Chap. I.).

A Máshá of gold therefore would weigh $6\frac{9}{45}$ 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 Krishnas, 1 Dharana = 16 silver Máshás, and 1 Pala = 10 Dharanas. A Pala of silver would therefore weigh 320 Krishnas. 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 Krishnas, 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 is equal to one Krishnala. A Trasarenu, as a measure of weight, therefore, is the equivalent of $\frac{7}{8}$ 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* (कुदाव), a vessel described as 3 Āṅgulis long, 4 Āṅgulis broad, and 1½ Āṅguli deep, with a cubical capacity of 13½ cubical Āṅgulis. 4 *Kudavas* = 1 Prastha, 4 Prasthas = 1 Ìdhaka, 4 Ìdhakas = 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 3½ 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 Paramāṇu in Technology, Silpasastra, and a Trasarenu in Natural Philosophy) follows directly from Varāhamihira's table:—8 Paramāṇus make 1 Rajas (or Ratharenu,—cf. the Manasara), 8 Rajas make 1 Vālāgra (filament of hair), 8 Vālāgras make 1 Likśā, 8 Likshās make 1 Yūkā, 8 Yūkās make 1 Yava, 8 Yavas (the Manasara has 4) make 1 Aṅguli (superior), 24 Aṅgulis make 1 Hasta (cubit, lesser cubit, 18 inches). The thickness of the minimum visible (the finest perceptible mote in the slanting sunbeam) is therefore taken to be $3.2^{-20}$, or $\frac{349523}{349525}$ of an inch. The volume of a spherical Trasarenu (or Paramāṇu of the Silpasastra) would therefore be $\frac{4}{3}\pi.3.2^{-63}$ of a cubic inch. It may be here noted that such a Trasarenu is supposed in the medical schools to contain 30 chemical atoms (Paramāṇus 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 $\pi.3.5^{-1.2^{-62}}$ of a cubic inch.\(^1\)

(परमाणुर्मोचलाद्रिभिषेकः यथोक्तर्मेव चच्चगुणाभिः पयोर्धरेऽपि चक्षुप्रेक्षाय भविष्यत् सङ्केतः.—Varāhamihira, Vṛihatsamhitā, Chap. LVII., Śloka 2. वायुअर्गो भानी यद्युतरं द्वेषेन रोगो याति तद्विनाशः परमाणुः प्रथमं तदं प्रमाणानां।—ibid., Śloka 1.—Cf. Utpala, तत्पराकृत्य नाम प्रमाणां जानीयात्। प्रमाणानां लक्षणां ततै प्रथमाङ्गां प्रमाणां परासुरमेंद्रः। Cf. also चतर्प्रकृति विशेषः विचिन्ता परमाणुभिः.)

The magnitude of a Paramāṇu is called Pārimāndalya (पारिमाण्डल्य) in the Nyāya-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 Paramāṇus were conceived to be spherical in shape. The Nyāya-Vaiseshika calls a Paramāṇu a mere point with infinitesimal dimensions, i.e. less than any assignable fraction of any finite quantum; but in the Sāṅkhya-Pātañjala, a Paramāṇu, though indefinitely small, had still assignable dimensions, being divisible into Tanmātras, which were themselves integrations of Bhūtādi. The diameter of a spherical Paramāṇu must have been conceived to be less than 3.2−20 of an inch (i.e. less than the conventional Paramāṇu with which linear measures begin), and the volume of a Paramāṇu would, therefore, in accordance with Bhāskara’s formula, be smaller than \( \frac{1}{2} \cdot \pi \cdot 3.2^{-65} \) or \( \pi \cdot 3.2^{-61} \) of a cubic inch, where \( \pi = \frac{\text{f.9}}{12} \). 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 Dhamanī or Nādi (nerve) that supply the pores of the skin (papillae? मुखाबन रोमन्त्र-प्रति, Suśruta) was supposed to be about a thousandth part of the finest hair in thickness, or \( \frac{1}{1000} \) of the minimum visible, and, therefore, about 3.10−8 2−14 of an inch thick (cf. दूरेनागार्मणरात्र: रोग: सहभागङ्गेनुस्मादृ प्रचरणि, Pañchadasī); 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 Śirās and Dhanamās in the body (three million fifty-six thousand nine hundred) is only a conjectural estimate (सन्निहितव्रमः परं तयनेव—Sārīrasthāna, Chap. VII.).

My account of the chemistry of the Sāṅkhya-Pātañjala, and of the affiliated Yoga and medical schools, has anticipated in several points the views of the Vedānta and the Nyāya-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 Sāṅkhya-Pātañjala, I will confine myself to the theory of the subject, and even of this I will attempt only the briefest outline.

The Vedāntic View.

The Vedāntists believe Māyā to be the "material cause" (उपदाताकार) of the world. The power of Māyā 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. Māyā is at once real and unreal, while the Brahma (Self) is absolute Reality, absolute Intelligence, and absolute Bliss. The world evolves out of Māyā (सत्तापरिक्रम), so that Māyā in the Vedānta replaces the Prakṛti of the Sāṅkhya. But Māyā, and by implication the world, originate out of Brahma, not by a process of evolution (परिक्रम), but of Vivarta (self-alienation). The self-alienation of the Absolute, acting through Māyā, produces in the beginning Ākāsa—one, infinite, ubiquitous, imponderable, inert, and all-
pervasive. The world thus begun goes on evolving, in increasing complexity. The other Sūkshma Bhūtas, classes of subtile matter, evolve from Ākāsa in an ascending linear order—Ākāsa giving off Vāyu, Vāyu giving off Tejas, Tejas giving off Ap, and Ap giving off Earth. Ākāsa (one, infinite, all-pervasive) has the capacity of sound. Vāyu (subtile gaseous matter) emanates from the universal Ākāsa, and is instinct with the potential of mechanical energy (impact, pressure) (ईरण् प्रकाशित, वहन, घूर्ण,—वायोध ख्वेषेक्षेत्रमेत ्तात्त्विनामृतमाल विद्वन्यमणरंजिनिः). Tejas (subtile radiant matter) emanates from Vāyu, 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 Mahābhūtas. There are five kinds of Mahābhūta (gross matter) corresponding to the five Sūkshma Bhūtas (subtile matter), and the process by which a Mahābhūta is produced from the Sūkshma Bhūtas is called Pañchikarana (quintuplication). All the five Sūkshma Bhūtas are present as ingredients, though in different proportions, in each Mahābhūta.

The Mahābhūta 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 Mahābhūta Vāyu is composed of four parts of subtile
gaseous matter and one part each of the other forms of subtle matter. And similarly with other Mahábhútas.

Hence if ak, v, t, ap, e, represent the five forms of subtle matter (Ákáśa, 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:—

\[ AK = ak_4 (v_1, t_1, ap_1, e_1), \text{ ak}_4 \text{ being the radicle.} \]
\[ V = v_4 (ak_1, t_1, ap_1, e_1), \text{ v}_4 \text{ being the radicle.} \]
\[ T = t_4 (ak_1, v_1, ap_1, e_1), \text{ t}_4 \text{ being the radicle.} \]
\[ AP = ap_4 (ak_1, v_1, t_1, e_1), \text{ ap}_4 \text{ being the radicle.} \]
\[ E = e_4 (ak_1, v_1, t_1, ap_1), \text{ e}_4 \text{ being the radicle.} \]

In forms of gross or compounded matter the potential energies (or qualities) become actualised. The Mahábhúta Ákáśa 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 Pañchadásí characterises the different Mahábhútas by their typical sounds: e.g., Ákáśa 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, Bhubhugu); Ap (water) by a liquid sound (imitative symbol, Culu-culu, gurgle, plash-plash, glut-glut); and finally, Earth by a splitting or rattling sound, a crack or a thud (symbol, Kad-kada). (Chap. II. Bhútaviveka, Sloka 3, Pañchadásí. Cf. also Jayanta, Mañjari.)

Others hold that Ákáśa (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):

\[
V = v_t (t_1 \cdot a_p_1 \cdot e_1).
\]
\[
T = t_2 (v_1 \cdot a_p_1 \cdot e_1).
\]
\[
AP = a_p_2 (v_1 \cdot t_1 \cdot e_1).
\]
\[
E = e_2 (v_1 \cdot t_1 \cdot a_p_1).
\]

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 \( T = t_2 (a_p_1 \cdot e_1) \), \( AP = a_p_2 (t_1 \cdot e_1) \), \( E = e_2 (t_1 \cdot a_p_1) \).

The Súkhsha 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 Sánkhya doctrine the atomic structure is ordinarily accepted. The Gunas are supposed to be परिस्थिति and चकळ, bounded and indefinitely small in size (except the Gunas giving rise to Ákása and Manas, which are unlimited परिस्थिति); and hence the Tanmátrás 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 Smrítis and the Puránas, the Vedántic theosophy with the Sánkhya cosmology, especially as regards Prakṛiti and the order of creation and dissolution. For example, the Vedánta-kaustubhāprabhá, 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 (तन्मात्राः), and that the Mahábhúta Ákása merges into the original Tanmátras, which then lapse into Bhútádi, the super-subtle 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 (परिनाम, transformation). Matter is constantly undergoing change of state. The effect is only the cause in a new collocation (कार्यस्व अस्त्यानवत्कार्येन). Change is of two kind:—

(1) Change by a spontaneous process, without external influence, including isomeric change (सामान्यविश्व-परिनाम). The Vedántists believe in spontaneous dis-integration 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 (त्रयोत्संयोज). Such combination may produce (a) a compound substance possessing like qualities with the constituents (समानतात्संयोगपर्वत), or (b) unlike compounds with new qualities, "heteropathic effects" (विभाषोत्संयोगपर्वत). Any new quality thus evolved through (chemical) combination is called Samhata-bhúta-dharma (संहथधर्मम्), e.g. the intoxicating power of the fermented rice and molasses, which does not exist in the ingredients taken separately (सफलोज्जयोऽपि चवचेतानापि समुदायसक्ता मद्वति: दृश्यते). This Samhúyakriyá (सम्भूषक्रिया, समुस्वाण) corresponds to chemical combination, and the Vedántists, like the Sáṅkhya, explain this only as the evolution of the latent Energy (एक्ष, प्रायोहक्ष) in a new collocation (संस्थान, अवधान-संस्थान). But, unlike the mediæval Sáṅkhya, 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 (पच-भीतित). 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 (परिस्पर्श, सांकोचपरिस्पर्श—Saṅkara; याम: परिस्पर्शादानकालात्—प्रारम्भ परिस्पर्शादानकालादेश—यहैतृ यथै यूक्तं च तत्क्षेत्र मनस्सौद्दत्तमाचय्—Saṅkara); but they give a separate substantive existence to the agents, the vital principle (प्राक), and the mind (मनः), though these are also evolutionary transformations of the Sūkshma Bhūtās (forms of subtile matter). What is common to the Nyāya, the Vedānta, and the Sāṅkhya is that Consciousness or Intelligence (चेतन) transcends Matter; but the Naiyāyikas, as pluralists, hold that vital and psychical activities are also immaterial and cannot be resolved into motion (परिस्पर्श). The Vedāntists resolve these activities into subtile motion, but ascribe them to a substantive quasi-material Life Principle and Mind, the all-mirroring Intelligence (चेतन) alone being immaterial and transcendent; and the Sāṅkhya system accepts the substantive existence of the Mind Principle (मनः) as derived co-ordinately with the Sūkshma Bhūtās or Tānmatrās from individualised Prakṛiti (Ahaṅkāra), but resolve Life into a mere resultant activity of the bodily organs, viz. the organs of sense and movement and the psychic principle (मनः).

पश्चाकरः — द्रिष्टा विद्याय चेतनेऽर चुः यापष्ट्य प्रवर्ण पुनः।
खेतरहि यावक्तियोऽयोजनतः पश्च पश्च ते।

यथा विकृतशुद्धि सृष्टिनां भूतानां सुदृढ़व्यवस्थानामहस्य कर्मोपयतया
विचृत्करणं पुनः तदः भूतपश्चं कस्तैत्तरः प्रणामस्वतः चाचित्ति च।
तदात् पश्चाकरः चाचित्ति प्रारंभोपयते सुदृढ़व्यवस्थास्य चाचित्ति योजना (विद्यावक्तियोऽयोजनाः)
— चाचित्ति हि शरीरे सांहत्वादास्य भूतानां कार्येन्मण्डिततिः चाचित्ति सूक्ष्मस्य प्रारंभचाचित्ति
नक्षेत्रदक्षिणानां स्वस्यनालुभवस्यवस्थानः। जगत्सत्त्वद्वारः पश्चाकरः प्रवर्ण भूतानि
रक्षितस्य देहे सर्वति विचारे तनुपर्यायस्य चाचित्ति पश्चाकरः—
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-sālinī, etc.).

The later Vaibhāṣikas 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 character-
istic dryness or roughness (\text{सर्वत्र}), and by their aggre-
gation form the Earth-element. The Bhūtas thus
originated combine to form aggregates, which are
classed as inorganic substances, organisms, and organs.
(क्षमेश्वरयक्षम्;—हरसमन्वये प्रवृत्ते यक्षमोऽयूः
इति जानकर,—also सर्वत्रहोऽरूपणस्वाभाविनः भूतानि).

**The Atomic Theory of the Jainas.**

Of the nine categories of the Jainas, that of Ajīva
(the not-soul or non-Ego) consists of five entities, four
of which are immaterial (चन्द्रे), viz. merit, demerit,
space and time, and the fifth, material (सूरे, possessing
figure). The last is called Pudgala (Matter), and this
alone is the vehicle of Energy, which is essentially kinetic,
\emph{i.e.} of the nature of motion. Everything in the world
of not-soul (the non-Ego) is either an entity (द्वस्य) or a
change of state in an entity (प्रक्षेप). Pudgala (Matter)
and its changes of state (प्रक्षेप), whether of the nature
of subtile motion (परिप्रवर्त) or of evolution (परिप्रवर्त), must
furnish the \textit{physical} as opposed to the \textit{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
(क्षेत्र) breaks up into several kinds of atoms qualita-
tively determined, and by differentiation, integration,
and differentiation in the integrated (संप्रवात, अश्राय,
संघात्—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 (मृगुक) to an infinitum (चन्नानुक). 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 (मृगुक), and so on ad infinitum. The ascending grades are (1) what can be numbered (संख्येष), (2) indefinitely large (चतुर्भेष), (3) infinity of the first order (चन्न), (4) infinity of the second order (चन्नानन्न), 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 (परिभाषां). 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 (सर, विपय, उपय, गोत) 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 (Ānus) 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 asafetida, 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 Umāsvatī'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 Bhūta and the chemical affinity of one Bhūta to another. The Jainas hold that the different classes of elementary substances (Bhūtas) 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 (पदार्थ) must be negative and the other positive (विपरीतार्थुक); the two particles must have two peculiar opposite qualities, roughness and smoothness (रचन्त and चिरपत, or dryness and viscosity ?), to make the linking possible. But no linking takes place where the qualities, though opposed, are very defective or feeble (लक्षणशुष्क). 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 रूढ़ि and फँग्न as dry and viscous must be rejected in this connection as untenable. The Tattvārthādhigama of Umāsvātī, which expounds the theory, most probably dates back to the first half of the first century A.D.

Cf. Umāsvātī-Tattvārthādhigama, Chap. V. —

शान्तवर्णाय भत्तिप्रमोदनारङ्गुलः। दूष्पाणि शोभाः। निमितिमयात्ताति चक्कापाणिः। कुपिष्ठः पुष्करः। भाकास्रेष्ठुद्रपाणिः। निमित्तपाणिः च। पुष्कराङ्गुलः क्षिपायनः। (क्षिपेति गतिमयमृह)। दार्कोङ्ग्रे प्रदेशः। सति चन्द्र पर्यायः। संस्कृतविशेषास्य पुष्कराः। नायः। स्याति महायज्ञः पुष्करः। तथा स्याति स्नानः। बादः मूद्देहुऽहः श्रीत चन्द्रः। चित्तूः। रसः। पयाधिभिः। बुद्धः। भ्रातायोऽयथाभिः। दशः। पदीशिः। बुद्धो निळो लोहितः। पीतः। मूलः।

श्राद्धस्यत्प्रक्षणसेर्मन्यस्या भवेदनमश्यामात्योऽशितस्य च। तथा श्राद्धः। पृष्ठिः। ततो वित्तो बचः। शुधीरो चर्मः भाषितः। चचः। श्लोयः। उसः। च । भारतेन देवच सूक्ष्णो निविष्य भयति परस्यः। श्लोकं गच्छन्ति निमित्तः। कामिनिः। तथायोऽयथः। श्लोयः च । श्लोकं लख्यः । संवादतः भूषणस्य च। मूलः। भ्रातायोऽयथः। दशः। पदीशिः। चचः। श्लोयः। उसः। च । भारतेन देवच सूक्ष्णो निविष्य भयति परस्यः। श्लोकं गच्छन्ति निमित्तः। कामिनिः। तथायोऽयथः। श्लोयः च। श्लोकं लख्यः। संवादतः।
The Nyāya-Vaśeshika Chemical Theory: A Brief Summary.

I must content myself here with a brief and rapid sketch of the chemistry of the Nyāya-Vaśeshika, 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 Nyāya-Vaśeshika to the following canons: 

(a) कार्यमधुः कार्यमधुः।
(b) समानान्तर्दायोऽर्जस्य: द्रुष्या-रम्भः।
(c) चाप्यकर्णेऽर्जस्यमेऽपरास्मार्जनः।
(d) हृदयसमानान्तर्दायोऽर्जस्य:।

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(d) हृदयसमानान्तर्दायोऽर्जस्य:।
\textbf{The Ancient Hindus}

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

\textit{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 (चक्राक्रमःसरस्वत्स्यस्त्यापरिस्मात्वेवप्राणीवेगाः).

Ákāsa has no atomic structure (निर实践中), and is absolutely inert (निरिष्ट), 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 (पाकमोद्यित) takes place.

Atoms cannot exist in an uncombined state in creation (Śiváditya, Saptapādārthi, \textit{vide} commentary), where, however, it is noted that still atmospheric air is believed to be monatomic in structure, \textit{i.e.} to consist of masses of atoms in a loose uncombined state (स्तिरिनिरपेक्षपुष्प रन चनार्थत्तौ). 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 (द्वामुक). In
the same way binary molecules of the other Bhūtas 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 tetrads, a pentad, etc., of atoms is one of the moot points of the Nyāya-Vaiseshika. The orthodox view is that the primordial infinitesimal particles (atoms) start with an incessant vibratory motion (*ṇaṇavarṣaparipāparakṣāparipāparakṣā-pāvā-reśāopa*, Raghunātha Śiromani; *गरिष्ठेऽख्यातः पतत्त्वदेभा: यज्ञीति*, 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 (*चूक, ब्रह्म*).

(*भुरेभिच्छिन्नराज्ये इत्यि निनयो, न द्राह्यो। परस्मयाय इति, व्यथानिषयः। कदाचित्त विभिन्नराज्यं इति, चाकुशलिकेऽपि, कदाचित्तकुतुरिकर्मके कदाचित्त प्रभावितः। यथेष्ठ कलना। चतुर्विस्तार- तथा तथा ते यथा यथा यथा तदार्थेष्ठु सयपरावयो श्रीयते। चतुर्विस्तारः सर्वायताः सुविदः।—श्रीधरा, न्यायाकंदाली, शृण्योरनिर्देश्यम। Cf. Vāchaspāti's report, Bhāmatī, Chap. II., Pada II., Sutra 2. यदा चतुर्विस्तारभूते चुकी व्यथानिषयार्थानातः।* Prasastapāda appears to have originated this view (*परस्मयानिषयेः परस्मयेः—तैलार्थे व्यथाकारे—दिलक्ष्ये—Prasastapāda, परिमार्यानिर्देश्यम।*); but that another
view was also maintained in the Vaiseshika school is
evident from the brief summary of Kanāda's system
given in Utpala's commentary on the Vṛihatsamhitā,
and this indeed also follows from Śrīdhara'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 (Tṛyanuka), then, holds together three
atoms (Anus), not three binary molecules (Dvyanukas),
as on the orthodox hypothesis. Similarly with tetrads,
pentads, etc. (चयनिकम्: परमाशय: नित्तिकनित्तिचाथ्वकानाम्) द्रावणो
परमाशयों ज्ञावयुक्तामाहेते विनिम: परमाशय्यद्वयुक्तामाहेते तत्त्ततः जनेः
त्यत्यथा द्र्र्र्यथास्थायतस्य:||—Utpala, Chap. I., Śloka 7; cf. also
Śrīdhara's admission, चयना यदि परमाशयो ज्ञावयुक्तामाहेत
tतत्ततं ज्ञावयुक्तामाहेते ज्ञावयुक्तसहितात् द्र्र्र्यथास्थायते तत्तति युवानसे नित्तिचा
विनिमय: चयनिकम्: चयनिकम्: चयनिकम्: चयनिकम्:●—Śāṅkara seems to speak of two binary molecules in the
Vaiseshika as forming a tetrad (द्र्यथास्थायते ज्ञावयुक्तामाहेत
t—Śāṅkara-Bhāṣya, Chap. II., Pada XX., Sutra 2, where
the Bhāmati gives a forced interpretation).

In Prasastapādā's view, these binary molecules are
grouped by threes, fours, fives, etc. (चशक, चशक
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 col-
location, खूंट, चयनिकम्: चयनिकम्: चयनिकम्:
which account for the specific characters (चप्पर्माति) manifested by these
isomeric substances. सा (पृथिवी) च चयनिकम्: चयनिकम्: चयनिकम्:
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 (सत्ता, कल्य), 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 (प्रकृतिप्रभा). 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 Vaiseshika holds that there is decomposition into homogeneous atoms, transformation of atomic qualities, and finally
re-combination, all under the influence of heat (पिठुपालक). The Nyāya, 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 (पिठरपालक).

This is the Vaiseshika view, but Jayanta himself inclines to the opposite view: प्रकृतिसुचितत्वेष्व कान्तेउद्दयत नम: चारधात्र: चलसेजः नकुरुन्दैवे स्वत्त्वपरापस्यः च च चिन्तक: बहुततवःस्वत्त्वनांस्य चारधात्रः स्वच्छलाहो रसकुरुस्तः नमः प्रतिकृतिस्तु साध्यमण्डलोऽपि संबंधे देवि। (Jayanta, Nyāyamañjarī, भूमिकतन्त्र-पूवेप्वय.)

II. Chemical Combination (समुष्टिक्रिया, संहारक्रिया).—Chemical combination takes place either between two or more substances which are isomeric modifications of the same Bhūta, or between substances which are modes of different Bhūtas.
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 (*विना or नोदन*) of heat-corpuscles, the substances in chemical contact (*सार्वभूत 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 परमायुं चपरमातिभें विना न च चक्षुमाण्डितसङ्गस्यस्य बाध्यविकः ।—Udyotakara, Chap. III., Ánhika 1, Sutra 4.

न च मुख्योपक्रस्यस्यस्य बाध्यविकः पारिशासिकः—Śrīdhara, Nyāya-Kandali, पुष्पवीति-रुपवान् ।) Under the continued impact (or, it may be, impulse) of heat-particles (*तेगाता यष्टिप्रज्ञेश्नानि तात्त्वा चनिष्टातात चचिष्टातात्*) (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 (सूर, तृतु, or मघम पाक); and (3) the species of Tejas-corpuscles that impinge on the atoms, or the nature of the impact (विस्फोटसंयोगा). । न ज्ञातिसंयोगस्वरूपात् अथवा रूपात् इति चाप्य हे पूर्द्धपादित्यिन्यायेऽपि। यदद्विप्रमेये चारीविसंयोगमेव सत्य ने पूर्द्धपादित्य्यायोऽयं च अग्नो विशेषसमयानाय: चारीविसंयोगः उत्तरात् रूपात्रिृत् विशेषायाचार्ये। Vide also Udyotakara, III., 2, Sutra 14. Cf. also Vāchārjya, I., 1, Sutra 4. अवस्था:स्वरूपमेव चाप्य उपांतस्य पिठस्य चौभावायाधिकृतस्य विषयसमय्य पूर्द्धपादित्यिन्यायाना ब्राह्मणार्णेवत्सः तिमाता विन्यासायाय मायाः गम्भरसम्यको इति सिद्धान्ते। ।

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 (धू, चन्द्रकांति) may vary, different compound substances may result from the same components.

(6) 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 Ener, वायु) to form the germ-plasm (कालकुट). 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 (कालकुटर्षिकर्मावर्तमान), 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. (समुन्नपापकान्तः: कालकुटर्षिकर्मावर्तमानः: कालकुटर्षिकर्मावर्तमानः: वपत्तिवतिपति: चाहा-र्षिकर्मावर्तमानः: सह सम्भूष शरीरान्तर्नार्थाये इत्येचा कल्पना। रिषु: ध्रुवेः मात्रः: क्षोभेऽति तथोः: कल्पतानान्तर
In this hypothesis 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 transformed into curd, one view is that the transformation takes place (under internal heat) in the constituent atoms of the milk-molecules, atoms specifically determined as milk, and not in the original atoms of the Bhūta (or Bhūtas) entering into the composition of milk. (Cf. नाघदुःपार्थिव्यः परमाशुभिन्द्र दृष्यार्थाय। रक्षामपि दृष्यार्थकर्तव्य परमाशुभिन्द्रि दृष्यार्थाय। Nyāyabodhinī, on Annam Bhatta’s Tarkasaṅgraha. Cf. Dinakarī—मयुसवपुरस्वर्णपियत्तपमेंद्र तस्य (द्रष्य)।) In these cases the atomic contact is called constituent contact (चाराभन्योऽः), and all the atoms are equally regarded as material causes (प्रादानवार्थ च चाराभन्योऽः) 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 Upashtambha, Vīshṭambha, or Avashtambha (उपश्वम्, वीश्वम्, or अवश्वम्). 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-sensitive 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 (उपश्वम्), and excite the Earth-atoms, and these substances, oils and fats (देहवगी and पृष्ठवगी), as well as acids (चक्षुवगी) are, because of the Earth-radicles, regarded
as Earth compounds (or Earth substances).

In the above instances, Ap (water) acts as dynamic (Upashtambhaka, Upahmrak), but Tejas and Vayu can also act in the same way on Earth-particles. Conversely, Earth-particles may act dynamically on the atoms of the other Bhuta.

For example, in the case of mercury and the metals which are conceived in the Nyaya-Vaiseshika to be igneous bodies (in fact, they are supposed to be formed under the subterranean heat, chara), the Tejas-corpuscles are believed to form the radicles, and the Earth-particles are dynamic (Upahmrak). (Suvishruti nirnayam atmanam gatvam param sv abhavantah. Upahmrako'pi paricchedayah: sarvam bhuvana padma pratyayatma. Yathu pustapada iti rajasartha duratyate paramam bhuvinaryakam vayuras. Sloka padaradhi yajnavalma. —Udayana, Kiranaval, tamaartipramano. Cf. also vishrutip tattvasanajjati suvastha tenayatra pariccheday maha pratyayatma.)

It may be here noted that Gangesa, the author of the Tattvachintamani, conjectures that even gold can be evaporated or made to disappear by the application of intense heat: cah dhantrastairata: amla: prabhavat: prabhavamaharangena suvastha anatra tattvataro nasa. But Mathuranaatha notes here: bhutam apsrayabhodekshanam.

But while every Bhuta can act dynamically
as उपरमक, "energizer," "exciter," it is the Earth Bhūta 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 (Vishtambha, विष्ठम्भ); or (2) the power of counteracting the tendency in a given set of atoms to fall into a peculiar order or group (यूहविरोधितनम्). (न च पारिपर्यणः चम्बो दृष्टान्तरं गङ्गहियताविष्ठम् पूर्वायुं वा विश्राविधि।—Udayana, Kiranávali, पृष्ठवेवनिर्देशायाः। पिताह्रवतं सामाविविवमुद्भृष्टायाः गिर्नियताविष्ठम्। यूहविरोधितनम् च सामाविविवमुद्भृष्टायाः पत्राद्वियताविष्ठम्।—Vardhamána, Kiranávalíprakása, ibid.)

Oils, Fats, Milks.—Bi-Bhautic quasi-compounds, with Ap as energizer: Oleaginous substances (चक्ष्यात्ताकं त्रेघिः) 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. विष्ठपूर्ण) 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 (वचवसविभेदः—तत्सामालयिकंभिष्ठामिल्यासतान्यानिधिः।—Udayana, Kiranávali). 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. (....)

—Udayana, Kiranávali, वृणिजीविनित्रयम्। Vallabha notes that ghees do not differ in kind as milks (and curds) do: चन्तराधिकारणिद्वारे दक्षिणयते दुष्किरदु सतमेवाल्याल्यामिति चेश।—Vallabhā, Lilāvati. Compare Váchaspati, II., 2, 65: चावदेशादोलो नामां गमनेन द्वरा रेणवं यहस्ते। चन्तराधिकारणिद्वारयां दक्षिणयते। त्वक्ष्यावोैगन्धरक्षविभावं। भान्तु तैलस्थानं योगः। वृणिजीविनित्रय रसष्ट्रशां। चन्तराधिकारणि खिरम्। न ह वाणिज्य तद्भन्द्रक्षस्य रामेदस्य चारिङ्गे चाचायाः व भास्याः।)

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 (रसेन पावकारिताविनित्रयादायः प्रवुक्त्वः—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 लि नाम उपपाकाराणां द्रव्याणां कार्यविद्येतानुसने सति द्रव्यानन्यप्रकाराणां पाकशोष्यती यः संयोगः व युव इति। द्येन पाकशोष्यविद्येतानुसने वाराणसः प्रमुखः \textit{Udyotakara, Vārtika, Chap. I., Áhñika 1, Sutra 14. Vide also Vāchaspati’s comment:} उत्सवपाकाराणां तत्त्वो संविन्या व विधमोगिकायवाणी द्रव्यानन्यन्ते संयोगः पाकशोष्यप्रकाराणां सति न चासी सहसा इत्यत द्रव्यानन्येन स्वरूपस्य। स च संयोगाभेदपव तोयस्योपेनु चस्यविव विशालियोर्वगरनामभानात। नापि यूषो तावातो तोयसंगोपितू द्रव्यो द्रव्यानन्यन्ति स्वरूपस्य। तत्त्वविव वादामुन्यो वादामुन्यो तत्त्वविव वादामुन्यो तत्त्वविव वादामुन्यो। इति तु तत्त्वविव न द्रव्यानन्यप्रकाराणामः स्वरूपाभेद एव तोयस्योपेनु च स्वरूपाभेद। स च चतुर्भविन्य: संयोगाभेदिरिकः \textit{Vāchaspati, Tātparyyatikā, \textit{ibid.}} For earthy salts in sea-water, vide Kiranāvalī: यत् गुप्तमुन्यविभिन्नैवेदन करारादित्य रत्: यासे उपपाकाः स द्रव्यानन्यप्रकाराः वादामुन्योपाधिकः। तथावत्य सर्वव धनात्मवर्त्त्य रते: न्युन एव एव। \textit{Udayana, Kiranāvalī, जङ्ञिम-हंसवन्न।}\\n
\textit{Chemical Action and Heat.}—The operation of heat is of course universally implied in chemical combinations. Where the application of external heat is
wanting, Vātsyāyana, the great doctor of the Nyāya, points to the operation of internal heat (e.g. पृथ्विवैषयः: चक्ष्यातुि संग्रहीतः: चामरेक तेजसा चिक्षान: रसदृढ़ि निपत्तीर्था! — Vātsyāyana-Bhāṣṭya, Chap. IV., Áhnikā 1, Sutra 47). In the case of combustion we have seen Vijnāna-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. (वृक्षार्दिविकारो यि पदि रूपादिपरावृत्रिष्टिज्ञापेशु: स नूननाम्यापेशेश तेजसा ब्रजेषः। तादुध्वः च पावे चारित्तिः निमितिः। न विचिरिक्तनिमायिन्ते। न हि स्रीरस्य तेजसः पृच्छामये हृतोऽहिरत्यानमः चामः। चष पिन्नैरो अस्तिद्रूपे विविख्यतः। वृगतिः एव नि-महतेन पुष्यादिदु एव सरोबो या च। चष रूपादिपरावृत्रिष्टिज्ञापेशेष्वर चारिः साम्ये तद्वस्मः। तस्य द्वानुस्तेन- ग्रास्य योग्यानुपल्लवाभितितबानः चतादुध्वस्य तेजोxabत्वन्न्योसेवायुक्तः चारिन्हमात्। —Udayana, Kiranavali, सृवत्त्वल्लाशियिभिनिरक्षमय्।) 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 (मोक्षेयअकः) even as the conversion of food into chyle and of chyle into blood are instances of chemical action due to the internal animal heat (महाचालक्ष्यदं च द्रोही तेजः). But the kind of contact with heat-corpuscles, in other words, the kind of chemical action (पावक) which transforms colours, is
supposed to differ from that which transforms flavour (विभूषणतेजःसंयोगं and पाक), and this last from that which produces a change of smell, or tactile quality. (पाको नाम विभूषणतेजःसंयोगं। सच नानागतिगैः। रूपजनको विभूषणतेजःसंयोगलदापेश्या रसजनको विभूषणती। रत्न स्यझाितीचिपि तथा। रत्नप्रभारेण भिषजभिनाती�। पाका: भावेश्वविषेण कालनौपा। तपानि नानागतेजःसंयोगलदापेश्या विभूषणतेजःसंयोगलदापारखवालय प्रीतहितुपकाः। पुषःस्यसम जम्बुवाकानुभवः। ब्रह्माः प्रीतहितुपकाःसेरेष्य प्रक्षारङ्गतितेजःसेरेष्या विभूषणतेजःसंयोगलदापारखवालय पुषःस्यनादापनासः मधुर-रसानुभवः। तत्तदूपजनकापेश्या रसजनको विभूषण रत्न गन्धजनको विभूषण त्वाकुरोकृतीिचिपि पुषःस्यनादापनासः विभूषणायाम-बाजाना कुलाविश्वाकोलो। रत्न स्यझाितेजःसंयोगलदापारखवालय ब्रह्माःस्यनादापनासः कलिनास्यान्तः मुस्सकानुभवः। चतरथु पारिवर्णरानानंतरेनकालाठीिचिपि पारिवर्णराना विभूषणान्तकालानुभवः। यथा गोभुस्वाहातीनं चारदानाक्षरं भक्ते गृहाः रथ्यवर्णपनाशयु प्रीतहितुपकाःसंयोगगालय प्रीतहितुपारिवर्णरानासः तदनरार दुर्बे यात्राहृितवाणिदिवशं वर्तंते तातुस्पर्शस्मांतप्रभास्मलास्यान्तेः। तत: भाषाजितेजः प्रहुतघुर्गमर्गमहिनारमण्डलते।—Nyāyabodhini 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 rectilinearly 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 (स्खलना), penetrate through the inter-atomic spaces with Parispanda of the nature of
deflection or refraction (नियोजनम्, Udyotakara), in the same way as when fluids penetrate through porous bodies (तत्र परिस्थिति: नियोजनं परिवर्तवितम् पात हृत—Udyotakara, commenting on Vātsyāyana's परिस्थितिपरिवर्ती, Sutra 47, Āhnika 1, Chap. III.); or (2) impinge on the atoms, and rebound back—which explains reflection (मृत्यु, विनिर्गमनम्—Varāhamihira, राजस्थानीचरण—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. (प्रथमौ द्वितीयं त्रितीयं च नियोजनं वार्तालोकविधिमयौ अवकाशितम् न भगवत्व मूलाक्रमित अवन्तोदेहु बालोकालविभिन्नो हरिचितानाम्।—Udayana, Kiranávali, तेजोनिद्रशयम्, taken from Vāchaspati, Tātparyatikā, प्रवचनशास्त्रद्वारा। Cf. also पारस्योऽति तेज: वेणवता वार्तालोकविधिमये तेजसला न प्रवचनशास्त्रद्वारा।—Vāchaspati. परमेश्वरविद्वाने पिक्षितसः परमेश्वरविद्वाने पिक्षितस: प्रसर्षतं प्रस्तावदेहु प्रवचनशास्त्रद्वारा। तत: वर्ष दोषोऽपूर्वविवस्तत: सहायत: प्रसर्षतं न स्वपरिमेयायुद्धविभाषिन: प्रवचनशास्त्रद्वारा। विख्यायते विशिष्टविभाषिन:।—ibid. Cf. स्वाधिकारितारिकोपदयितिः प्राप्तिकारिताः स्वाधिकारिताः तेजोगतेरप्रतिष्ठावतः प्राथ्मिक्षम् वाच्याविद्वाने।—Udayana, तेजोनिद्रशयम्, in reply to the objection: यदि हि ग्राम्य गृहीतां गुणोद्वृत्तां स्वाधिकारिताः प्रवचनशास्त्रद्वारा नाद्वृत्त ग्राम्य गुणोद्वृत्तां स्वाधिकारिताः।—Udayana, ibid. Definition of खंडहाता—दृष्टान्तबं—स्मृतिकृत्ताः। खंडहाताः। दृष्टान्तबं गुणोद्वृत्तां: वाच्याविद्वाने स्वाधिकारिताः।—Udyo-
takara, Chap. III., Áñhika 1, Sutra 38. चादिवर्गः: स्मार्टिकारिते स्थापित द्राक्षेविषयात्।—Sutra 47, where Udyotakara notes: जोत्यप्रविषयात्—यथा द्राक्षेयायण्या न यूढःस्तेऽतस्य चन्द्रास्वयम्: चण्डालस्मानस्य चतुर्भिनस्य: सोप्यितत इति। Váchaspáti explains यथा द्राक्षस्य भगीनकपालादेः भगीनकपालादेः यथा न यूढःस्तेऽप्रत्यक्षयायण्यास्वादेः र्यामीनस्य चन्द्रास्वयमैव्यामिमस्माय: यथैः सोप्यितताः। Cf. Vátsyáyana on Sutra 47, Áñhika 1, Chap. III. On the other hand, in chemical combination, जनःप्रेषः: कृष्णान्तरोऽपिते। जेन चेयता वहितृप्लेष नौदनात् ज्ञितात् च चयंपेषु: क्रिया, क्रियाते विभागः, विभागाः चाच्यम्बियोगविनायकः: etc.—Jayanta, Mañjarí, भूम्यस्यस्यपह्रः। For opacity, shadows, etc., vide चायाः हूः तेऽगायायोरार्यात् भूमिनिता परमाणुता तेऽगायायार्यात्। यथ च चायाः चायाः तेऽगायाः। विचारेः:सम्बन्धीविन द्राक्ष्युपपर्यावृत्ती चायाः इवनिप्पेत्। सम्बन्धीविन चायाः हूः तात्त्विन तमःसहसरातिन—Udyotakara, Chap. IV., Áñhika 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. (निलं परिमाणं—परिमाणेऽव पारिमाणस्य—Saṅkaramisra). To conceive position in space, Váchaspáti 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. (रक्षेपियः दिशः चादिलोद्यदेशः प्रवालवदेशः संप्रक्रमणः यः स इतराशुचिप्रकृतियासंयोगात् परमाणः: पूर्वः रक्षादिवासमयदेशः प्रवालवदेशः संप्रकृतियासंयोगात् परमाणः: पूर्वः च पूर्वेषः च पूर्वेषः च पूर्वेषः च पूर्वेषः च पूर्वेषः च पूर्वेषः च पूर्वेषः च पूर्वेषः। रक्षादिवासमयदेशः प्रवालवदेशः संप्रकृतियासंयोगात् परमाणः:। रक्षेपियः तैवृद्धिसमाचितः सत्य चार्येन चार्येन चार्येन चार्येन तैवृद्धिसमाचितः सत्य चार्येन चार्येन चार्येन चार्येन। —Vāchaspati, Tātparyyatīkā, Chap. IV., Áhnika 2, Sutra 25.)

The original physical arrangement of atoms is also given. Each (spherical) atom is in contact with six other atoms. रक्षेपियः दिशः चार्येन चार्येन चार्येन चार्येन चार्येन चार्येन चार्येन चार्येन चार्येन चार्येन चार्येन। यथार्थता। यथार्थता। यथार्थता। यथार्थता। यथार्थता। —ibid. Cf. also the objection in the Buddhist Kārikā, यथार्थता। यथार्थता। यथार्थता। यथार्थता। यथार्थता। प्रायः स्नायुमात्रः। This is the typical primordial arrangement, and variations in the collocation of atoms and molecules (चूह, चवयवसीयः),
as we have seen, were conceived to account for the variety of isomeric modes of the same Bhūta, as well as of mono-Bhaustic and poly-Bhaustic compounds.

The molecular arrangement in the case of bi-Bhaustic 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. (संयोगकं, संयोग:) उत्तरशास्त्र निरोपवास्थ या निर्भौवस्थ कारकसंयोगिकारण: कारका- 
कारकसंयोगपुंश्ल: कारकसंयोगिक: संयोग: . . . उत्तरशास्त्र उत्तरहर्गति:। 
काल । यदा पारिवारकयोरक्रृतः संयोगे सति चन्द्रन पारिवर्ण पारिवर्त चन्द्रन 
चायेन च चायस्य चन्द्रमल्लेनो भवति च तथा संयोगान्य पारिवर्णोपख्येय: 
चन्द्रमल्लेन:। तत्स यस्मिन् काले धर्मायः: कारणमुष्टेनेक रूपाभविषः: 
सहिष्ठेय काले इतरकारणवार्ता कारणात: संयोगाः इतरकारणवार्तासंयोगाः 
संयोगी गुणधर्मसतः। भि कारण:। कारणसंयोगिना भि च कारणसंयोग नाथ: 
चतुर्य पारिवर्ण कारणसंयोगिना चायेन 
चन्द्रमल्लेन:। पारिवर्णोपख्येय: कारणसंयोगिना पारिवर्णोपख्येय:—Prä- 
सातपाद—भाष्य, गुणधर्म चायेन संयोगवादवम।)

The whole process may be graphically represented
as follows:

Molecules of a bi-Bhautic Quasi-Compound:
Graphic Formula of Complex Contact.

\[
\begin{align*}
E &= \text{an atom of Earth.} \\
W &= \text{an atom of water (Ap).} \\
E \downarrow &= \{ \text{a binary molecule of Earth.} \\
W \downarrow &= \{ \text{a binary molecule of water (Ap).}
\end{align*}
\]

I will conclude this account of ancient (and mediaeval) 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 (किरण, चापार) 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 (वैद्युविधनसपीतन — Saṅkara). Ākāsa, in the Vedánta, as we have seen, is the first stadium in the evolution of Matter, which gives off Vāyu, which gives off Tejas, and so on; but Ākāsa (ether) itself passes through two stages before the emanation of the Súkshma-bhúta Vāyu: (1) the motionless ubiquitous primordial matter-stuff (answering to the Sáṅkhya Bhútádi) called Puránam Kham (पुराण क्षम); and (2) a subtile integration, the pure un-quintuplicated Súkshma Bhúta called Váyuram Kham (वायुर मक्षम), answering to the Sáṅkhya Tanmátra stage. It is this subtile Ākāsa, 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 (सार्वोऽपरिस्पन्दः—Saṅkara). So also the biomotor and sensorimotor principles apart from the directive intelligence of the Self (प्राप्तं परिस्पन्दः—युक्तं सूक्ष्मं सत्त्वं मन:स्मिद्धमाच्य:—Saṅkara). The Sāṅkhya also conceives this Parispanda to characterise every process and phenomenon of cosmic evolution (यथा सत्त्वं परिस्पन्दः—Vāchaspati, Kaumudī). Bhūtas, organisms, mental organs, as modes of Prakṛiti (considered apart from the Intelligence of Puruṣa) are all subject to this Parispanda (पुत्रादिदी देखि देशानारे पथातूते हति तेषां परिस्पन्दः। सार्वोऽपरिस्पन्दः परिस्पन्दः प्रकृति रच।—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 (सदृढ़परिश्रावः), is devoid of all Parispandic motion (यथापि चन्द्रादित्यापि परिश्रावः निन्दाय, तथापि परिस्पन्दः नालित।—ibid. on Kārikā 10). The Nyāya-Vaiseshika finds Parispanda in all forms of matter, except Ākāsa, which in that system is non-atomic and incapable of any change or activity (विद्वेष्यः). 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 (चचन्त्रपरिस्पन्दः। मानामपरिश्रावः—Raghunātha; compare also Udayana-Kusumānjali, Stavaka V.—परमाणवः र्यं गतियोऽर्चनात् पतनमवेदेः पतनीति।). All physical action consists in motion. The Nyāya-Vaiseshika 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 (चतांतिक्रियापार) is put forward as a philosophical (epistemological and metaphysical) proposition to justify the Nyāya analysis of the causal nexus into mere invariable and unconditional antecedence among phenomena without productive power or efficiency (अष्टांतिक्रियास्मृत्त्वा नियतत्तुत्त्वाचरणिता—Bhāshā-Parichchheda). It is not, of course, intended to question the existence of Paripanda, which is of the nature of motion, and which, though subtle and therefore infra-sensible (सूक्ष्म and अनुभवस्मृत्त्वा, not चतांतिक्रियास्मृत्त्वा), is the ultimate form of all physical activity. (परिपालन च न कीर्तिको चाप जनाइते: समीक्षान्तु चापारस्मृति जनाते फलम्। न घुलजलमात्रोऽस्मृत्त्वा चापार यज्ञपालने।—Jayanta, Nyāyamañjarī, Āhnika 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, समुद्रंदेवसाराक्तवारकनिवारकपरिपालन च चिन्हानुपालिता: पाक इत्यादि। . . . चच चापार शष्यः सहाय: समुध साधयं। अर्था पलकेयापास्ते व: तत्त्व समुद्द साधारान। —Jayanta, Nyāyamañjarī, Āhnika 1.)

But, in the Nyāya-Vaiseshika, 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 Sāṅkhya-Vedānta, 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 Paripandic motion. (क्षिप्राविश्वेषेऽन्याय्य चापर: सागुराण्यः। स्मद्वामकस्वनितिक्ष्रियालक्षणविचित्रम्।—Quoted in Jayanta’s Nyāyamañjarī, Āhnika 4.)
ADDENDA.

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

A. Searing of hard rocks to enable them to be cut (or pulverised) (क्षित्यादार्थ).
   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 Bisflorus) 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).—(Varāhamihira, Vṛihat Samhitā, Chap. XXXIII., Ślokas 112–117.)

B. Hardening of steel (शालमयन).
   (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, सदुपक्षिण, Chap. XLIX., Ślokas 23–26.)

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

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 Ἄγλε 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 gauya (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 Varāhamihira, Chap. LIV., on वृक्षसौर). 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 Haridrá (turmeric). This process will succeed even with the Tintidí (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—तक्ष्य) in a decoction of eight roots (Ásphota, Ámalaki, Dhava, Vásika, Vetasa, Suryyavalli, Syáma, and Atimukta, i.e. the jasmine, the myrobalan, the Grislea Tomentosa, the Justicia Ganderussa, the Calamus Rotang, the Gymandropsis 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 (महस्वोऽद्वेन श्रीमोन्न चावानां शेषः इष्टे—पृष्ठाभेंि, 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 Bhāṣya¹ on the Vaiśeṣika¹ Aphorisms, written probably in the third or fourth century of the Christian era, if not earlier, Praśastapāda begins the Section on Motion (तथेत्राय) 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 (तत्त्वद्वा निरंतरं पे भाष्यते). He regards karma (motion) as instantaneous (काल) in its simplest form, distinguishing it from vega (impressed motion, momentum), which is a persistent tendency, Sanskāra, and implies a series of motions. Accordingly in one and the same particle there can be only one motion (कार्य) at any given moment, since its change of place at that moment is one and definite (रक्तदा रूंधे अन्तः रक्ते बहँ तत्त्वद्वा प्रकाशं, बहँ द्वींद्रिकं). 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 (चन्द्र चादिक कालमित्य कालमण्डल: तदा रक्षकां वचनसे: द्वितीयकल्पनानातेयब्रम्हप्रोक्त —Praśastapāda). One and the same motion can effect only one particle, as the changes of place of different particles must be different (एवं कर्मे न च चने व वस्ते—Ibid.).

Now motion is always marked by a certain direction (दिर्ग्रिहिताश्वमर्भावमय विप्रेषिः).

(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 (उर्बेषयं, चपोषयं), or (b) other forms of rectilinear motion, contraction, dilation (चाकुषणं, प्रसारणं); or

(ii) the directions of the successive motions may be different, as in curvilinear motion (उदनियत्तदिन्महत्त्र-खंडोगनीभावांतर्गत तदगमन), e.g. भ्रमण (rotatory motion), स्वदन (vibratory motion), etc. All these are varieties of Gamana (गमन, curvilinear motion). उर्बेषयादिन्महत्रे: चन्द्रवह्नानि भष्यवपतनस्य नादान्यानि चचरोथां च मनवह्नां कृतम—Ibid.; cf. Śankara Miśra, गमनं प जातिविक्रम: भविष्यत्वस्तुपद्यत्वेऽशुरंनमलोकनामिवापि. In another sense, all kinds of motion in material (inanimate) objects, whether rectilinear or curvilinear, are called Gamana (गमन).

(यत्व पदविवर्तानि कर्मे छापोरावयवेनुष तत्त पभवेनुष तत्त प्रभवं पर्ययं । यत्त चन्द्रेऽ चादिकायमेव तेषु चन्द्रेऽ च तत्त गमंगमयित्व प्राशस्तपादां, जमीनस्य।)

Single particles, then, may have a serial motion. When particles (चयवते:) combine to form a body (चयपरी), they may move continuously in a straight line, in
which case the body is said to move in that direction (चवयविक्रिया वाष्ट्रविक्रियानिविजत्वात्, 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 (अन्वय, स्पन्दन) and a vertical downward motion (वर्ग) 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 तन्त्र, 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. रक्षामानर्कर्मिक युगपत्रद्रव्यां अस्वायत्नप्रेणस्तत्रापि: चर्च भवति । चर्च नम सवयवायविनो दिरिविक्रियाने संयोगविभागान्तो 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 (प्रयल), e.g. the movement of the hand.

(2) Movement as of a falling body. This is caused
by gravity (गुर्ण), which in the astronomical treatises of Āryabhata, Brahmagupta, and Bhāskara is ascribed to the attraction (प्रक्वेष, pulling force) exercised by the earth on a material body. The force of gravity may be counteracted by volition (विश्वाक्रमम), 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 (स्वप्न). This is due to fluidity (विद्युत), 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 (चलमपदिवार्त) ; the efficient cause (नित्याकार) is even in this case gravity (गुर्ण) in the particles of the fluid. नास्तक्षरं स्वप्नं तस्मात्संतुष्टिमात् चरमवाचिकारखात् संस्कृते, गुर्णाद्वायु नित्याकारवात् चलमपदिवार्तको (Śankara Miśra, Upaskāra, on Sūtra 4, Âhnika 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, Adriśta (अद्रित), 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 (चिन्हर्वेद) as of liquid particles from the root to the stem of a plant. The upward motions
of water-particles in evaporation and in boiling do not require the hypothesis of Adrīṣṭa, as these are caused by the pressure of heat-corpuscles (रेख: वर्णाणु) and the contact with air-particles (लोकायोकनार् संयुक्तयोगाण्—Vaiśeṣika Sūtra, Chap. V., Âhnika 2).

MEANING OF ADRĪṢṬA (चड़ृष).

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

(1) The operation of merit and demerit (चः and घः), 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 (उपवार्तक वपवार्तक). Such natural properties must be ascribed to Adrīṣṭa, final causality (उपवार्तक वपवार्तक चब्रवारित), provided the cause cannot be ascertained by observation or inference.

1. अवस्थितज्ञ श्रेष्ठोपायायाम् कर्मोपपत्तिः—Ibid. उपवार्तक वपवार्तक वपवार्तक, etc.

2. अवस्थिताय गहावृत्ते नासकातानात्मनात्मनुष्मानांकारार्द्ध उपवार्तक वपवार्तक अ अवस्थित अवस्थित वपवारित—Ibid.
Jayanta in the Nyāya-Manjari notes that Adṛṣṭa is resorted to in explanation of observed phenomena only when these cannot be derived in any way from the operation of known causes—यदि चतुर्दशंकरेश दूस्रे न सिद्धात्म कामनाहुं कल्याताम् चन्यम् प्रयाय पतितुः साप्तिके नाधुपकाश्यामेन। दूस्रं सिद्धान्ते चादुः कल्यातेन नयु दृढविशालाय। नायकसम्रोऽहिनका 1.

Similarly, Jayanta notes that, when anything is put down as natural (सामान्यिक), 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 (सामान्यिकम् नात्र विनिर्धाने विनिर्धानं सामान्यिकम् कार्यत्वं या। न तथः कार्येऽव वाचं सम्भवित् . . . . . . . नायिका कार्यत्वं कः यस्मिन् सम्बन्धितः—नायकसम्रोऽहिनका 1)

This sound interpretation of Adṛṣṭa was afterwards obscured. In modern writers of the Nyāya-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 (प्रायाप्रभम्).

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 (नर्तन), 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, प्रेष) of the wind, etc. याजुमुक्ति: प्रशस्तपाद, यात्रिकयुक्ति: भानुपातिक, राजपारिप्रवर्तक, लेखावेदाद्रि: स्त्रीर्घात, भौमार्दी: वेचार्ग्रेश्वर, विषमार्दी: नायर्ज्ञयोक्ति: (Udayana, Kiranāvalī, याजुमुक्ति).

N.B.—Udayana makes a similar reference to balloons filled with gas or smoke (सूक्ष्मपूर्वकमेनुतमं) in discussing the opinion that air has weight (Kiranāvalī, याजुमु-कंकड). These passages show that balloons were known in Udayana’s time (970 A.D.—vide उदयन, Laksanāvalī).

(2) Motion due to direct contact for an instant with a body that strikes and produces an impact (चन्वमण), e.g. in the cases of a stone falling against a hard object (पामार्गमं निदुर्गलुतमं चन्वमणे—स्त्रीर्घात), 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 (तच्च चन्वमणवं दृष्टु सूक्ष्में चन्वमण विच्छिद्रदो नोदसं चापतति—चोगर—नायकमंत्रें).

(3) Motion due to direct contact with an elastic body which exercises a moving force by means of its elasticity (स्वश्वत्यापनम) in the act of restitution of the original form (वपार्यतं स्वापवति), 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 (स्वश्वमतयुक्तमार्गमं चापवादि: सूक्ष्मोत्तरमं स्वश्वत्यायापनमं संध्ययते—प्रस्तावभाष्यं, 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) (वेगवन्तस्यवस्थितकर्मयोग). 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 (चगचायत).
3. Persistent tendency (संक्षार), 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 (रिसेटिलिस्यायकस्थितकर्म).

N.B.—The psychical sanskāra (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. Adrista, 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 (संस्कृतमूर्ति).

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 sanskāra or persistent tendency to move (Vega), which is the cause of continued motion in a straight line, i.e. in the direction of the first motion (नियताधिकारी प्रभावादि—विवाहविनवण्ण विज्ञापिते नव्ये तद्र दिशाभिनुपरीतिव विज्ञाविनवण्ण रघुराजः—रघुराजः—रघुराजः—रघुराजः)

The Vaiśeṣikas accept one sanskāra (impressed motion, momentum) lasting till the cessation of the motion. Udyotakara and other writers of the Nyāya school suppose a series of sanskāras, each generating the one that succeeds it. (संस्कारेऽउत्पत्तिबालोस्माणानाके जायः सम्भवतरत्नयोगेन कमैश्च नवे संस्कारेऽकमैश्चरणवनानं तब इव संस्कारः समैश्चरणवनानं: न्यू कमैश्चरणवनानं संस्कारसम्मानान्यं चमुपासमुपासः—शक्तिकन्तः ।) It will be seen that the Nyāya view is adequate to explain acceleration, which it logically implies. The force of sanskāra (संस्कृतमूर्ति) diminishes by doing work (कामकश्यांत्र) against a counteracting force, and when the sanskāra is in this way entirely destroyed, the moving body comes to rest (संस्कारे यथान्तरसंततिः तथा तथा संस्कारसंततिः—संस्कार—रघुराजः—रघुराजः—रघुराजः—रघुराजः). 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 (स्वरूपावलुप्तमयीयोग), e.g. by impact or friction, including friction with the still atmosphere (स्थितिवायु), as in the case of the arrow.

Vega (momentum) produces work in opposition to the resisting force, and thereby becomes weaker and weaker (न्दददर न्दददल) until it comes to an end (तथ वेग एवं न्ददर न्ददलि क्षेत्रं न्ददलि क्षेत्रं प्रमाणं न्ददलि न्ददलि क्षेत्रं न्ददलि क्षेत्रं प्रमाणं न्ददलि न्ददलि क्षेत्रं). Prasastapada, संस्कार-निधनन्ददलि—न्ददलि वेग: स्वरूपावलुप्तमयीयोगसिद्धिः पति चतूरगतिः इत्य: (स्थितिवायु-प्रतियोगिता—चीहार, संस्कार-निधनन्ददलि).

**Causes of Pressure (न्ददन) and of Impact (अभिधार).**

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 (न्ददन) 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 (न्ददन). (तथ न्ददन गृहस्त- द्रव्यम्-येग-प्राणायाम् समस्त-रघुलान् चेतािमान: या: संयोग-प्रियों: नादनन्द चाच्याभायभागे: एकस्य क्षेत्रे: कार्यश तत्साधि चचेन्द्र वाहिकासे: वामे भस्ति . . . . . . यागारो या: संयोग-प्रियों: वाहिकासे: एकस्य क्षेत्रे: कार्यश स सहवाह सत्साही चचेन्द्रे-वाहिकासे: वामे भस्ति—प्रसाहामामा भव।)

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 (तीव्रत्मकादिभेद). 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. (पारिहारीकरण गति प्रभावित) (ततः संचारनिदानाय तत्तवः कमोगिः भवनिः यावतः हस्ततोपरेक्षिताभावम्).

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 sanskāra (persistent tendency to motion, impressed motion or momentum), but the subsequent motions are produced by the pressure acting concurrently with the sanskāra (impressed motion). (तस्मात् संचारात् नोदन-वहायतः तत्ततः कमोगिः भवनिः यावतः कुमार्या-विभागः—प्रभाव-पादः, कमोगिः—प्रथमः विनाशपिनी वधत्वेयोगः अतः तद्विविधतः उपरोक्तपरिशिष्टः कमोगिः चालितात् कमोगात् संचारात् स भवनिः द्वारिकन्ते तु धर्मो तद्विविधतः संचारात् वर्जितात्। चालितः, विनायकः, कमोगिः।)

(2) Impact (चालिताः) with impressed motion (संचाराः), as when the mortar thrown by the hand rebounds after striking the pestle (संचारारपेक्षाह चालितात् गुह्यः वस्त्र्वन-कमः—प्रभावम् भाषा).

(3) Pressure (नोदन) acting concurrently with impact (चालिताः), 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 (संचारनिदाने).
(4) Gravity concurrently with sanskāra or persistent 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 (Praśastapāḍa). (चार्क कये गुहवत्त भवति। तेन बभेंवस संश्चरः क्रये। ठानरन्त उत्तरक्षेति गुहलवस्करार्यं गायत्रे इयोरचर प्रकरेऽ चन्द्र वल्मिकश्चर्यात्—गोपर, नाय-वालोहो, बभेंवसं लालक्ष-कमलसंहस्त।) This case will be further noticed below.

Udyotakara, the commentator on the Nyāya-Bhāṣya, 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 (गुहवत्त) of a body (चपेत्थवाणि) as a whole composed of particles (चपेत्थवाणि) 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 imperceptible. The concept of mass in the New Mechanics of Lorenz may lend some countenance to this curious metaphysical speculation. (Śrīdhara, गुहवत्त, गुहवत्तिनृमित्त।)

(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.

Sanskāra (impressed motion, momentum), with or without pressure (नोदन) or impact (चविवत), may be transmitted (दक्षेमुक्तत स्थततिव उत्तरक्षेति) Śrīdhara (चपेत्थवाणि संश्चरात् गुहवत्तिनृमित्त।—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 (गुह्तत), 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 (सभवशास्त्रादि) 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. (चाहैं कब्रे गुह्ततान् भवित तेऽैव कामैंका वेंधारः निभते तदनादेव चक्रवर्त्तिपि गुह्त-वेंधाराैं नायने प्रजारिपि प्रवें च नायन बास्कापाबाबावाक्—चीर्घक, कव्यंक—तत् चाहे गुह्ततान् दिनेवादिदिनि न गुह्तवेंधारास्याम्।—प्रातःपादः कामैंकाय।)

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 (गुह्त) 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, Prāṣastapādā expressly states that gravity (गुह्त) and sanskāra (Vega, momentum) both act in the second and following instants. Prāṣastapādā seems to have thought that some sanskāras (e.g. the Vega of an arrow or other projectile) suspend the action of gravity (गुह्ते संभोगस्य संस्कारविरोपि, Prāṣastapādā, गुह्तग्रन्थम्). वेयेन प्रतिष्ठाणां चप्तयं पवित्रिगतया शक्ति निगृह नाहि नामादिव सामने कृपायं नुस्त्रोपराय दुहुं-संस्कारदेवतापतनान्तरे Prāṣastapādā, कम्येन्द्रम्). Other sanskāras (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 (नियतदिर्घिनक्षत्र) the resultant motion or Vega is in a straight line, and may be conceived as one (विन्यायकद्वीप-वैव्यक्त, Prāṣastapādā, कम्येन्द्रम्). 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 (नियतदिर्घिनाभिमुख) 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 (वलय, e.g. the wheel) results from the combined motions of the particles (वत्सपतन). 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 (वत्सपतन) after impact (वत्सपतन). 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 (वत्सपतन), 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. (वदनगंधनयोरभविषयाः संयोगो- नुस्सल्लगतेनगपेषिनाः: मुखः वत्सपतनकम् करोति यथा भाकनवद्वारो विनाः: तथापि मुखोछाकायोः संयोगः पद्वमोऽववाध्वः तस्य वस्त्रारतम- सारिश्चन्मयो भवति जयया भाकन वद्व पुनु वस्त्रारः जाभिष्णाम् चविन्द्रवन् चापिश्च इति et seq., Praśastapāda, कमेवथ ।)

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. (चष विमृणं संबूञ्जनं नान। समानश्चयः (उद्वेगयो: सार्गोद्धत्त्वदिवकृतियो: सतिपातः Praśastapāda, वायुविद्ययो:) त्वथ च. The scholiast Udayana adds: स्थानोरिक्ष्मसूञ्जनं स्पौष्ठयोरिक्ष्म | विसंविस्यम्। भर्या यथा द्रुषानां—संबूञ्जनं अत्योगनं परस्यराह्वतस्तदीयः — उद्वेगः, द्रुषाविश्रावलो। Śrīdhara notes: तिथेञ्ज्यानां द्रुषाद्वाह्वतस्तदीयः परस्यराह्वत-अवतारेखाय्र्येकनयत् वस्त्रात्सपेययो संबूञ्जनं न भवति रक्षेन चयर्ख्य | विषयाय—Śrīdhara.)

**Vibratory Motion** (सम्पन, स्वनन).

This will be analysed in the chapter on Acoustics.

**Rotatory Motion** (अभिन).  

Each particle of the rotating body, *e.g.* the potter's wheel (कक्ष), 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 (संवार), 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 (अन्वयाः); 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 (साहन) and the persistent tendency (संवार) 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 चक्षुदं च चर्चयनान् पत्रिपाति: प्रतिनिधित्वेऽर्दृश्यः समस्तार्दिनिधित्वे विद्यमानं संस्कर्तादिनिधित्वे विद्यमानिनिः समस्तार्दिनिधित्वे च नाम तथ्यसम्बन्धः। तथादयं गलनतिरऽव्रा:—प्राशस्तापाद, कम्पेयन्यः। तथं तेनागाः दृश्यसंभयोयः शास्त्र गः दृश्यसंभयागाः । चर्चयनायेन परां संस्कर्तादिनिधित्वे दृश्यस्य च चर्चयनायेन परां समस्तार्दिनिधित्वे विद्यमानिनिः संस्कर्तादिनिधित्वे च चर्चयनायेन परां समस्तार्दिनिधित्वे विद्यमानिनिः। तथादयं गलनतिरऽव्रा:—श्रीधराः।)

SECTION 4.

MOTION OF FLUIDS.

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

1. Current Motion (खस्त्दन).

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 (गुस्त्दन निनिधित्वार्दिनः च विद्यमान्यायेकराः—Śankara Miśra, उपस्कराः). When the water is enclosed on all sides, as in a vessel, the downward flow (खस्त्दन) 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 (प्रतिठिक्ष) of the latter, which is transmitted to the other particles, and this counteracts the fluidity. (पोस्तब्राहान्यां स्वशानिम्ब्येद्विषैं यह तत् द्रवयात् स्वद्वम वर्ष समनात् रोषः संयोगेन चचयिष्ठउत्तम अभिष्ठं उपरौषसारानवप्रवत्तानि संयुक्तयोगे: प्रतिशानिन्—प्राशस्तपादाः, कार्ये।)

2. Upward Motion (चारोहणं, 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 (नोटस) or impact (सभ्यात) 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. (नायरो वायुस्योगात् चारोहणं नोदनायोगात् संयुक्तयोगात् ॥) Sūtras 5 and 6, Āhnika 2, Chap. 5, Vaiśeṣika Aphorism. यषा स्वाधोस्या चाय: आयमात्: वायुस्यपि-रक्षम अत्यंत नयनि—Śankara Miśra, उपपाद ।)

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 (संयुक्तयोग) of the air seems to lend some countenance to Gangādhara's view, and the word Nādi (नादिः) offers no difficulty, being taken in its usual sense, "pipe" (नालिका, Nalikā), while the current interpretation does violence to the common acceptation of the word.

3. Capillary Motion (चभिष्ठिक्षयः).

Two instances are given—the ascent of the sap in plants from the root to the stem (चभिषित: सत्यं दूसे नितिक्षा—
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This is ascribed to adriṣṭa, as the cause cannot be ascertained by either perception or inference (including hypothesis) (अब्राह्मानानाम् चतुर्दशमानवार्तन—Śrīdhara).

SECTION 5.

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

The first motions in primordial atoms at the beginning of Creation are attributed to adriṣṭa. Among movements in masses of matter so caused are noted the motion of the globe of the earth and similar other bodies (महाभुतानि भूगोलकारोनि प्रवर्तने चमकम्—Praśastapāda with Śrīdhara's commentary, जमेियग्रस्त). Most probably this means earthquakes, tides, etc. Āryabhata 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 Bhāskara 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 Miśra notes) towards the magnet is another
example of unexplained motion in matter. Cleaning and right-placing of the magnet (संमाध्येर्व, चुऊँपाघनम्) are necessary (सूचनां होहसाहाकान, चपकाननिक्षुस्तगमनम्, सूचनापुपखब्रव चेवाचनाजूढ़ोहसाहचनामभेतस्—Śankara Miśra).

Similarly, amber attracts grass, straw, etc. (सूचनायामक खाओहकान तृकानं गजने—Śankara Miśra, on Sûtra 15, Āhnikā 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 ($kṣanās$). The Nyāya unit of time therefore measures $\frac{1}{25}$ of a second. The smallest measure of time mentioned by the astronomers is the Truti, which is $\frac{1}{3875}$ 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 (स्वरूपभाग—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. Mahavirachâryya gives formulae for computing the space travelled over in cases of Sankalitagati (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 (छूत्नाम—), but where the velocity is variable (मित्यां न समागतः—Bhâskara), an indefinitely small quantity of time (छूत्नाम) 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, छूत्ना). It was in this way that Bhâskara determined the instantaneous motion of a planet (तात्त्वास्तिको 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 (गतिक्षण) 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. दे ज्यां ज्यां भागार्थं भागार्थं इत्यतिक्षणस्य गतिक्षण सजं ज्यांमाणाः—Bhâskara, Siddhânta-Śiromaṇi, Gaṇitâdhyâya, Ghatîśphuti-prakaraṇa).
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, Vāchaspāti 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.: वचस्पति वाचस्पति, Vāchaspāti, Nyāyasmṛtisūchihīnibandha) 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).

Bhāskara (1150 A.D.), in computing what he calls the "instantaneous" motion (तत्त्वज्ञातिहारी 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 (सूक्ष्मज्ञाता). 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 Bhāskara’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 (नाम्यायस्य गृह्यः प्रबंधीदोषोनि विभागानिः अपेक्ष अस्त्रः यान् — Kumārila, Śloka-Vārtika, p. 520). Astronomers like Āryabhata 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 Santānas (series) of motions are incidentally noticed, e.g. vibration (स्पन्दन, कम्पस्वर्ण), wave motion (वीणीकलन), current motion (स्पन्दन).

In an interesting passage, Charaka notes three instances of serial motion, viz. those of water, sound, and light (स्वदम्यन, स्वत्सत्सर्वन and चित्रःत्सर्वन), to which he compares the course (स्वदम्यन) of chyle (or chyle-blood) in the Dhamanīs (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 Chakrapāṇi points out that the Santāna (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 Santāna of sound travels more rapidly than that of water, and less rapidly than one of light (चित्रःत्सर्वन), and Charaka's meaning is that the metabolic
course may complete its circuit with greater or less speed. Whether, in this passage, the three Santânas are viewed as waves or currents, is not specified; but the difference between a wave (शौच) and a current (स्वतःन) was well known.

A current of water (स्वतःन, downward flow) consists of particles moving in an uninterrupted series under the action of gravity and fluidity (गुरुत्व and द्रवत्, Śankara Miśra). A wave (चौचितिक), on the other hand, is constituted by the transmission of vibratory motion (स्वतःन) in the water-particles (e.g. Jayanta, पत्रवन्य-चोरिसुस्न्दहस्यपप्रवाहम्—Nyâya-Manjarî, 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 (चिन्त्यते चेगातिङ्गः: तेन: प्रकरणे पृष्ठयावाहः—Udyotakara, Vâchaspâti).
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 logos, which are eternal (निन्य,) ubiquitous (वायुक्त), and noumenal (निराभार, lit., without substrate or ground—Kumârila). The Sphotas are manifested by the Dhvanis (audible sounds), of course only in the case of words (शब्द, वेरा). Upavarṣa, 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 वायुः: वायुः यदि अस्वेत—Kumârila, Śloka-Vârtika; वायुरेव तात्तादिस्यानि, जस्त्या तत् निष्कृतम्, जम्भयानि जायुःकाष्वे नेतित्तथम—Pârtha - Sârathi Miśra, Nyâyaratnakara).
Others, including the teachers of the Śikṣā (Vedic chanting), hold that the physical basis of sound is a series of air movements (वायुवस्तु, 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. गुहनायामपि नावायुः समानात्मकोऽविलये गुहनायामपि नावायुः . . . समानात्मकोऽविलये गुहनायामपि नावायुः —Jayanta, Nyāya-Manjari). But the orthodox Mimāmsā view is that of the Mimāmsā doctor, Śabara Svāmī, 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. संयोगविभागानेतरं संयोगविभागानेतरं संयोगविभागानेतरं: नादसम्भवता: (17–1–1) संयोगिकता रहे प्रतिष्ठान चापण: संयोगिकता रहे प्रतिष्ठान चापण: संयोगिकता रहे प्रतिष्ठान चापण: संयोगिकता रहे प्रतिष्ठान चापण:। ते द्वारा समाधानमविशेष संयोगिकता नोदुरुद्धारे। चनुरत्रेणु रहे छेद रहे मुद्धां रहे मुद्धां रहे मुद्धां रहे मुद्धां रहे मुद्धां रहे मुद्धां रहे मुद्धां रहे मुद्धां रहे मुद्धां रहे मुद्धां रहे मुद्धां रहे मुद्धां रहे मुद्धां रहे मुद्धां रहे मुद्धां रहे मुद्धां रहे मुद्धां रहे मुद्धां रहे मुद्धां रहे मुद्धां रहे मुद्धां रहे मुद्धां रहे मुद्धां रहे मुद्धां रहे मुद्धां रहे मुद्धां रहे मुद्धां रहे मुद्धां रहे मुद्धां रहे मुद्धां रहे मुद्धां रहे मुद्धां रहे मुद्धां रहे मुद्धां रहे मुद्धां रहे मुद्धां रहे मुद्धां रहे मुद्धां रहे मुद्धां रहे मुद्धां रहे मुद्धां रहे मुद्धां रहे मुद्धां

In this view, the particles of air (वायुस्वर्णेः) are subject to a vibratory motion (a sort of parispanda) in the production of sound (स्वर्णमत्यापद्वृत्तिः —Jayanta, Nyāya-Manjari). The Vākyapadiya describes articulate sounds (varnas), and indeed all sounds (sabdas), as only forms of air set in motion, with rarefaction and condensation (प्रत्ययः), and capable of variations of velocity and configuration (रत्नयां: रत्नयां रत्नयां-
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Nyāya-Vaiśeṣika.—The early Nyāya writers hold that the sound-wave (सन्धि-नाल) has its substrate in Ākāśa (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 Ākāśa, the substrate, is, in the Nyāya view, incapable of motion (न तावह परिस्परदशय गृहैतंत्रितानां द्रष्टेन निनति निनयूक्ते वा ज्ञातेन गृहैतंत्रितानांभवाद—Tattvavindu). At the same time the propagation of sound must be conceived on the analogy of waves in water (सोमतंत्र-क्षाय). Udyotakara in the Vārtika, Vāchaspati in the Tātparyyatikā, and Jayanta in the Nyāya-Manjarī controvert the three views current in the Mimāmsā school—(1) that Nāda, 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 (वायुसमान), and (3) that it is not air-currents but air-waves, series of conjunctions and disjunctions of the air-particles or molecules (वायुसमानाः, वायुपरसांवकः), that constitute the Nāda, the sound physical, to which, in the case of significant sounds, the Mimâmsakas assign the function of manifesting the Sphota, “transcendental” or “intelligible” sound (logos, the word). Vide Udyotakara Vārtika, Adhyāya 2, Āhnikā 2, Sūtra 14; also Tātparyyatikā, मातृत वायुसमानो मा ज ज्ञातेन नादः: सन्धि अध्यक्षः वायुसमानो संयोगविभाज्यका भवति इत्यताह, etc., loc. cit. Against these views the early Nyāya doctors
maintain that sound is a specific quality of Ākāśa (ether) and not of Vāyu (air). At the same time they admit that the impact which originates the sound phenomenon (वायाप्रस्थानवत्ता वायावत्ता भावति विभेदगुण) in Ākāśa 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 (प्राप्तिरहत: अपामितिभावगुण). In other words, though Ākāśa is the substrate (धार्मिक), the efficient cause of sound (निर्गताकार) is to be found in the mechanical impact (अभिलोह) of vibrating molecules of sonorous bodies against contiguous molecules of air. As to the propagation of sound, the early Nyāya-Vaiśeṣika writers content themselves with stating that the first sound thus produced in the substrate Ākāśa 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 Ākāśa, 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 (क्ष्यमकुमित). Of course, this propagation of sound-wave in Ākāśa (ether) is effected by means of the air-wave as its vehicle. This is the Nyāya-Vaiśeṣika hypothesis (बयन) of an independent sound-wave (शब्द-समान). Ākāśa (ether) is motionless, but the air-wave would not be transmitted if the air-molecules were not interconnected by Ākāśa. Praśastapāda, the Vaiśeṣika doctor, for example, describes the first sound as giving off a second, the second a third, and so on, expanding in Ākāśa, in the same way as waves are supposed to propagate themselves in the ocean.
On this hypothesis the locus of the sound at any moment forms a circle in Ākāśa, 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., Svântantra, Mimâmsa, Śabara, Vâkyapadîya), implies longitudinal waves, parihsayakâryeṇa tathâgataḥ kâriṣṭaḥ kârâsvarakâyaâyâyanâh: kâsyâyâyaâyâh (Viśvanâtha, Bhâsha Parichhedâ,
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Śloka 165); परिप्रेषाणु सत्तानसिद्धः। तत्तत्त्वः ःत्त्वंथ-विभाग-हेतुः। तत्तत्त्वः ःत्त्वंथराविश वद्वागोऽलङ्कर्यायेन सर्वत्रिवानि। तेह्यः पृथ्वित्वभिः। ःत्त्वः गत्तरतग्रामपरावेदनायामातथानुविन्योपयानाः प्रागुपायः। तत्रेष्यक्ष्यात्माकारात् ःत्त्वः ःत्त्वंथराविशः—शास्त्रिक्षेन तेन पेतिष्य गतिविषयस्मात्

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.

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 (शब्दश्रुत्ति) as to one produced by conjunction and disjunction (संयोगम् or विभागम्). In other words, the sound-wave (शब्दवस्त्र) in Ākāśa necessarily implies an
air-wave. The Mimâmsâka 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 (सायनीय: संयोगविभागः—Sabarabhâya), or rarefaction and condensation (पतम्य—Vâkyapâdiya), is also implied in the Nyâya-Vaiśeṣika doctrine of the sound-wave (सन्द्वन्नन—), the difference being that in the latter the air-wave, which is conceived as a mode of serial motion (सत्र-सम्बन्ध), is only the vehicle or medium of propagation of a so-called sound-wave in Âkâsa, which is not itself a mode of motion. This is what we find expressly and elaborately formulated in the later Nyâya-Vaiśeṣika (vide Gangeśa, Chintâmanî, 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? Vâtsyâyana 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 Sanskâra (here a kinetic Sanskâra, momentum) is generated (संक्षार, कम्पसंन्वत्स्र—Vâtsyâyana and Vâchaspati), and the molecules swing forward under the action of this Sanskâra 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 Sanskāra 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 (क्षण). 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 Nyāya-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 Sanskāra (elasticity, Sthitisthāpaka-sanskāra) as converted from its potential state (प्रतीत्येऽयत्व) into kinetic energy, and thus contributing to the momentum (vega). He uses the generic term Sanskāra, which comprehends elasticity as well as momentum due to impressed force. His commentator, Vāchaspati, does not go into details, and does not analyse the momentum. Later writers, however, expressly state that elasticity (Sthitisthāpaka-sanskāra) 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. Viśvanātha).

श्यामाभिन्धमानादी तासाधारे नरी मर्यादा शिला सुतितिभेरवा-नायकानी चरित्रक्षेत्रे चौथे (Vātsyāyana, II., 2, 3, 6) पारिवर्त्यो-नयेपनावार्तमये: पाषि-वहाराङ्गश्रेष्ठ पाषिनगवनगालवाती बहावाही वैभवमभिववशालां विभागवसितासां संसारं करोति। या वहाराङ्गाधिपत्ये राष्ट्रपुपप्रज्ञपति सा च राज्याभिरहिता पुनः वर्ते करोति।
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.

Pratiśamya (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 (pratiśamya) is due to the reflection of light. There is an element of hallucination in either case (pratiśamya—tāpasyaḥ)—the image in water is not a real image, neither is the echo the real sound it is taken to be.
Section 4.

Pitch, Intensity, and Timbre.

Sounds differ from one another by their pitch (तारस्त्रांवंदिते), by their intensity (प्राणमदिते), and by their quality or timbre (वासापारः चम्के). When a bell is struck, an indefinite number of notes (चुमिते, 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 (सम्प्रवसत्त्वक) 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, चुमिते) as well as the degrees of intensity (प्राणमदिते) must be ascribed to variations in the vega (momentum), and, by implication, the frequency, etc., of the vibrations.

Cf. Vātsyāyana, II., 2, 36—घटाष्ट्र समानपुष्पिस्तेस्वस्तरूपेन| प्रकृतिपद्धति बताते तथ्यानुपवत्सा जातिस्मणानुपविति: पंपमानपाच| तीव्रत्वा अस्तम्य तत्वस्वाभावः चुमिते: Vide also Udyotakara’s analysis of vibration based on Vātsyāyana: घटाष्ट्रभिभवन्यानां तारस्त्रांवं संदर्शनं इति चुमितेद्वारानांसंदर्शनानो हि चाविदेशन चुमिते। समानपुष्पिस्तेस्वस्तरूपेन मन्दरुपमानपाच्छिदाविनां ज्ञातं अत्यां संस्कारः—Udyotakara, Vārtika,
Adhyāya 2, Āhnika 2, Sūtra 36. समानवृत्तिनां कार्येन चुरिततेवर्तनष्ठि—Vāchaspāti, Tātparyyatikā, loc. cit.

Sounds also differ from one another in volume or massiveness in the case of coalescence (समानजातियोपयोग). A sound both loud and massive is called महान् (large)—
संयुक्तमेवं शब्दं सत्: महान् इत्युच्यते सत्तायिदं समानजातियोऽपयोः: प्रभुवं श्च प्रभुवतनम् महात् प्रभुवते:। चयनयप तथा इति महानित्युच्यते—
Vāchaspāti, II., 2, 36.

Śabara, the Mimāmsā doctor, explains massiveness (महत्त्व) as due to नादज्ञि, the coalescence of different air-waves, which by their simultaneous impact affect a comparatively large tract of the ear-drum (तत्रेता युक्तिभिर्माध्यानार्थः: प्रभुवर्तियुक्तिं श्च उपशुद्धिः। न यथार्थतः प्रभुवार्तियुक्तिः। युक्तिभिर्माध्यानार्थः: प्रभुवार्तियुक्तिः। चयन यथार्थतः चयन यथार्थतः कथेश्य चयन यथार्थतः । संयोगशिर्भागान्नतावैष्णवाध्याया: चन्द्रमाहत् महान् इव चयन यथार्थतः। संयोगशिर्भागान्नतावैष्णवाध्याया: चन्द्रमाहत् महान् इव चयन यथार्थतः। तेन्त नादस्यम् वृद्धि: न शब्दम्—Śabara on Jaimini, Sūtra 17, Adhyāya 1, Pāda 1). The Mimāmsakas, 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 Vāchaspāti's report, जयानां हु संयोगशिर्भागान्नतावैष्णवाध्याया: चन्द्रमाहत्।; cf. also the later Nyāya-Vaiśeṣika, which accepts air-waves as vehicles of sound-waves: वायोरेव मन्तरतमादिश्रेण नदरित्रशुद्धिः—Gangeśa, Tattva Chintāmaṇī). It may be noted that the terms तोष and मद 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 (शब्दम् समाधार्थायं): 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 *veṇu* and a stringed instrument like the *vīṇā*. Similarly, there are sexual and even individual differences of voice (चालिं हि सुवार्तिकामन्दुर्यस्यविनम्यं दुःखविनम्यं सुधर्मन्यं...प्रयोगमयः) (तत्त्वायस्यकालिङ्क सर्व चतुष्णयोगसः...हस्तश्रवणम्) —Vāchaspati, Tattvāyaratikā, II., 2, 14. वीणा वादने वेणु: पूर्वने वीणावेणुयुक्तथे...तत्पत्रार्थी चरणे:—Udyotakara, II., 1, 15. वेणुपाद्यायार्थकारिण्यवेणु...वेणुपाद्यायार्थकारिण्यवेणु...चरणमयः) —Gangeśa and Mathurānātha). The sounds emitted by impact of the different Bhūtas (echo from Âkāśa, 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* Panchadaśī, Bhūtaviveka, Śloka 3).

The Vākyapādiya (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 (सन्ततिः सन्वार्तिकारतः), and are capable of variations of velocity (momentum, *vega*) as well as of rarefaction and condensation (धार्यार्थायामः) (प्रयात्मकः).

There are passing references to the obscuration (समतत्त्वः) of sounds in Vātsyāyana, Udyotakara and Vāchaspati, but the subject is treated more from a psychological than from a physical point of view. (तत्त्वायस्यकालिङ्क...सूत्रायस्यकालिङ्क...कालू प्रायोगिकायांत्याधिकारं सर्वाधिकारं तत्त्वायः तद्यस्य तत्त्वायः) —Vātsyāyana, II., 2, 14; *vide* Udyotakara and Vāchaspati, *loc. cit.* Here तोषत् = loud, and नशेत् = 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 (सङ्गीतालक । च अन्तिनि वेदाक्षरादान पद्धति क्षणिकः । संगीतसंतन । cf. संगीतप्रकरण । केलायत्सुभाषेन पृष्ठोन्ति द्रुतव: स्त्रीत: । संगीतपरिणाम, 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, चनुरकान). 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 (हस्तकिरिमान), are always found certain partial tones (चनुरकान). बधारे वक्ते पेषा हर्द मद्द्रोभविषये । कड़े मध्यो बुधितारे हिगुह्योक्षरो; (संगीतसंतन) हरिद्रोपालोमभो मूढ़े तार इति क्रमात् । हिगुहः युवकवेषात्—Dāmodara, Sangita-darpana, Chap. I., Śloka 49. चनुरकक्षाभावे य: विषेशमुर्चात्तां नामकः । स खरे: उष्णे—Sangita-ratnākara. स खरे: युवकवेषाने खनन् हर्दयरक्ष: (संगीतसंतन) साविभाषितिष्ठे मद्द्रोभानि: स्वायते
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The relation between a Šruti and a Svara is variously conceived as (1) परिशालन modal change; (2) अभिनव manifestation; (3) तादात्मान भाविक प्रेषण the relation of genus and species; (4) विषालेन (पुस्त चक्र त्रयेश्वुर विषालेन) reflection; (5) क्षणकार्याभाध्य, the relation of cause and effect; cf. संगीतपरिषाद by Ahobala, चृताशु इत्या ध्यान: भाषाशासन हेतुना। चंद्रकुक्तितः तच भद्रतेषि शास्त्रसंस्करता। —संगीत-परिषाद, 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 (तम्रोत्सुङ्करो हेव: महर्षिस्वलमानाः — श्रेयस्तीवादानि, quoted by Mr. Devala in his “Hindu Musical Scale”).

The pitch of the fundamental note to that of its octave is as 1 : 2 (गतहन्यानस्य: वहः विन्यास: — रागविवेक, quoted by Mr. Devala).

The pitch of the fourth note (F) to that of the fundamental (C) is as 4 : 3 (भयोः भजयोयेयेन्वयन खरमाधरति — संगीतपरिषाद, quoted by Mr. Devala).

The vibrations of the fifth note (G) to those of the fundamental (C) are as 3 : 2 (विभावलक्षणयां परम: स्वात्र-द्वियने। — श्रेयस्तीवादानि, quoted by Mr. Devala).

Concord (स्वादिष्ठ) is either perfect or imperfect. The
ratio of perfect concord is $3:2$; that of imperfect concord, $4:3$ (स-प-त-त सुख्या: संयोगिन: खरा: रक्षसङ्ग्रहा: प्रायः—रागचिरोप, quoted by Mr. Devala); e.g. if D be the Vāḍī, A would be a Samvāḍī; if E be the Vāḍī, B would be a Samvāḍī: 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 $455\frac{3}{4}$ 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 “Sono-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 (नेहागतस्यमूख-पंक्फ्राग्नायन्—रागचिरोप, 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 Vāḍīs, Samvāḍīs, Vivāḍis, and Anuvāḍīs. The
metrical 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 Vādī might in that case answer to the key-note (or tonic), and the Samvādīs to the two consonances, the fifth (2 : 3), and the fourth (3 : 4).

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

C being the Vādī, G and F are stated to be the Samvādīs.

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

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

The notes that do not come under these heads are Anuvādīs (e.g. the sixth); cf. Bharata, Nātya-Sāstra, Chap. XXVIII., Ślokas 23–24.

Also Sangīta-ratnākara:—

चतुर्विषा खरा वादी सम्बादृ विषालय अनुवादोति। वादीस प्रयोगे पहुँचर: भावो ब्राह्मणी व योगरत्नोपचार: निष्ठ: सम्बादिनी तो लो निम्पार्तीविभादिनी। रिथपोरेव वा स्वाते ती तयोंतिरिभाषिपि। भ्रमण-मुनुसादित्स। (खराभाषा).
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) Vānaspatyas, trees bearing flowers as well as fruits; (3) Aṣadhis, herbs that wither after fructification; and (4) Virudhs, other herbs with spreading stems.

Chakrapâni notes in his commentary on Charaka: The Virudhs comprise two classes, (1) Latâs, creepers; (2) Gulmas, herbs with succulent (or cactaceous) stems and shrubs. The Aṣadhis 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 Dûrvâ (Cynodon dactylon).

Suśruta:—Suśruta’s division is identical with Charaka’s. Dalvana, the commentator, gives some details. The Plâka (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 (*praṇaṇyas*), and (2) herbs with succulent (or cactaceous) stems (*gulijyas* or *śāhīyas*: गुलिज्याः or शाहीयाः). *Auṣadhis* are those that wither away after fructification, e.g. wheat, barley, etc. (*ṣeṣākṣaraṁgaṇe gopālaya*). 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.

*Praśastapāda* :-—*Praśastapāda*, the Vaiṣeṣika 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.

*Sṛidhara* in the *Kandali* gives *Ulapa* as an example of a grass, wheat as an example of *Auṣadhi* (annual), the *Ketaki* (*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 *Kiranāvalī* notes the *Kuṣmānda* (a species of Cucurbita) as an instance of a creeper (*Latā*), and the palms *rākṣāyas* as modifications of the grasses (*Triṇas*).
Amara:—Amara, the lexicographer, in the Vanausahaan and the Vaisyavarga (enumeration of wild plants and of food-grains) gives some interesting particulars. (1) The trees (the flowering Briksas and the flowerless Vanaspatis) are fruit-bearing, and possess woody stems or trunks (प्रवास: प्रबास: स्वभावतः स्वाभाविकः स्वाभाविसिदः). Next come (2) arboraceous plants and shrubs (षूप, इत्यादि: षूप: ) bearing flowers as well as fruits. (3) The Latas are next noticed, flowering plants with herbaceous stems, some of them creeping on the ground (प्रमाणिने), others succulent (गुलिने), others twining or voluble (सुतांशगत: खतः, पूणामिनी खतः—Amara, cf. Mukuta, तहजुलाः प्रसूल द्रापारस्यान्त गता गुलिनचि खताभि चाप्रोहः—others call this खता). Cf. Suśruta—खता: प्रमाणव: गुलिनव. (4) Next come the Ausadhis (in the narrower sense), herbaceous plants bearing fruit with or without flowers, and dying or withering away after fructification. Some instances of Kandaśaka (tubers, rhizomes, corms) are noticed, e.g. the Palandu (the onion, पलांदु मुख़दकः), the Labhna (garlic, महाभन), etc. But the graminaceae enumerated in the Vaisyavarga are the chief instances of the Ausadhis—plants that die after fructification. These are cultivated Ausadhis, but their affinities with the next class, the grasses (Triṇas), are also noted (e.g. चामे: त्रीण: साहले: साहले: मुख़दकः मुख़दकः हृष्णायानि नीवारा: नाप्रियाः प्रकोश्य:). 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—षच्छो गुलेः त्रिणाधिनः मथुरायुग्मयोः). It is worthy of note that, in the enumeration of the grasses, the bamboo is considered as a sort of giant grass.
The reeds (नालाधार:) are also placed among the grasses (नालाधारसूर्द गरुढवालाकाभारावरन । मनुस्यभास्व नौकाराखा:) (6) Finally, the Palmae (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. तृणी (तृणरागावलाख: नारकेल्सु ठाकुरी तृणी, रोटे इह्तारकारिथालाख: सहुर: बेतकी ताली सहुरा च रुखुरा; —cf. also the Rûjanighantu).

I may add that Amara places parasitical plants among the Latās (वन्द्र षुष्णदनी। षुष्णहा। गीवनबेलचिक) They climb trees and feed upon them. These are to be distinguished from climbing plants, like the Guduchi (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 avarohās (चवरोहाः). The name śipā is ordinarily applied to the rootlets and suckers by which the tendrils of various creepers are attached to the soil. (शालास्वरोह: स्वाद:। गढदे: शालापा: चवरोहिनी शिया | शूड़ाराये गता खरा | शूड़ादूहें गता खरा स्वाद—Amara with Bhānuji Diksita's commentary. But the Mukuta notes:—तक्षसुखात प्रत्य पृष्ठापरिमेयमगत गुदुचादि खरालिपि चवरोहः ।) The Guduchi is also called गद्दादनी, विसारहा.

The Hindu Materia Medica mentions Ākāśavallī, 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 Śāvāla, mosses and lichens (e.g. द्वैपवेद्यर्यमालाभ तर्केन श्रेष्ठे पीते षुष्णवेदर्द—Chakrapāṇi - Samgraha, also Bhāva-
Prakāsā). These are not classified, but like the mushrooms must come under the Pākaniṣṭha ausadhis, Ausadhis that die after maturing, without bringing forth flowers or fruits.

Section 2.

Elementary Ideas of Plant Physiology.

Characteristics of Plant-Life.

The Nyāya-vindu-tīkā of Dharmottara, the Buddhist scholiast, notices the phenomenon of sleep (contraction of leaves in the night) in certain plants (खाय: रात्रि पश्चास्थोः).

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 (पुष्पादयः प्रतिनियत्वभोजनविविधता: चीवनमर्शास्त्रालगारतत्त्वोपयोगः
पोतसमातीयानुवधानकूलोपापमतिखंडायिण्यं: प्रतिखंडायितः
—Udayana, पृष्ठपाठनिर्धारण). I may add that metaphors drawn from the heliotropic movements of the Sāryya-mukhī-flower are among the stock-in-trade of Sanskrit poetry and belles-lettres.

The Jaina writer Guṇaratna, in his commentary on the Saddarśana-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 (पुष्पाखरो); (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 (रस) in animals; and (10) special food favourable to impregnation. (विक्रियारैस्त्रियां वित्तीयक्रियायः स्वा ज्ञातिक्रिय तथाविक्रियारैस्त्रियां पुष्पाखरो वत्तयानं वत्तयां ज्ञातिक्रियायः वत्तयां पुष्पाखरो वत्तयां।) Even the Vanaspatis (flowerless, but fruit-bearing trees) may be made to flower (cf. Vârahamihira's recipes for the treatment of plants for similar purposes; cf. Guṇaratna, Tarkarahasyadîpikâ, Jainamîta, Śloka 49).

Śankara Miśra in the Upaskâra notes as an additional characteristic the growth of organs (or tissues) by natural recuperation after wound or laceration (अग्निवासियोपक्रोचयः, Upaskâra, Chap. IV., Ahnika 2, Sûtra 5, S. B. H., Vol. VI.).

Guṇaratna gives a list of plants that exhibit the phenomena of sleep and waking (समध्यपतिखरोवत्तयानं वत्तयां ज्ञातिक्रियायः वत्तयां कृतिक्रियायः, ibid.). He also notices the sensitiveness to touch of plants like the Mimosa pudica, तुष्कादारी तुष्का, which show a manifest reaction in the form of contraction, तुष्कादारीहस्तादिश्रवस्त्रायेन येन तुष्कादारिवा परिपुर्वभूतव्यथा उपस्थतः (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 these elements (and the terms signifying them) are the same (सैनिक सुमनस्यां पुष्पं प्रवृत्तं समन्—Amara, Vanauṣadhi-varga). Charaka (Dridhavala), indeed, distinguishes between the male and the female vatsa (or kutaja), considering the variety that bears white flowers and large fruits as male (पृङ्ख्लक्षेत्रपुष्पः पुष्पाः, Holarrhena antidysenterica), and that which bears red or yellow flowers and small fruits as female (व्ययप्राप्तापुष्पो जी—चाविकृतयुम, Wrightia tinctoria; Charaka, Kalpa-sthāna, Chap. V.; but this is hopelessly wrong. Even these vague ideas were afterwards completely lost, and the Rājaṇighantu 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! (Rājaṇighantu, प्रत्यङ्ग प्रजनो वगः: स्थायुपुष्पबलानेन वेदिध्व स्त्रावेभाय, etc.).

Consciousness.

The Hindu Scriptures teach that plants have a sort of dormant or latent consciousness, and are capable of pleasure and pain (जन्तुः संसार भवन्ते लुक्तुः साक्षात्कारः). Chakrapāṇi notes in the Bhānumati that the consciousness of plants is a sort of stupefied (darkened or comatose) consciousness (पृङ्खलु चेतनायथाय तन्मय्रवहानत्वा शाम्रोपदेर्विषया रथ).

Udayana also notes that plants have a dormant unmanifested consciousness which is extremely dull (चतुर्विद्या संभिपत्या, etc.).
The *Mahābhārata* adds that plants are sensitive to heat and cold, to the sound of thunder, etc., as well as to odours both pleasant and unpleasant:—

उष्णातु झापते पंकु तासु पुष्पनेव च।
झापते झोरोवे रािपि सम्भवेनाथ तिवरते॥
वायुन्यायनां निलोऽणि: पदरु पुष्प निर्रोणेते॥
झोरोवा गृहात पश्चात्साज्ञ्यायनं पादपः॥
पनी वेंहुस् पुष्पं सल्लशतेव गत्वति॥
नक्षुःकुरु मागोऽसि तस्मात पश्चात् पत्तिनं पादपः॥
पुष्पावस्थाना गायेक्षेपच विपन्नेरिवः॥
परोऽरु: पुष्पता: सति तस्मात्तिन्यरिव पादपः॥
पातीः सङ्कुः-पानाच वायुनास्यायि दश्चनात॥
व्याधिमर्यादात्साज्ञ्यात्स तिवरेऽ रस्यः हुः॥
वषधेषोऽवमोऽक्षणः योंभोऽः महामादस्॥
तपा पवनबंधुः पाती: पिवाति पादपः॥
सूक्तेऽपि वनकत्र ग्रहणात् तिमन्य विलोह क्षात॥
मोहेत पश्चात् वृक्षायामेऽत्समते न विचाते॥ ्षान्यितः, 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 Usmaja), born of moisture and heat, spontaneously or a-sexually generated, e.g. worms, mosquitoes, etc.

(4) Udvijja, born of vegetable organisms (भूतानाः पृथिवियाः भोजितेऽवृत्तीकाविन्यासं शिष्यां—Sûrîrasîhaṇa, Chap. III. यथा योजित: सप्तरसस्याधिता भवति भूतानामालकविः परिश्रमोपसत्—Ibid.).

Praśastapāda.

Praśastapāda begins with two great divisions: (1) Ayonija, animals that are a-sexually generated, of small dimensions (बुद्धवस्तु); (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, Sarisripas (reptiles, etc.) of oviparous animals. Udayana in the Kiranvali notes that Jarâyu means the placenta (Gamayenaprasamputrajarâyu; cf. Sridhara in the Kandali, Jarâyuva as gama prasamputra, prasamputra, tene vichitram naaya iti Jarâyuva). Udayana adds that the term Sarisripa includes insects and fishes as well as reptiles, these being all oviparous (sarasripa: parit: prasamputrartha: sarasripa: prasamputra:—pujaparitaprasamputra).

Patanjali.

The a-sexually generated animals, as we have seen, are also called Ksudrajanus (lit. small animals). Patanjali in the Mahabhasya gives several alternative definitions (or descriptions) of this class of animals. They are defined (1) as animals without bones, janastra: buhunam; or (2) as animals that do not possess any blood of their own, vaca va janastra navikate buhunam; 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), janastra nuhunam: buhunam:—Mahabhasya, 2–4–1.

Susruta.

Susruta 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) Jarâyûja, viviparous or placental; (3) Andaja, oviparous; and (4) Udvijja, 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) Jarâyûja, (2) Andaja, (3) Svedaja, (4) Udvijja. One reading gives the order: (1) Svedaja, (2) Andaja, (3) Udvijja, and (4) Jarâyûja. Some commentators point out that the order in the text (whatever that may be) is intended to indicate the order of creation by Brahmâ.

Suáruta 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 Pipîlikas (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 (वोतितवर), 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 (पि़ष्ठः, winged animals), bats and Valâkâs are viviparous (वहाकार जगसः जगाप्यम् जारायम्); indeed, Valâkâs are some of them oviparous and some viviparous (पिष्ठस वहाकार जारायम् चक्षुया). Among snakes, the Ahipatâkâs, a species of non-venomous colubrines snakes, are viviparous (ovo-viviparous?). Among the moisture-born, there are some kinds of ants (पिष्ठिनिंत्रः) which also lay
eggs or burst forth (from the ground, or perhaps from some previous unmanifest shape) (संस्करणभाव काविताः पिपीलिका चढ़ना वत्तिकाः).

The oviparous animals are divided by Suśruta into birds, snakes, Sarisripas, etc. Dalvana notes that the Sarisripas include fishes and Makaras (sea-fish with fierce teeth, सिंधुदेवकः), and the "et cetera" comprehends tortoises and crocodiles (सरोवर: श्रीमान्विन: जूठासप्रदयो मौनमूनवादयो या प्रभृतिभोजन खुम्मेनक्रादौना यश्वान)!* The "moisture-born" are due to the moisture and heat either of the earth or of organisms (संस्करण: गुप: मािरस्वा व संस्करण: खण्डः जायत:). Of these, the Krimis (worms) arise from the moisture of the faeces in the bowels (वृणय: कोपुराचारियापथामय:—Dalvana); from putrefying dead bodies (शब—Suśruta; cf. सरोवरे निलखः चेतान्तरे समुपचाराया नृम्यादौना चरे चेतामयः—Guṇaratna, Tarka-rahasya-dīpikā (Jainamatam); from decomposing curd or milk (e.g. चैत्यु च चोतादिना चन्दनिद्वयीयाचा मात्रान दस्यास्वयम् च चुम्हः चरतान्तिकृतिपीया उपखःको—Jayanta, Nyāya-Manjarī, Âhnika 7, बुद्धचतुर्थयशः).

The second class, Kitas, noticed among the moisture-born, include the scorpions, the six-spotted venomous insect śadvinda, etc. (शोदा यूर्थिवसहिष्ठिणु पुष्पवः—Dalvana). Of these the scorpions arise from cow-dung, excreta of snakes, rotten wood (चरे गोमशाय पुष्पकः चायते—Pātanjali, Mahābhāṣya, 1-4-3); cf. also Suśruta, Kalpaśṭhāna, Chap. VII.

The third class, Pipilikas, 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 (पुष्कर्मिको नात्ता विष्णू—Dalvana). The gnats and mos-
quitoes (तेर्समनवादर) are also usually placed among the moisture-born. An anda (egg) is described as oval, of the form of a pèsī (पैसी—Dalvna; cf. Śrīdhara, Kandalī, चक्रो बिन्यें तेन वेंटिते जायनते तत् चक्रवर्ग, पृष्ठोतिनिक्योह).

Chhândogya and Śankara.

It may be noted that the Chhândogya Upanishad classifies animals on the basis of their vīja (ovum or seed) as three-fold:—(1) Andaja, born of eggs; (2) Jivaja, viviparous; and (3) Udviṣha. Śankara explains that the udviṣha animals arise from vegetable organisms (वहुभिर्स्वायरं ततो मात्र उद्विषा), 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 udviṣha (vegetable-born) class (चक्रोर्चितंयोरवेत परासभाबभवमादाव—Chhândogya, Prapáthaka 6, part 3).

Evidently the idea is, that though vegetable organisms may pass off into animal, there cannot be generation without vīja (seed or ovum), and inorganic matter without vīja (seed or ovum) cannot give rise to animal life. Pātanjali, in the Mahābhāṣya (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 Dūrvā 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. Pātanjali notes the orthodox Sāṅkhya-Vedānta explanation that these are not cases of growth (or transformation) but merely of coming out (यम्मानिः),
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 dietetic 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 (चाहिपा योगिन्द्रेवः):

1. Prasaha, carnivorous as well as non-carnivorous (Chakrapânti), comprehending land quadrupeds and birds that fall on their food with force.
2. Anupa, animals that live in marshy or water-logged lands or graze on river-banks.
3. Bhûsaya or Vileśaya, animals that live in underground holes.
4. Vârisaya, 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. Viśkira, 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 (षोदसंख्या चतुर्दश चतुष्पद:। संस्कृतम् निर्मितादेव वर्गसंख्याय रूपमाथ तेन गहनेः इति नियमार्थम्—Dalvana, Sûrasthâna, Chap. XXVII.). These thirteen classes of dietary animals may be enumerated as follows:

I. Jângala animals—Janghôla, Viškira, Pratuda, Guhâsaya, Prasaha, Parṣamriga, Vileṣaya 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? तिमिनहस्ति महां: तिमिनहस्तस्तकालिक महस्तम्—Dalvana) find a place, as also the makara (shark, विश्वस्तानाः:—Dalvana).

The Kośastha (living in shells—mollusca) are distinguished from the Matsyas (fishes). In this class are enumerated sankhas (Conchifera), sankhana (smaller Conchifera), sukti (pearl-mussels), sambuka (Helix) with spiral shell (चावलस्तकालिक:—Dalvana), valluka (a species of Helix, according to some, चावलस्तकालिक:—Dalvana), etc. Dalvana adds vûrika, jalaśukti, and various species of Helix (चावलस्तकालिक:—Dalvana).
The Pādinas, aquatic animals having pedal (or long dorsal) appendages, comprise kurmas (oval or oblong-shaped tortoises, turtles), the kumbhiras (crocodiles, Emydosauria, Reptilia), karkatas (white and black crabs, Crustacea), the śiśumāra (a species of the Delphinidae 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 (दुरासारोशरकः पपिनिपार्व नुसारी सोयपि दिनिप्धः पुरुसमेवनेतः—Dalvana). The Pādinas do not represent any natural division.

Of the other Anūpa 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 Gāvaya (Bos gavœus), 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 (Raptores), comprising the vulture, kites, hawks, owls, etc. (Charaka's Prasaha is a much wider class); (2) the Viśkiras, 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 Columbe.
mammals, with the exception of several species of Vileśayás, which are reptiles. The Parṇamrigás (arboreal animals) comprise the apes, sloths, squirrels, as also some of the reptiles and carnivora. Among the Parṇamrigás, the Putighasa is a kind of tree-cat giving out a pungent odour; the Madgumuṣíka and the Briksaśayíka are arboreal rodents; and the Avakusa is a species of cow-tailed monkey (vide Dalvana). The Janghālas are wild animals, herbivorous quadrupeds that are strong-legged and quick-footed, comprising various species of deer and antelopes.

The Grāmyás (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 (कृष्ण—Suśruta, मांसाद—Charaka). Some are Ḗkaśapha (animals whose hoofs are not cloven) (मास्त्वक्कव्यं एकान्त्वित्वक्कव्यं मास्त्वक्य:—कृष्ण: सुषान:—Dalvana).

The Guhāśayás are carnivorous quadrupeds (कृष्णादा:) living in natural caves or hollows. They comprise the lion, the tiger, the wolf, tho hyena, the bear, the panther, the cat, the jackal, the mrigevaru, 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 mrigevaru is described as a jackal-like animal that kills deer.

Finally come the Vileśayás, animals that live in holes or burrows, comprising various species of Rodents and Insectivora, and several species of Reptiles.
Snakes in Suśruta-Nāgārjuna.

The Snakes (Ophidæ) are especially noticed by Suśruta-Nāgārjuna in the chapters relating to Toxicology (Kalpasthāna, 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 Darvakaras (दर्विकार, महाकृष्ण, पदु, महापदु, श्रस्वपाङ्क—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 Mandalis (Vipera, Viperidæ?) are thick (पत्तक), slow-moving, nocturnal in their habits, and bear circles or rings on the body (चादासिन्हविकल). 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 Nirvişas, non-venomous snakes, twelve varieties are mentioned, including Boidæ (चमगर) and the Colubrine Dendrophis (पुष्पसंग). Of the Vaikaranja (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 Darvakaras are most deadly when young, the Mandalis 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 Purâṇa gives the following additional information. The Nāgas (Naśe) copulate in the month of Jyaistha or Āśādha (May or June), gestate during the rainy months that follow, and bring forth about two hundred and forty eggs in the month of Kārtika (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 Purâṇa).

Eggs of a golden hue like that of the (red) flowers of the Calotropis gigantea (कूलत्रोपिसगिगांतेआ) produce male young ones, those somewhat paler and of an elongated ovoid shape (कूलत्रोपिसुद्वहारान दोषिराजीववसतिभात) bring forth female snakes, and those of the hue of the Sirīśa-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 (संक्रम) in three weeks, and becomes deadly in the twenty-fifth night. In six months Nāgas shed the skin (तुङ्क).

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—सच्च्व) are two hundred and forty in number (perhaps the sub-caudals were not counted).
Snakes are killed by men, mongooses, peacocks, Chakoras (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, बविस्य वराण).

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 Kurâli and Makarî, which seem to stand for two hard (maxillary) teeth accompanying the two fangs (cf. also Charaka—Driḍhavala, Chikitsâsthâna, XXIII., नियमितविकलित).

Umaśvati’s Classification of Animals.

A more thorough classification of animals is found in the ancient Jaina work, the Tattvârthâdhigama of Umaśvati, which the Jaina chronological lists enable us to assign with great probability to the fourth or fifth decennium after Christ (circa 40 A.D.). Umaśvati’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) *Nāpuraka* (ring-like, with pendants, Vermes with unsegmented lateral appendages, Annelids).

(c) *Gandāpada* (knotty-legged, Arthropoda, including Crustacea, Myriapoda, etc.).

(d) Some forms of Mollusca, *e.g.* *Sānkhā* (Conchifera, Lamelli-branchiata), *Śuktika* (Pearl-mussel, Lamelli-branchiata), and *Sambuka* (Helix).

(e) *Jalākā*, 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 (Formicidae, Hymenoptera).

(b) *Rohinikā*, Red-ants (Formicidae, Hymenoptera).

(c) *Upachikā*, *Kunthu*, *Tuburaka*, Bugs and Fleas (Hemiptera, Hemimetabola).

(d) *Trapusaviya* and *Karpāsāsthikā*, Cucumber- and Cotton-weevils and Lice (Aptera, Ametabola).

(e) *Satapadi* and *Utpataka*, Spring-tails (Aptera-Ametabola).

(f) *Trīnapatra*, 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*, *Varaṇa*, and *Sāranga*, Bees, Wasps, and Hornets (Hymenoptera, Holometabola).
(b) Makṣikā, Puttikā, Dansā, and Maśaka, Flies, Gnats, Gad-flies, and Mosquitoes (Diptera, Holometabola).

(c) Vṛiṣchika and Nandyāvarta, Scorpions and Spiders (Arachnida, Arthropoda).

(d) Kīta, Butterflies and Moths (Lepidoptera, Holometabola), and

(e) Patanga, Grasshoppers and Locusts (Orthopteran Hemimetabola).

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

(a) Matsya, Fishes.

(b) Uraga.

(c) Bhujanga.

(d) Pakṣi, Birds, and

(e) Chatuspada, 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 (Ophidae).

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 (Varanidae Lizards, Reptilia), Krikalása (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 Satapadi).


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

C.—Potâja, a class of placental mammals comprising the Deciduata with the exception of Man, the Apes, and the Carnivora, e.g. Šallaka (Porcupine, Rodentia), Hasti (Elephant, Proboscidea), Śvavit and Lâpaka (Hedgehogs and other creatures that lap up, Insectivora), Šâśa and Šayika (Hare, Rabbit, and Squirrel, Rodentia), Nakula (Ichneumon, which though carnivorous is
supposed to come under the Deciduata), Mūṣik (Mice, Rodentia), and the Charma-pakṣa Pakṣis, so-called birds with leathern wings (Bats, Chiroptera) e.g. Valguli (Flying-Fox), Pakṣivirāla (Flying-Cat, Micro-Chiroptera) and Jalūkā (apparently meaning blood-sucking Bats or Vampires, though these are scarcely found in the Old World).

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

The term Potajā is intended to signify that these animals are born without the placenta which is thrown off as an afterbirth, whereas such of the Jarāyujas 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).

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THE POSITIVE SCIENCES OF
SECTION 2.
RECAPITULATION.

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

A.—Kṣudra-jantus, boneless and without (red) blood. Invertebrata, divided into—

(a) Ayonija, a-sexually generated, e.g. the Svedaja, born of moisture and heat, and the Udvijja (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 Udvijjas and Andajas.

The Kṣudra-jantus (Invertebrata) comprise—

(I.) The Krimis, Vermes: (a) Apādikas without lateral appendages (cf. Scolecids), (b) Nāpurakas, Annelids (a section), (c) Gandāpadas, Arthropoda (a section).

(II.) The Jalūkās, Leeches, of which twelve species are described, six venomous and six innocuous (cf. Suśruta's careful description, Sūtrasththaṇa, Chap. XIII.).

(III.) Kośasthas, Shelled Animals, some forms of Mollusca, e.g. the Śankhas (Conchifera), the
Suṣṭikas (pearl-mussels), the Sambukas (spiral-shelled Helix), the Vodiṇkas, etc.

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

(a) Pipilikā, Rohiṇikā (ants, Hymenoptera).
(b) Upachikā, Kunṭhu, Tuburaka (bugs and flies, Hemiptera).
(c) Cucumber- and cotton-lice (Aptera).
(d) Satapadi, Utpataka (spring-tails, Aptera).
(e) Triṇapatra, grass- or plant-lice (Aptera).
(f) Termites (Neuroptera).

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

(a) Bhramara, Varāṭa, Sāranga, bees, wasps, and hornets.
(b) Makṣikā, Puttikā, Dansa, Maśaka, flies, gnats, gadflies, and mosquitoes.
(c) Vriṣchika and Nandyāvarta, scorpions and spiders (Arachnida, Arthropoda).
(d) Kīta, butterflies and moths; and
(e) Patanga, grasshoppers and locusts.

Suārūta-Nāgarjuna names six varieties of ants, six varieties of flies, five of mosquitoes (including one marine and one mountain kind), eight varieties of Satapadiś (centipedes), thirty varieties of scorpions, and sixteen of spiders (Lutās). Of the Kītas, the glow-worm and the Tailakita (lit. oil-worm) are said to be luminous (phosphorescent, cf. Rājanighantu राजनिघंटु).

B.—The Tiryyakyoni 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, Kumbhīras, and Śśunāras (tortoises, crocodiles, and dolphins) are excluded from the class, as also the so-called shell-fish, being placed among the Pādinas and the Kośasthas 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 (पुष्पादि: कोटा: पञ्चनासा:—Dalvana).

The Bhujangas include:

1. Godha, Grihagolika and Krikalāsa (Varantas lizards, common lizards, and chameleons). Suśruta names four varieties of the
Kanava, a species of chameleon-like lizards (cf. Lādvyāyana quoted by Dalvna, Kalpasthāna, 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 Satapadi). Eight species of frogs are named. The frogs are explained by the mythologist to have arisen from dirty water in the rainy season... (i.e. Mahāvaruṇa) nagaḥ (cf. Dalvna, Kalpasthāna, Chap. VIII).

2. Kūrmas and Nakras, tortoises and crocodiles (Chelonia and Emydosauria, Reptilia). Some species of the former are oval, others elongated.

3. Śisumāras, the Delphinidæ (Odontocete cetacea).

Suśruta’s Pādinas (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). Umāsvati’s Bhujanga class, being a natural sub-division of Vertebrates, does not include Crustacea, which are rightly placed among the Invertebrates.
(d) *Lomapakṣa paksi*, winged animals with feathery wings, birds proper. These are oviparous, while the winged animals with leather wings (ष्ट्र्येपप्प्यः) are placentalia of the Decidua class (षोष्यः).

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 Scanores, the Rasores, and the Columbæ.

(4) *Prasahas*, birds of prey proper (Raptoreis).

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

"कूलेन्द्रसाह...हुः ज्ञर्दि सुकुण्डागो...गाहर्य ुपर्ति—" *विष्टपुष्टसमालि...श्रमराशः शर्यसाढः सक्तलांतपिसाहः मचरेनि: विनिष्वः। मणिमि ज्ञर्दि सुकुण्ड दोर्ति—"##स्मरति हुः स्यां। कार्कसः सुकुण्डसामेव:...छन्वे कार्कसाहुः...उक्तः "कार्कसः काजः-वद्वसो दीपेकः कृष्णकेंद्राः...ति। प्रवेकाताह...वहुः दीपेकः दीपेकः सुकुण्ड:...उनः च "वादस्याः वाद-मकास्यो नामाणियांतः...लोहोऽहो दीपेकाः: वषाधः सकुण्डकेंद्राः।" 

हुः।"
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) Chaṇḍapakṣa pâkṣis, leather-winged animals, which are Deciduata (Potaţa). 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 (Suśruta, Kalpāsthāna, Chap. VI.).

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

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

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

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

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, Guhāśaya (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 Pasus (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-deciduala). The Deciduata (including the Proboscidea, the Rodentia, the Insectivora, the Chiroptera, etc.) were termed Potajâ, 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 (गङ्ग जन्त, 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) Dotting or markings, (2) wings, (3) pedal appendages, (4) mouth, with antennæ or nippers (गुलवर्ज—Dalvana), (5) claws, (6) sharp, pointed hairs or filaments, (7) stings in the tail, (8) hymenopterous character (संयमन: पश्चारीरिति), (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. बहुभि: विद्युक्षाभि: पदे: पादे: नसो: नसो: बहुभि: बहुवाक्षाग्नि: संस्कृति: परमेनभि:।
खाने: प्रकाशिं: संस्कारे हिन्दूः पाप्पृतापि ज्ञेयानि:
विषयवेत्ताभि कोदानं इत्यादि वचनं विभाषते॥

(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 Âkâśa-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 Âkâśa-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 Mahásrotas (the great channel).

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

In the stomach (जलाब्ध्य) the food becomes mixed up, first with a gelatinous mucus (चेतोभूत वज्र) which has a saccharine taste, and then gets acidulated by the further chemical action of a digestive juice (विदाहाददान्त गत:, 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 Grahanî Nâdî, to the Pittâsâya (duodenum, lit. bile-receptacle), and thence to the small intestines (the चानणजाक्ष्य). 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 (रजः), 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 (शृङ्खलाग) 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 (खूर्तभाग) proceeds along the Dhamanis, being driven by the bio-motor force, the Vyāna Vāyu, all over the body.

When the blood has been formed, the essence of chyle in the blood, acted on by Vāyu (bio-motor force) and Māṃsāgni (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 Vāyu (bio-motor current) and the fat-forming metabolic heat (मेटाफोर्मिंग) in the menstruum of lymph (समापितम्), 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 Vāyu (bio-motor current) and the marrow-forming metabolic heat, in the menstruum of lymph (समापितम्), becomes hard (crystalline) and forms bone, the Earth-, Vāyu-, 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 Vāyu 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 Dhamanīs or ducts (द्वृत्तांक), lodged in its receptacles (सुषुभत्रम्—प्रस्थवद्), and discharged by means of another pair of ducts (द्विप्रकाश). 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 (परिप्रस्थति चक्रम्, 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 (पात्र—पररासर्वावध पात्र) 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 (पितासाप), which acts on the chyme to produce the chyle (चायय पड्क पायचाक्य शिख); and (2) a colouring bile-substance in the liver, which adds a red pigment to the chyle and transforms it into blood (राखाक्य शिख). Besides, there are three other biles, of which the aqueous humour in the eye is supposed to be one (शाल्पुपर्य शिख), helping in the formation of visual images (रणवाहिन). This is the view of Dhanvantari and
his school, but Ātreyā 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 (श्वासपि—केदारोक्वाल्याय—कलेखपोत्त्वाष्टिति प्रथा भाव्येक्षतः:—चक्रपाणि, भानुमति, सूत्रस्थान, XIV., 10; also his commentary on Charaka, Sūtrasthāna, XXVIII.), but my account is based on the second hypothesis, which has the preference of Chakrapāṇi (करक). It may be added as a curiosity that each element of the body (भाज) under the metabolic heat is supposed to give off a finer essence (ब्रह्मचार), which serves as the material of the next succeeding element, and a dross (वह), 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 Vāyus (bio-motor or vital currents), or by the Srotas, 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 Dhamanīs, 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. Vāgbhata, तः हथत्वा: विसरा: रसाल्कर रोजः भाविन्यः:) श्वासपि सेते भारां पानिभोजः। विषः पशचा सम्यक् गहानः शानिभवसेवः। —Suśruta, Sūtrasthāna, Ch. XLVI.; cf. also विषयस्यसनात्माया नृत्यमागीति नाहतः। शानिययेव यद्यथे तेन विनायास्ये। —Ibid., Ch. XLI. भौसाहा: वाने। पशोभाकान् सता:। पवाहा—
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Charaka quoted by Dalvana. चाहीं बहुजनमयें महुरोघसिद्धैन, केशक्षणैं कष्टे यात्रा विद्राहाद्वत्रा गति। वायुना समसामयें महुरोगोजिनीयां। वहीं विद्यम् नाम या कचा परिवहिती। चायम्यक्ष्यायानांस्या यहाँ साधितं। \( \text{चायम्यक्ष्यायानांस्या यहाँ साधितं} \)

Charaka-Dridhavala Samhitā quoted by Aruṇa in his commentary on Vāgbhata.)

यथा वेदांतनिधिभुज्यां ब्रह्मसन्ध्या बेदारोगिनायपित। तथा रस रश प्रथम रश्य मायवरित। तथा रसायनसम्बन्धैत रसायनृधृर्य रसायनपद्धति चतुर्विधित। रश्य च रसायनोन स्वभावितः प्रथम पोष्यति। ततो रसायन नास्तायपित, रसायनोनस्तुर्वृत्तरुस्तुर्वृत्त रसायन आन्यवरित। (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 रसायन नास्तायपित)। This will be abundantly clear from the following account of the course of the chyle and the blood:—

ततो सास्त्रमाहाराजस त्रिभूतिभवत:। श्लोकः शुक्लः ... ततो
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The finer essence of chyle which nourishes the flesh is also carried in the blood, on the irrigation channel hypothesis (केदारी-कृत्यान्वय).

SECTION 2.

THE CIRCULATORY SYSTEM.

The standing puzzle of Hindu anatomy and physiology is the classification of the Śīrās, Dhamanīs, and Srotas, 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 Dhamanīs and Srotas are only modifications of the Śīrās, 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, Śārīrasthāna, Chapter IX.). Charaka also accepts the established division, but points out that the numbers as estimated are conjectural (चनिमेंथवत्:परं तथास्वाय, Śārīrasthāna, Chapter VII.).

The Śīrās, Dhamanīs, and Srotas form networks
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 (पीता), 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:

सम झिरायमानि भविष्या याभिरिद्व झिरायमानि इस शाहदारिकाः श्रेयः श्रेयः श्रेयः श्रेयः श्रेयः श्रेयः श्रेयः श्रेयः श्रेयः श्रेयः श्रेयः श्रेयः श्रेयः श्रेयः श्रेयः श्रेयः श्रेयः श्रेयः श्रेयः श्रेयः श्रेयः श्रेयः श्रेयः

The *Dhamaṇīs* 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 *Dhamaṇīs* 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 *Śīrās*, (4) the ducts for urine, sweat, and other secretions, and (5) lastly, certain classes of bile-ducts and conductors of *Vāyu* currents, possibly those connected with the venous system and the chyle-ducts.

The first group of *Dhamaṇīs*:_—Special features:_

Each of the ten ascending *Dhamaṇīs*, 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 (हृदय विषेषेन चेतनास्थानम्, Suârûta, Sârîraṭhâna, Chap. IV.; हृदय चेतनाविशालनेवम्, Charaka, Sârîraṭhâna, 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 fibrillae, 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, embroacations, 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, शाक, and flows to all the parts of the body by means of connective passages), and *Kapha* (lymph)—make use of the *Dhamanis* as well as the *Śirās* and *Śrotas*, *i.e.* of all manner of conductors in the organism (*cf.* Charaka, चारकप्रत्ययमात्र युजः सौभाग्यिकमरेद्धी सत्तांतसत्तांति—*Vimānakāsthaṇa*, Chapter V.).

The functions of the *Śirās* 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 *Dhamanis*, 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 *Dhamanis*, which, in common
with the Śirās and Śrotas, conduct Vāyu, Pitta, and Kapha, the prime movers of the organic life.

The Vascular System.

The anatomical arrangement of the Śirās and Dhamanīs 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 Śirā cords as 700, and of Dhamanī 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, Śirās and Dhamanīs, 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. Vāgbhata takes the heart to be the origin of the Śirās.

From this central alimentary tract two sets of vessels (Śirās and Dhamanīs—Rasavāhīnīyah) issue for the flow of the chyle and other lymph, and two sets (Śirās and Dhamanīs, "arteries" and "veins"—Raktavāhīnīyah) for the flow of the blood.

The Lymph (and Chyle): Distribution.—The chyle is conducted by the chyle-bearing Dhamanīs (Rasavāhīnīyah), and the lymph (other than chyle) by the lymph-bearing Śirās and Dhamanīs (Kaphavāhīnīyah).
The lymph-bearing Śīrās 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 (Rasavāhīnyah Dhamanyah). The chyle-ducts issue from the Nāvī (possibly the receptaculum chyli in this case). A Dhamanī 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 (Dhamanīs—Rasavāhīnyah and Kaphavāhīnyah) 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 Dhamanīs (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) Śīrās, which break up into capillaries (Pratān) and distribute “pure” blood from the liver (and spleen) to the heart, and from the heart to the rest of the body (asrigvahāscha rohinyah śīrāh nātyuṃnasātalāḥ,—Suṣruta, Sarīrasthāna, Chap. VII.; cf. Vāgbhata: dasa mūlasīrāh kritsthāh, Chap. III., Sarīrasthāna), and (2) Dhamanīs (Raktavāhīnyah), 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 Dhamani 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, Sirâs ("arteries") proceed to the heart. The liver (and spleen, a minor blood-vascular gland) and the heart are the centres of origin of the Sirâs ("arteries"), and distribute pure blood by their means over the entire body.

Arrangement of the blood-bearing Sirâs and Dhamanîs. — Two blood-bearing Dhamani 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 Sirâs bearing pure blood proceed from the alimentary tract to the liver and spleen, which are joined on to the heart by means of both Sirâs and Dhamanîs. The ten Sirâs are subdivided into 175 branches, which are distributed over the body in the same way as the lymph-bearing Sirâs (vide supra).

It is clear that Charaka and Suârûta 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 Sirâ and a Dhamani, thus illustrating Suârûta'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.

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

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SECTION 3.

THE NERVOUS SYSTEM IN CHARAKA.

The Nerves.—Dhamanîs as nerves: The anatomy of the nervous system in Charaka and Suârûta 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 (Motores 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 sacrococcygeal and sacral plexuses, if not also of the lumbar plexus). The obliquely branching Dhamanis, 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 fibrillae round the pores of the skin. They carry to the heart cutaneous sensations, external as well as internal. A fibril (शूकलापी) is said to be as minute as the thousandth part of a hair (कोश: सहस्रभागे तुष्यासु प्रचरत्वं—Panchadasi).

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 cerebrospinal system. The soul (the Jiva) has its special seat within the Brahmaramadhra above the foramen of Monro and the middle commissure, but traverses the whole cerebro-spinal axis, up and down, along the Susumna (the central passage of the spinal cord). The Brahmadanda (vertebral column) contains the Susumna, the Brahmana Nadî, and the Manovahâ Nadî. The cerebrospinal axis with the connected sympathetic system contains a number of ganglionic centres and plexuses (Chakras, Padmas) from which nerves (Nadis, Siras, and Dhamanis) 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-coecygeal plexus, with four branches, eleven angulis (about nine inches) below the solar plexus (Kanda, Brahmagranthi); 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 Nadî, by preference, for nerves. They also mean cranial nerves when they speak of Siras, 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-sikhā.

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

(3) The Nāvikanda (corresponding to the solar plexus, Bhânumbhavanam), which forms the great junction of the right and left sympathetic chains (Pingalâ and Iḍâ) with the cerebro-spinal axis.

Connected with this is the Manipuraka, 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 Bhâratisthâna, 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 Lalana 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 Ājnâ 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 Šaudavahā Nāḍī (auditory), the Rasavahā Nāḍī (gustatory), and the Šparāśavahā 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, meditativeness, gravity, earnestness, resolution, determination, magnanimity, etc.; and lastly

(9) The Sahasrāra Chakra, thousand-lobed, the upper cerebrum with its lobes and convolutions, the special and highest seat of the Jiva, the soul.
The cerebro-spinal axis and the heart: their respective relations to the conscious life.—Vijnàna-bhikshu, in the passage just quoted, identifies the Manovahà Nàdî (vehicle of consciousness, विज्ञानस्वायत्त) with
the cerebro-spinal axis and its ramifications, and compares the figure to an inverted gourd with a thousand-branched stem hanging down. The *Susumna*, 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 *Manovahā Nāḍī* is the channel of the communication of the *Jīva* (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 (धिशिश्वानम्). A communication must now be established between the *Jīva* (in the *Sahasrāra Chakra*, upper cerebrum) and the sensory currents received at the sensorium, and this is done by means of the *Manovahā Nāḍī*. When sensations are centrally initiated, as in dreams and hallucinations, a special *Nāḍī* (*Swapnavahā Nāḍī*), which appears to be only a branch of the *Manovahā Nāḍī*, serves as the channel of communication from the *Jīva* (soul) to the sensorium. In the same way, the *Ājnāvahā Nāḍī* brings down the messages of the soul from the *Sahasrāra* (upper cerebrum) to the *Ājnā 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 *Manovahā Nāḍī*, are sometimes generally termed *Jnānavahā Nāḍī*, lit. channel of presentative knowledge. There is no
difficulty so far. The Manovahā Nāḍi and the Ājnāvahā Nāḍi connect the sensori-motor tract at the base of the brain (Mānaschakra and Ājnāchakra) with the highest (and special) seat of the soul (Jīva) in the upper cerebrum (Sahasrāra), the one being the channel for carrying up the sensory, and the other for bringing down the motor messages. But efforts of the will (Ājnā, Prayatna) are conscious presentations, and the Manovahā Nāḍi must therefore co-operate with the Ājnāvahā 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 (Ātman, Jīva), an effort of which we are conscious through the channel of the Manovahā Nāḍi. But how to explain the presentation of effort in the motor nerves? Śankara Miśra, the author of the Upaskāra on Kanāda’s Sūtras, argues that the Nāḍīs (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 fibrillae among them). The consciousness of effort, then, in any motor nerve, whether Ājnāvahā (volitional-motor) or Prāṇavahā (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 Prāṇas implies an (automatic) effort (मीत्तमनस्मिरिक्यं) 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 Prânavahâ Nûdîs).

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 (क्षाप) 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 (suṣupti), when this last faculty is likewise merged in the mere automatic activity of life.

 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 Širâs, 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.

\[
\begin{array}{c}
\text{PUSĀ} & \text{GĀNDHARĪ} \\
\text{PAYASVINĪ} & \text{SUKUMĀ} & \text{SANKHINĪ} \\
\text{SARASVATĪ} & \text{KUHU} & \text{ĪDĀ} \\
\text{PINGALĀ} & \text{VĀRANA} & \text{VIŚVODARĀ} \\
\text{JĀSASVINĪ} & \text{HASTIJHVA} & \text{ALAMBUŚĀ} \\
\end{array}
\]

*Right.*

The *Suśumnā* is the central cord in the vertebral column (नाभिकक, में). The two chains of sympathetic ganglia on the left and the right are named *Īḍā* and *Pingalā* respectively. The sympathetic nerves have their main connection with *Suśumnā* at the solar plexus (आम्लालय, नाभिकक in the क्ष, नाभिकक or तापप्रति). Of the seven hundred nerve-cords of the sympathetic-spinal
system (भूतित्व: Sangīta-ratnākara), the fourteen most important are:

1) 
Sūsumnā, in the central channel of the spinal cord.

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

3) Pingalā, the corresponding chain on the right.

4) Kuṇu, the pudic nerve of the sacral plexus, to the left of the spinal cord.

5) Gāndhārī, 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) Hastijīhvā, 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) Sarasvatī, to the right of Sūsumnā, stretching up to the tongue (the hypo-glossal nerves of the cervical plexus).

8) Puṣā, 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) Payasvinī, between Puṣā and Sarasvatī, auricular branch of the cervical plexus on the right.
(10) Sankhinī, between Gāndhārī and Sarasvatī, auricular branch of the cervical plexus on the left.

(11) Jābasvinī, 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) Vāranā, the nerves of the sacral plexus, between Kuhu and Jasaśvinī, ramifying over the lower trunk and limbs.

(13) Viśvodarā, the nerves of the lumbar plexus, between Kuhu and Hastijihvā, ramifying over the lower trunk and limbs.

(14) Alambusā, the coccygeal nerves, proceeding from the sacral vertebrae to the urino-genitary organs.

(Vide Sangīta-ratnakāra, सराम्याव, फिसहोतप्रिमकवर्ष—Ślokas 144–156. Also, the Yogārṇava.)

SECTION 7.

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

Charaka describes Vāyu 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 Vāyus with their functions in the maintenance of the animal life. Suśruta mentions Prāṇa 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. (Suâruta—Nidânasthâna, Chapter I.)

In the mediæval physiology the number of Vâyus is given as 49. As in Charaka and Suâruta, the Vâyus are regarded as the moving or impelling forces that work the organism and all its automatic and reflex machinery. The Âjnâvahâ Nâdis (efferent nerves) are only channels for the conduction of commands of the self or the will (ज्ञानमयः); 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) Prâna, 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 faeces, 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) Udāna, concerned in maintaining the erect posture of the body.

(6) Nāga, which is concerned in involuntary retching, vomiting.

(7) Kūrma, 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.

Cf. the summary in Raja Sourindra Mohan Tagore’s edition of the Sangītā-darpana.
SECTION 8.

FOETAL DEVELOPMENT (AFTER SUSRUTA).  

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 (Saptatvaachah), 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. Vâyu, with the accompaniment of animal heat, impels the "currents" (brotâmsi) in the system; Vâyu acting on the flesh gives rise to the muscles; and it is Vâyu, again, which, with the essence of fat (or marrow), produces the nerves, arteries, and tendons (Suârûta, Sûrîrasthâna, Chap. IV., and Sûtra-sthâna, 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, Sûrîrasthâna, 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, Sûrîrasthâna, Chap. IV.—भिक्षुद्वेषिः वनः सम्प्रभुते विषः पेवतुंशतः। तथ वनः विषः पुश्चः सर्वे पेवते चढ़ेद्याः नुस्वकः। Chakrapânî notes वनः वहिनः। विषः साम्बासारः। पेवरी दरिक्षितपेशुयकारा। चढ़ैः परस्योवत् 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 Brāhmaṇas) 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 (Sāṅkara, Brihadāraṇyaka-bhāṣya). Species (षोभन) 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.

गम्भेष्य दि सम्भवत: . . . सत्त्वाक्रमांकुक्ष्यिनि दुग्धवं सम्भवति इवाद वन्मार्गः।

Gambhaṣya: Sattvākramāṅkukṣyaṁ durgacāṁ sambhavitāṁ evaṁ vanāravgaṁ.

Gambhaṣya: Yuṣṭānām noipālamāṁ yanḍākuraṁ puṣṭākuraṁ tathāṁ pūrṇakṣaṁ pariṣṭhakṣaṁ keśarīkṣaṁśeṣāyaṁ: puṣṭāṁ durgacāṁ kālākramopadāṁ. Taṇḍyaṁ taḥsye noipālamāṁ yuṣṭānāṁ. Tathaṁ keśarīkṣaṁśeṣaṁ pratyakṣaṁ kāraṇiṁ stotreṇaṁ yanḍākuraṁ ratnavāṁ: Sarvaṁ gambhaṣyaṁ taḥsye saṁbhuṁ cakṣubhāṣṭreṇaṁ tathuṁ sūkṣmaṁ—
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 (सरोत्सर्वायामं सुकृतं चक्रवत्तावरण समभवति। Charaka, Śārīra-sthāna, Chap. IV.; cf. Śankara on Brihadāranyaka).

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 Ātreyya. The fertilised ovum, it is true, is composed of elements which arise from the whole parental organism (समुदायाभिम, समुदायप्रभव), but it is not the developed organs of the parents, with their idiosyncrasies or acquired characters, that determine or contribute the elements of the sperm-cell (or seed). The parental Viḍa (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 Vîja (seed, germ-plasm) is an organic whole independent of the developed parental body and its organs. In the parental Vîja an element representing a particular organ or tissue may happen (for this is accidental, दैव) to be defective or underdeveloped, 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 Vîja 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 Vîja 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, Sarîrasthāna).

...
N.B.—The seventh tissue (the Śukradharā kalā, sperm-bearing or reproductive) contains the parental Vīja, which is a minute organism (समुदायाल्पक) 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 Vīja in the reproductive tissue that determine the physiological characters and predispositions of the offspring. We may call this Ātreya's germ-plasm theory, for it is an advance on the conception of gemmules and of idas, but in Ātreya'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 Ātreya'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 (षोभ) 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 Ātreya and Charaka conceive it to be, is nowhere expressly deduced. On the other hand, Ātreya and Charaka emphasise the influence of abundant or defective nutrition, and of the constituents of the food, etc., on the characters of the Vīja in the reproductive tissue, especially as regards the sexual character, the stature, and the colour-pigment.
(वर्ग) of the offspring. But though the influence of nutrition on the विजा 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 विजा must be regarded as a matter of chance (सें), 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 विजा. 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 Prayogachintāmanī 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 fetus 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 (पुजवननीर्गत). As for the colour-pigment, it is the animal heat (तमोपत्र) which is its source; but where the Ākūsa 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.
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 lodestone. 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 (ख्रेत्र, उष्ण, दंशमञ्जित्य), 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 Sūtras, reports the Chārvāka explanation of instinctive emotional expressions in babes: Sūtra 20, Āhnika 1, Chapter III.; cf. the explanation of the movement preparatory to sucking: Sūtra 23, ibid. Jayanta, in the Nyāya-manjarī, reports the Chārvāka explanation of consciousness (and life).


For spontaneous generation, vide Jayanta’s report:—

The Sāṅkhya 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 (वैचन्त) 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 Bhūtas or particles, cf. Vijnāna-bhikṣu’s comment on the Sūtra. \( \text{Sūtra 22, Chapter III.} \) \( \text{नतु वना मादवताःकां नासं नासं तत्तुभवः} \) \( \text{ततियं चैत्यमापि स्वार्थिन्ती प्रक्रिकारितं तत्तुभवः समभचेत।} \) \( \text{चन्द्र्कृष्णनं प्रक्रिकारितं तत्तुभवः समभचेत।} \) \( \text{नतु सनुसिो चैत्यमापि स्वार्थिन्ती प्रक्रिकारितं तत्तुभवः समभचेत।} \) \( \text{नतु सनुसिो चैत्यमापि स्वार्थिन्ती प्रक्रिकारितं तत्तुभवः समभचेत।} \) \( \text{नतु सनुसिो चैत्यमापि स्वार्थिन्ती प्रक्रिकारितं तत्तुभवः समभचेत।} \) \( \text{नतु सनुसिो चैत्यमापि स्वार्थिन्ती प्रक्रिकारितं तत्तुभवः समभचेत।} \) \( \text{नतु सनुसिो चैत्यमापि स्वार्थिन्ती प्रक्रिकारितं तत्तुभवः समभचेत।} \) Cf. also \( \text{भागादाप्रकरणुकानो महायताकारयुग्मवत्ता कारणे चैत्ये विषा} \) \( \text{देहे} \) \( \text{वैत्यामापित।} \) \( \text{ibid.}. \)

\( \text{नमो गुणो गुणो} \) \( \text{महाभाबादयो विपुरस्ययङ्गिनयो यह} \) \( \text{सत्य कवे} \) \( \text{मे} \) \( \text{कार्मिकराने नाछासमेरोपिरोपिये} \) \( \text{शुष्मते प्रभाय श्रीत।} \) \( \text{चैत्यार्दिवं न कवे} \) \( \text{Gangadhara’s Jalpakalpataru (1867, Calcutta), explaining} \) \( \text{the distinction between property (गुण) and power} \) \( \text{देहे} \) \( \text{Sūtrasthāna, Jalpakal-} \)

The Sānkhyya view of Prāṇa (life):—

Life, according to the Sānkhyya, is not a Vāyu (bio-mechanical force) nor any mere mechanical motion resulting from the impulse of Vāyu. The five vital operations, Prāṇa, Apāṇa, etc., are called Vāyus, but this is only a metaphor. Life is in reality a reflex activity, a resultant of the various concurrent activities of the Antahkaraṇas, i.e. of the sensori-motor (अनेकार्ण अकार्णत्रथः), the emotional (मनः) and the apperceptive reactions of the organism (for some add चर्च्चार). 

Vijnāna-bhikṣu notes that this explains the disturbing (elevating or depressing) effect on the vitality of pleasurable or painful emotions, like love (भाष्म), which
are activities of *Manas*, one of the *Antahkarana* concerned in the reactions of the living organism. On the Sânkhya view, then, *Prâna* or life is not a *Vâyu*, nor is it evolved from the Bhutas, inorganic matter. *Prâna* is only a complex reflex activity (*Samvâda* *pr̥cba*) resulting from the operations of the psycho-physical principles or forces in the organism. Cf. Śankara reporting the Sânkhya view—*karma* *nimajjana* *vajra*: *sattâ* *samvâda* *prâkāśa* *vûcba* *pratibandhane*!—*Śatīraka-bhāṣya*, Chapter II., *Pada* 4, *Sûtra* 9.

Also *Sûtra* 31, Chapter II., where Vijnâna-bhikṣu notes:—

> यावः सम्बारात्व वायूः प्रतिलक्षणः। भवाये नायेन विनयमः कदाचन्द्रचण्डः।
> वायुस्माचारणति चतुःचतुर्भुजः। सामयोसामयते सति चन्द्रेश्वरीपीतः।


The Vedāntic View of *Prâna*.

The Vedāntists are believers in an independent vital principle. They agree with the Sânkhyas in holding that *Prâna* 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 (सममतारूपम्) between the motions of the individual birds and the resultant motion of the cage, but the sensations do not explain life. *Life* (Prāṇa) must therefore be recognised as a separate principle, just as the Manas and the Antahkarāṇas generally are in the Sānkhya Philosophy. Life is a sort of subtle rarefied “ether-principle” (वायुप्राविशी) 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 (प्राण) is “material” (चक्षु).

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 पृथिवीदेशात्), Chapter II., Pāda 4, Sūtra 9; *vide* Śāṅkara-Bhāṣya Śāṅkara; also Vāchāsati Miśra, Bhāmatī:—

सिद्धान्तु न समानेनिद्रयुगित: प्राण:। न हि सिद्धान्तानां या वृजयात्रेषु प्राणेषु य। न नाति सिद्धान्तानां। सदहिष्ठिसुरिदिद्राभावेऽतद्रावणयुग्मः। न लक्षणा वृजयक्रियात्योग्मनायाप्राप्त्य unavoidable अविनिर्मित।। न च वृजयात्रानां विनिदिद्राभावेऽतद्रावणयुग्मः। न च अविनिर्मित सर्वार नाति सान्नाविर्मिर्मिचुवशेषः।। चापि च यत् सम्भूवनन्त्य कारणेऽत्तथा निनिद्रायन्ति तत् प्राणान्त्याति नृत्यान्त्याति। यथा ववसं प्रात्तिकिः कारणं पिन्दान्त्याति नृत्याति।। इति कथानार्थवाद्यात्याति अवाहिनी सम्भूवनन्त्य। चापि च यत् सम्भूवनन्त्य कारणेऽत्तथा निनिद्रायन्ति तत् प्राणान्त्याति नृत्यान्त्याति।। इति कथानार्थवाद्यात्याति अवाहिनी सम्भूवनन्त्य।।

—Śāṅkara, ibid. *Cf.* also, जोगेश प्राण: प्रांकुलितादेशादेशाय तत्त्व वृजयाभाद्। नेतृत्व तत्त्व तदानन्त वृजयाभाद् स्वात् पुरशं पृथिवी न सम्भूवनन्त्याति जोगेशाय तत्त्व तदानन्त अस्तित्वादिवादिसमाजनिन्यमो वृजयाभाद्। इति —Śāṅkara, on Sūtra 9, Pāda 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 सम्बादिद्धान and विस्म्बादिद्धान। Also compare प्रमाणार्थोवेप्यप्रतिपत्ती प्रृथ्विसामय्यात् अस्थिन् प्रमाण—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 (सम्बन्ध), 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 Khâdyâ, on the relation of प्रथम to कोयकपित्त). 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 [तत्ततं परिमिति (identity) सम्बन्ध अपच्छन्निति (non-contradiction) तुलीयमाराजारथिया एव सुचिति (excluded middle) हि रसमनाशयिपारः—Jayanta, Nyâyamañjarî, प्रसादेशिवभक्तिनम्].

Perception.—The conditions of Perception, and its range and limits, were carefully studied. The minima sensibile (e.g. the minimum visible, the Trasarenu, the just-perceptible mote in the slanting sunbeam), the infra-sensible (चनूमधुर, दृष्टि, sometimes termed चालिमेट्र), the obscured (चाूत, e.g. a meteor in the mid-day blaze), and the potential (चनूहलपृति), 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—Vâchaspati 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.—प्रिियो नामि वन: सम्प्रदाने पिक्स: पेस्थुङ्गे वा। तत वन: पिक्स: पुरुष: खो पेड़े चार्ये जन्युक्तम्। Chakrapāṇi notes: वन: कविन्द। पिक्स: सम्याकारः। पेशी श्रोचानांस्यास्याकारः। चार्ये युगुलोकतम् loc. cit.). In Phonetics (as in the Prātisākhyas, circa 600 B.C.), in Descriptive and Analytical Grammar (as in Pāṇini), and in some important respects in Comparative Grammar (as in Hemachandra's Grammar of the Prākrita
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 Varāhamihira, Śrīpati, 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 दृष्टिकोष. 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.)

*Experiment.*—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 गृह and गुजठ 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, गूं) 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, गूं) and air have no weight. The Hindus appear to have been ignorant of the principle of Archimedes. Vallabhacháryya, in the Lilávatí, 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 (नुस्तेःन, 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 :—वायुनिक्षणम्, र्वं च (बायो:) पृष्ठिनाते गृहम्निप स्थान। न च यठनापुरितस्व समीपत्वादेः प्रपूरणद्वांः
THE POSITIVE SCIENCES OF

चाषियं जनननम्। उद्वीयनानस्य पूणापूरितेन हस्तम् जनेरानिष्ठयं एवं पेत्त
न्। चतुः पूणाद्यायं तथापि गरिमास्योष्टरणनितनिस्वेयस्य चमत्कारे।
—cf. Vallabhachāryya, Lālāvatī—गुहविन्निवेणिप गापाकालापुरुषः
प्रभुपालसापायो तवोत्तक्षणासामायो पतंगक्षणानिन्यो 
अहिंसातीति पेत्त न। अतायस्यलने शिलेन भार्य्यं पतंगमात्रिवर्ण उनम्यन्त 
रत्नां अत्स योग्यक वस्त्रविदेष पतंगमात्रिवर्णसामयो। दूरहेशुभेषिव न
सम्यन्त उम्मफत्त।] Cf. Mathurānātha, अद्वितेयादार्चा on 
Gaṅgeṣa's Tattvachintāmani—तत्त्व (तिंक्तोपलस्य) न सुर्वे
पीतानितिञ्जनां तिष्ठु पीतारा गुहवेल्लास्कारकाल्नेव तत्त्व।

Fallacies of Observation.—Mal-observation and 
Non-observation:—These were carefully studied in 
relation to errors of observation, and hallucination 
(धम, स्मास्य, चारोप), which were ascribed to three 
causes: (a) Dosha, दोष, defect of sense organ, as of 
the eye in jaundice, or of the skin in certain forms of 
leprosy (leading to tactile insensitivity, cf. Suṣrutas), 
or defect of necessary stimulus, e.g. too faint light, 
or undue distance or nearness, in vision; (b) Sam-
prayoga, 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 estab-
lishment of an invariable concomitance (Vyāpti, 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 (साधारणन):—

(1) The probandum, the statement of the proposition to be established (प्रतिनिधिः, साधारणन), *e.g.* yonder mountain is "fiery"; (2) the reason, the ascription of the mark (रेतृ, रेत्वपदेश), *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 (उपपत्ति), *e.g.* yonder mountain's smokes; (5) finally, the conclusion, the probandum proved (सिन्धु), *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 Anumána, it will be seen, anticipates J. S. Mill's analysis of the syllogism as a material inference, but is more comprehensive; for the Hindu Udáharana, 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 (चालम) 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 Chárváka View.—Among the Chárvákas there were two classes, the cruder school of materialists who accepted perception (प्रभाव) as a valid source of knowledge, as well as the reality of natural law (समाय), 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 Nyáyamañjarí to तुनिसितपाणिकाः; also पालिका १ विषय हे व्यत्यास्याम इति प्रतिहार्य प्रतिपादनस्यवत्तात्यात्तवात्यातियन्याच्छात्यात्वकर्षायोकोयमेव व्यत्यात्वात्—अत्निकाः १, माँजारी.

The Chárvákas hold that the principle of causality
which the Buddhists assume to be a ground of an induction (आधार), is itself an induction (a case of Vyápti), which amounts to reasoning in a circle (प्रत्यय); 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 (जनादिपरम्यता), 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 (प्रतिरूप, समावरूपवत्ता, 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 (कारणार्थात्, कारणोत्पत्तिः, 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 Sirsapás 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 (तदात्म, समास—Nyáya-Vindu). To
these two the Buddhists add a third ground of inference, non-perception of the perceptible (चूपज्ञान, 
दुर्बालगतिः), which is employed in inferring the absence (मनिष्य) 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 (सहस्वाभाव) 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, कार्याविषेष) is invariably preceded by a specific cause (कार्याविषेष). 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 Nyāya 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 Nyāya authorities, but this device to obviate the plurality of causes is common to the early Nyāya and the Buddhistic systems.

\[ \text{पृथिवी} \text{ः यथा कार्योऽव मात्रेनान्तरेषाऽः उदाहरणम् —} \]

\[
\text{नेत्रोऽज्ञाते भविष्यति वृहिर्दिता कार्योऽव मात्रेनान्तरेषाऽः कथे पुनर्वस \ प्रयोगः। वृहितत्त्वं रते नेषा: गम्भीरसाधनिन्द्रेषा सति चेतुपल्लायस्य सति \ चुक्तरसाधनिन्द्रेषा सति \ ज्ञाननिद्रेषा सति उदाहरणेषाः।}
\]

\[ \text{श्लेष्यम् (पथ कार्योऽव मात्रेनान्तरेषाऽः) उदाहरणम्} —
\]

\[ \text{उपयोगः पृथिवीवस्त्रार्थम् मन्यित्वं नाधिकारते: शोकने सति पृथिवीवस्त्रार्थम् निवियम्। (Udyotakara, Chap. I., Ānhika I, Sūtra 5.) Vāchaspati puts this clearly:} —
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\[ \text{यथापि कार्यान्तरेषां भविष्यति कार्यान्तरेषां तथापि यादृशं न भविष्यति तथ नियुष्णे प्रतिप्रतिभिः भविष्यतः। सत्यम् पृथिवीवस्त्रार्थमि विभेद्धवस्त्रार्थमि न पृथिवैवस्त्रो गम्बोऽषं । In other words, a single condition called a cause is not invariably succeeded by the effect, nor does the effect-phenomenon in general point to any particular cause as antecedent, for there may be a plurality of causes of a general effect. The skilful observer will therefore select the full complement of causal conditions which is invariably succeeded by the effect, and also the specific effect (e.g. पृथिविश्लेष) which points to a specific causal antecedent. Compare also} \]
Jayanta: “We infer an effect from a specific assemblage of causes”—न ज बारणामारण हेतुः ब्रुमये वेदांस्य वा भिषजः वाचः ||
चाप ज श्रविष्ट्यन बारण हेतुः || न ज बारणाविवेक दुर्योगः ||
गम्भीर-गद्धिशाहार्यमनिर्विलापितम्: रोहितमयंद्वशाहार्यमानिर्विलापितम्: ||
... वृढि वर्धिपत्रिन प्राचूः पिनः || जन्ममुग्धे वै जन्मातनानस्य वा भिषजः
न ज्यावृत्तिनविवेकागारिव वोतुवाक्षिं ||
Similarly, we infer a specific cause from a specific assemblage of effects:—
वेदांस्य ज्ञेकः बारणमारणोऽयः नदीपूरेकः उपरितवर्तेऽदेशे
पुनः पुनः पुनः पुनः शरस्तकः इति नदी ऋणामुकाद्वाराविनिर्विलापितम्
वेदांस्य: यत्यथा ज्यावृत्तिनविवेकागारिव वोतुवाक्षिं || इति तत्वायिनम्
इति स्वयात्—

प्रमादार्थावर्तमानोऽविवेकः यो न यथायतं \nनामात्मानस्य रोपणिक वै वेदांस्यविवेकः।

(Nyāyamaṇḍarī, Āhnika 2, on Gotama Suṭra 5, Āhnika 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 (चन्द्रम) and their agreement in absence (शत्रुरेक) 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 (चद्मिनाच न दशीनार); 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 Vāchaspati's report of the Buddhist doctrine of Inference—स हि प्रतिपवानी न दशीनासावनेव).

तस्मात् तादात्म्यतुपर्तिविनिवेचनं सव प्रतिपवानी। यदाह बायेराङ्गाभाभवाक्षर्वभास्पः सव तस्मात्। चविनधारिनिविनिवेचनाद्वमनाएव न दशीनार्—a Buddhist Kārikā quoted in Vāchaspati, Udayana. Srīharsha, Mādhava, etc.—कायेराङ्गाभाभवाक्षर्वभास्पः सव—चविनधारिनि तस्मात्—वत्सु चरि तस्मात्। चविनधारिनि तस्मात्। न चरिनधारिनः तस्मात्। तस्मात्। (रवि तादात्म्यतुपर्तिविनिवेचनं प्रतिपवानी।... तस्मात् तादात्म्यतुपरिनिवेचनेव प्रतिपवानी।
Váchaspati, Tátparyyatiká, Chap. I., Áhniká 1, Sutra 5, अणुमानसम्बन्धः—आत्मियहोरायः

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 Pañchakāraṇī, 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 Pañchakāraṇī is no sufficient answer to the question with which we started. The Pañchakāraṇī
is only a method; it shows only how in a particular case the relation of cause and effect is to be established (प्रतिपत्ति विद्यमान होपाय). 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 Pañchakārani 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 (चलनविभाजन) 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 (नादालम्ब, समान). It is only when we perceive that the characters of a Sinsapā are co-inherent with the generic characters of a tree in the same individual object (a Sinsapā-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 Sinsapās are trees. For as there is identity of essence, a Sinsapā would not be a Sinsapā if it were not a tree; it would lose its self-identity, which is a contradiction. Hence the relation of identity of essence (नादालम्ब, समान), as in the relation of the species to the genus, is the sole ground for establishing uniformity of co-existence (प्रतिवचन, समानप्रतिवचन).

For the Buddhist Method of Induction in its later form, the Pañchakārāṇi, vide Sarvadarsana Saṅgrahā—Buddhist reply to the Chārvāka attack on Inference:—

यथवचारणे चिन्तनाभावात् तद्भवन्त:। गदाहित्वागुरसाधन्त: चिन्तनाभावपर्यं तद्भवन्त:। तद्भवन्त:—कार्येकार्वमहाबाभवात् या समानप्रतिवचन। चिन्तनाभावाचविभावमत: न दुस्तः॥ As for the Nyāya view, ज्ञेयचिन्तनेऽव चिन्तनाभावाचविभावमत: इति।—the
Buddhist objects: नन्दु पत्रो साम्यशासनगृहचित्तको दूरवचारकः भेदः। भूतस्य, भविष्यास्य वहनाने जनार्क्य नन्दुपल्याणाने भविष्यार्क्याया चिन्तारक्यायाः।—the Nyāya retorts: नन्दु तथाविवरणको तावकरति नन्दु पर्यत्नाया दूरशाहरः।—the Buddhist answers: नन्दु पर्यावरण कार्योथमानुपचारण होते विवाहाः। भावाचायाः भिन्नमां निवृत्तिवात्। नन्दु वि साम्यार्क्य विनिवासायाः नानात्मात्। नन्दुपरिष्ठस्य वाच्यायनो निश्चितवात्। नन्दुपरिष्ठस्य कार्यायनो: प्रवक्तपरंप्राणधार्मय-पवक्तपरंप्राणधार्मय-निवृत्तिवात्। नन्दुपरिष्ठस्य कार्यायनो: प्रवक्तपरंप्राणधार्मय-निवृत्तिवात्। नन्दुपरिष्ठस्य कार्यायनो: प्रवक्तपरंप्राणधार्मय-उपवृत्तिवात्। नन्दुपरिष्ठस्य कार्यायनो: प्रवक्तपरंप्राणधार्मय-उपपरिष्ठस्य कार्यायनो: प्रवक्तपरंप्राणधार्मय-उपवृत्तिवात्। नन्दुपरिष्ठस्य कार्यायनो: प्रवक्तपरंप्राणधार्मय-उपपरिष्ठस्य कार्यायनो: प्रवक्तपरंप्राणधार्मय-उपवृत्तिवात्। नन्दुपरिष्ठस्य कार्यायनो: प्रवक्तपरंप्राणधार्मय-उपपरिष्ठस्य कार्यायनो: प्रवक्तपरंप्राणधार्मय-उपवृत्तिवात्। नन्दुपरिष्ठस्य कार्यायनो: प्रवक्तपरंप्राणधार्मय-उपपरिष्ठस्य कार्यायनो: प्रवक्तपरंप्राणधार्मय-उपवृत्तिवात्। नन्दुपरिष्ठस्य कार्यायनो: प्रवक्तपरंप्राणधार्मय-उपपरिष्ठस्य कार्यायनो: प्रवक्तपरंप्राणधार्मय-उपवृत्तिवात्। नन्दुपरिष्ठस्य कार्यायनो: प्रवक्तपरंप्राणधार्मय-उपपरिष्ठस्य कार्यायनो: प्रवक्तपरंप्राणधार्मय-उपवृत्तिवात्। नन्दुपरिष्ठस्य कार्यायनो: प्रवक्तपरंप्राणधार्मय-उपपरिष्ठस्य कार्यायनो: प्रवक्तपरंप्राणधार्मय-उपवृत्तिवात्। नन्दुपरिष्ठस्य कार्यायनो: प्रवक्तपरंप्राणधार्मय-उपपरिष्ठस्य कार्यायनो: प्रवक्तपरंप्राणधार्मय-उपवृत्तिवात्। नन्दुपरिष्ठस्य कार्यायनो: प्रवक्तपरंप्राणधार्मय-उपपरिष्ठस्य कार्यायनो: प्रवक्तपरंप्राणधार्मय-उपवृत्तिवात्। नन्दुपरिष्ठस्य कार्यायनो: प्रवक्तपरंप्राणधार्मय-उपपरिष्ठस्य कार्यायनो: प्रवक्तपरंप्राणधार्मय-उपवृत्तिवात्।

The Nyāya Doctrine of Inference.—The Nyāya easily demolishes the Buddhist contention about identity of essence. The Nyāya writers, being realists, do not impugn the reality of the genus (जातिः) 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 (चःचार्यारच, i.e. by जनवर्णितेरेकी, द्वैनादेही) 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 Nyāya 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 (प्रक्रिया), or an ultimate form (जातिशीलता), 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 (चन्द्रचापितिविभूषणं निबद्धपूर्वपरिपतिता, being the definition of जातिशीलतांयां). 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 जातिशीलता). 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 Ākāsa (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 (चन्दनात्मक्याकालापथं च जाते देवेष्वर वाक्याकर जो निर्माण न च जाते कथानां) 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 Visvanātha:—निवासपत्यनिनियमानिनिवासपत्यासे च अभावाय: सम्बन्धः वाचास्पति, तत्पर्ययत्तिकाः, Chap. I,
Áhnika 1, Sútra 5. This shows that the doctrine of जन्त्रधारितिसिद्धम् was long anterior to Gaṅgesa).

[Visvanátha in the Bhásha-Parichchheda mentions five kinds of जन्त्रधारितिसिद्ध, conditional antecedents—(1) जन्त्र सहस्रभाष्य; (2) यस्य वा कारकादाय (पूर्णभ्राच; (3) चर्चित्रभाष्याय स्वत: यहुद्विभाषाविज्ञानम्; (4) सन्त्य वै जन्त्रधारितिसिद्ध चारित्रभाष्य यस्य (पूर्णभ्राच) न गृह्ये; and (5) वचार्य यत् नित्यादेशस्मृतिभाष्याभिनिः चारित्रभाष्य भवेत् (स्वत: पवश्य चारित्रभाष्यार्थी—Ślokas 19 and 20), यस्य खालकक्ष जन्त्रधारितिरेवी न स: रिततु खऽचारकादायिन्य जन्त्रधारितिरेवी गृह्ये तद्जन्त्रधारितिसिद्ध—Siddhánta-Muktávali, loc. cit.—The Dinakarí points out that the first two cases are comprehended under the formula इतरजन्त्रधारितिरेवमुक्तायजन्त्रधारितिरेव–जातिसिद्ध। There are several classifications of these irrelevant antecedents (जन्त्रधारितिसिद्ध); I quote one of the best known.]

The unconditional (जन्त्रधारितिसिद्धम्), 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 (परिस्कर्तान न्य म्बो घनिष्ठो घाताः करोऽये—गतिकीद्वीप्युप घाताये नासिः—Jayanta, Mañjarí, Áhnika 1), but would emphatically reject if it is advanced in support of the notion of a mysterious causal power or efficiency (निरप्रत्यक्ष). With the Nyáya all energy is necessarily kinetic. This is a peculiarity of
the Nyāya—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 Sāṅkhya conception of power or productive efficiency as metaphysical or transcendental (चतुर्रत्व), and finding nothing in the cause other than an unconditional invariable complement of operative conditions (कारकसाधन), and nothing in the effect other than the consequent phenomenon which results from the joint operations of the antecedent conditions. (समुदितलस्तकावचनिवर्परिस्माद् द्वारा—Jayanta. सामसी वाचै—सामसीवाचै वु काश्यमात्र विभाजनार्थविशिष्टम् सवा—Jayanta, *ibid.,* Āhnika 1, न्रीविनिराक्षितम्। It may be noted that the Nyāya, while repudiating transcendental power (Śakti) in the mechanism of Nature and natural causation, does not deny the existence of metaphysical conditions like merit (*प्रमे), which constitute a system of moral ends that fulfil themselves in and through the mechanical system and order of Nature—vide Jayanta, चतुर्दृष्टो विभाजि कार्यं कालसमेत भविष्यदि—Āhnika 1, न्रीविनिराक्षितम्।)

The causal relation, then, like the relation of genus to species, is a natural relation of concomitance (शांबके: समयः—Vāchaspati) 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 Pañchakārani. 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 (विभ्राच) 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 (अवाच) 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 (कालाधिपत्त), 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 invarableness 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 Chārvāka sceptics) can be urged against this ascertainment of universal invariable and unconditional concomitance (ध्यात्मकसहित्यons) 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 (उत्तरपति and नाटाक). Ultimately we all have to fall back on the rational practice of thinking persons (च्यादाक्षय), and such persons are always content to act on practical certitude instead of hankering after an unattainable apodictic certainty in the affairs of life (सन्तुष्टि अवभावमयता अचिंतने वैविध्यमयाः). 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 Vāchaspati, of the Nyāya school, pertinently and acutely object as follows:—]

सबे यह रिकार्तु छाँगत हृद्वेत तस्य श्राव प्रतितिष्ठा। तत्तदेः तस्य तत् गम्बर रच इति जन्मानीमः। स दश तु प्रतितिष्ठा न तापति तदपेता सम्भवितः। त्वा पुनर्वेति तदपेता। स्वात्त् विष चृयन्नमयार्थ भावः। स तारुः चाँतिर राजभयायि। त्वात्रिविवृणां धृती। स्वात्त् विष चाँति राजभयायि। चाँति तदंतरेष्य भावः। न च राजभयादिर भविष्य तद्नायवेश्य भवति, तत्तदेः सति चाँति वासि गर्नें तद्भावात्। चाँति चाँति तत्तदेः वासि गर्नें वहीं तद्भावात्। चाँति चाँति धृती विष्णुभावातुविचाराम तनोयवेश्य, तनाविरे दैवविष्णुरेष्य तद्भावोऽयस्मात्। चाँति चाँति धृती विष्णुभावातुविचाराम तनोयवेश्य, तनाविरे दैवविष्णुरेष्य तद्भावोऽयस्मात्। चाँति चाँति धृती विष्णुभावातुविचाराम तनोयवेश्य, तनाविरे दैवविष्णुरेष्य तद्भावोऽयस्मात्। चाँति चाँति धृती विष्णुभावातुविचाराम तनोयवेश्य, तनाविरे दैवविष्णुरेष्य तद्भावोऽयस्मात्। चाँति चाँति धृती विष्णुभावातुविचाराम तनोयवेश्य, तनाविरे दैवविष्णुरेष्य तद्भावोऽयस्मात्। चाँति चाँति धृती विष्णुभावातुविचाराम तनोयवेश्य, तनाविरे दैवविष्णुरेष्य तद्भावोऽयस्मात्। चाँति चाँति धृती विष्णुभावातुविचाराम तनोयवेश्य, तनाविरे दैवविष्णुरेष्य तद्भावोऽयस्मात्।
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Buddhist reply: — स्वादेशु। यो यो भूमिदृकः। स सहीतः। चापृथवितादिह वध्यनसरस्य न पियारानार्य। स च चाद्वित्तापि चिन्नविशेषनाको चायनरस्य नयते सदेह सत्याचार्यविभारं निमित्तं करोति, न हु चापृथवितादिह चायनार्य। नापि सहितः चापृथवितादिह नायन्तरं वध्यनसरस्य न पियारानार्य। चार्यो चेतः अन्य चापृथवितादिह नायन्तरं चायनार्य। नापि चापृथवितादिह नायन्तरं चायनार्य। न यदि न चापृथवितादिह नायन्तरं चायनार्य। नापि चापृथवितादिह नायन्तरं चायनार्य। नापि चापृथवितादिह नायन्तरं चायनार्य। न चापृथवितादिह नायन्तरं चायनार्य। नापि चापृथवितादिह नायन्तरं चायनार्य। नापि चापृथवितादिह नायन्तरं चायनार्य। नापि चापृथवितादिह नायन्तरं चायनार्य। नापि चापृथवितादिह नायन्तरं चायनार्य। नापि चापृथवितादिह नायन्तरं चायनार्य। नापि चापृथवितादिह नायन्तरं चायनार्य। नापि चापृथवितादिह नायन्तरं चायनार्य। नापि चापृथवितादिह नायन्तरं चायनार्य। नापि चापृथवितादिह नायन्तरं चायनार्य। नापि चापृथवितादिह नायन्तरं चायनार्य। नापि चापृथवितादिह नायन्तरं चायनार्य। नापि चापृथवितादिह नायन्तरं चायनार्य। नापि चापृथवितादिह नायन्तरं चायनार्य। नापि चापृथवितादिह नायन्तरं चायनार्य। नापि चापृथवितादिह नायन्तरं चायनार्य। नापि चापृथवितादिह नायन्तरं चायनार्य। नापि चापृथवितादिह नायन्तरं चायनार्य। नापि चापृथवितादिह नायन्तरं चायनार्य। नापि चापृथवितादिह नायन्तरं चायनार्य। नापि चापृथवितादिह नायन्तरं चायनार्य। नापि चापृथवितादिह नायन्तरं चायनार्य। नापि चापृथवितादिह नायन्तरं चायनार्य। नापि चापृथवितादिह नायन्तरं चायनार्य। नापि चापृथवितादिह नायन्तरं चायनार्य। नापि चापृथवितादिह नायन्तरं चायनार्य। नापि चापृथवितादिह नायन्तरं चायनार्य। नापि चापृथवितादिह नायन्तरं चायनार्य। नापि चापृथवितादिह नायन्तरं चायनार्य। नापि चापृथवितादिह नायन्तरं चायनार्य। नापि चापृ�
The Nyāya 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.

The Nyāya Analysis of the Causal Relation continued: Co-effects.—In the enumeration of different varieties of irrelevant antecedents (चन्द्रानिस्क), 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 Pārtha-sārathi Misra on Kumārilā, Śloka-Vārtika—इन्द्रनासारिस्य । वनारकारण । वनारकारण ।—Śloka 157, Śūnyavāda). 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 (उष्णा), which disturbs the elements, viz. the earth and the atmosphere (महाभूमि); the ants being affected by this heat earlier than the atmospheric movements which bring the clouds and the rain.

(Udyotakara and Váchaspati: न च विपोषित्वाक्षरं सर्वं वैद्यमाणं वारसं भारस्तु गुप्तवमानं सर्वं वैद्यमाणं। चलनं गतिः सत्त्वं च वैद्यमाणं। चलनं गतिः सत्त्वं च वैद्यमाणं। चलनं गतिः सत्त्वं च वैद्यमाणं। चलनं गतिः सत्त्वं च वैद्यमाणं। चलनं गतिः सत्त्वं च वैद्यमाणं। चलनं गतिः सत्त्वं च वैद्यमाणं। चलनं गतिः सत्त्वं च वैद्यमाणं। चलनं गतिः सत्त्वं च वैद्यमाणं। चलनं गतिः सत्त्वं च वैद्यमाणं। चलनं गतिः सत्त्वं च वैद्यमाणं। चलनं गतिः सत्त्वं च वैद्यमाणं। चलनं गतिः सत्त्वं च वैद्यमाणं। चलनं गतिः सत्त्वं च वैद्यमाणं। चलनं गतिः सत्त्वं च वैद्यमाणं। चलनं गतिः सत्त्वं च वैद्यमाणं। चलनं गतिः सत्त्वं च वैद्यमाणं। चलनं गतिः सत्त्वं च वैद्यमाणं। चलनं गतिः सत्त्वं च वैद्यमाणं। चलनं गतिः सत्त्वं च वैद्यमाणं। चलनं गतिः सत्त्वं च वैद्यमाणं। चलनं गतिः सत्त्वं च वैद्यमाणं। चलनं गतिः सत्त्वं च वैद्यमाणं। चलनं गतिः सत्त्वं च वैद्यमाणं। चलनं गतिः सत्त्वं च वै�्यमाणं। चलनं गतिः सत्त्वं च वैद्यमाणं।

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 (दूरस्तबाल) to be apprehended (देवप्रामाण्य), 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—हेतुस्तुतेन्तो विद्यमाणं शीर्षमाणिदिनेत्रं,—यथा प्रदीपम्याहुते, दूसःकल्याणसि तत्स्न:। न तुवृज्जलः स्वतः वेशः नस्तं प्रवत्तम्यते 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, Kshana, खशन) 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 (सिभार्यनुकाश्यशास्त्रानुसार मानान्व—
सम्प्रवचनान्विन्हः काठ: खशनः—Śapta-Padártih, Śiváditya—
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 Sāńkhya, we have already seen, determines this ultimate unit by reference to the motion of a Tanmátra.

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 Sāńkhya 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 Vyápti to the principle of Causality.

**The Nyáya Ground of Inference—Vyápti चिन्तामणि.**

—Inference, then, in the Nyáya, 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 (प्रतिविरुधः तथाविकः संवयः अधिकः—Udyotakara and Vāchaspāti). Of the two phenomena so connected, one is called the Vyāpya or Gamaka (the sign, mark, or indicator), and the other Vyāpaka or Gamya (the thing signified, marked, or indicated). In the relation of fire and smoke, for example, smoke is the Vyāpya or Gamaka (sign or mark); and fire, the Vyāpaka or Gamya (the thing signified or marked). Now the relation of Vyāpti between $A$ and $B$ may be either unequal or equipollent (दिशासार्थि or यथागति). When $A$ is the sign of $B$, but $B$ is not the sign of $A$, the Vyāpti is one-sided or unequal, and here a Vyāpti 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 Vyāpti is an unequal one, as between smoke and fire, it is expressed in the proposition—Wherever the Vyāpya (sign or mark, e.g. smoke) exists, the Vyāpaka (the thing signified or marked, e.g. fire) also exists. From this it follows by necessary implication (a sort of अवेदनच) that whenever the Vyāpaka (e.g. fire) is absent, the Vyāpya (e.g. smoke) is also absent (उपवेदनच अवेदनच). Again, the Vyāpti 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 Vyāpya and Vyāpaka, 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 Vyāpti exists between smoke and fire, for wherever there is smoke there is fire, but we cannot say that a Vyāpti exists between fire and smoke, for we cannot say that wherever there is a fire there is smoke. The combustion of an iron ball (चनोगोलब्ब), for example, is a case of fire without smoke. But it would be correct to say that a Vyāpti 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 Vyāpti implies unconditional invariable concomitance, and the relation between fire and smoke is not therefore a Vyāpti (natural unconditional concomitance), for fire requires a "condition," Upādhi, 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 Upādhi, and (2) Vyāpti, or unconditional invariable relation, between a mark and that which it marks, a relation without any Upādhi or determining condition (उपाधिविपु: सम्बन्ध:). 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.

Asscertainment of Vyápti according to the early
Nyáya (्यात्मिकोपाय).—Briefly speaking, the observation
of agreement in presence (चबय) as well as agreement
in absence (चाविरेक) between two phenomena, with the
non-observation of the contrary (चिव्याराद्विनम्), is the
foundation of our knowledge of Vyápti (द्विनाद्विने
—Váchaspati). This suggests a natural relation
(चावाधिप्रवचन्न—Váchaspati) of invariable concomitance
(स्वतांत्यार्थ्य—Váchaspati) between the phenomena, which
is fortified by our non-observation (द्विन) of the
contrary (चिव्यार). But this does not establish the
unconditionality of the concomitance (चावाधिप्रवचन्न),
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 accom-
paniment) which conditions the relation between the
supposed sign or mark (Gamaka) and the supposed
signate (thing signified, Gamya). 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,
Gamya), 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 (जड्डतोपायि) 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 (धरोषव, मेघावान). When doubt overthrows the foundation of all rational practice (प्रानाज्ञातहोरूपण्य), or leads to a stoppage or arrest of all practical activity (होक्षपहार), it stands ipso facto condemned, and must be abandoned (आभागविचारः—Śrīharsha and Udayana; अभाबः is mentioned by Váchaspati). 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 (भूयोद्देश) we have established the principle of the Uniformity of Nature (समाबधमिरत्व), 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 (भूयोद्धान) and the ascertainment of innumerable particular inductions of uniformity or causality (भूयोद्धानगतसंस्कारसहितम् इत्ययथ वामार्थसम्यक्याति—Váchaspati). Thus Tarka also helps in dispelling doubt (सन्दहैं). Śrīharsha, however, questions the validity of this verification—cf. the well-known couplet ending तर्कः ज्ञात्वः स्वतः।

It will be seen that the process of disproving all suspected Upádhis (व्यांविष्णवानितरास), 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 (चन्द्र), even in the absence of the Upádhi, fortified as this is by the instances of agreement in absence (अभिरूचि), 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 (व्यांविष्णवानितरास)
into the relation of Vyāpti (Concomitance), even as the same mark of unconditionality (अब्धप्यतिसत्त्वम्) had been previously introduced into the definition of Causality (शास्त्रविद्यार्थिनश्च). The difference between the early Nyāya 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 Vyāpti, 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 Nyāya:—

(a) Method of Agreement and the Joint Method without the device of the Upādhi:—

Cf. Jayanta on शास्त्रन्त्य—तस्मन् समेच भवने न पिना भवन्
ततः। चतुर्दशाविनानावयो निन्यनः सहचारिता। ‘तस्मन् समेच,’ ‘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):—चतुर्दशाविनानावयो निन्यनः सति भवने ततो यथा न भवने इति भूसोदेशायम्। तद्भ
तस्मन् सति भवने इस्तव्यसात्माश्चर्क्कोटमेवाद् नागृहीतो निन्यनः स्वाह। ततो
(b) Doctrine of the Upádhi: unconditional concomitance distinguished from conditional:—

यो या न या चशु सम्वन्धः यस्य चतौ स्थानोऽध्याविको नियतः स द्वयङ्गचः,
गम्याचा इत्यतः स्वस्मीति युज्यते। तथा हि धृतादेशाः वा नादिसम्बन: स्थाना-
विहः। नतु वहृत्यादेशाः धृतादिभिः। उपवयाने से हि नियतिः धृतादिभिः।
यदाः सार्वभुग्नादिसम्बन: गुणभविः तदा धृतादिभिः नह संबन्धने। प्रलाभे
हृत्यादेशाः सार्वभुग्नाद्भाविकृत: सम्बन्धो न स्थानोऽध्याविकः। ततो न नियतः।
स्थानाविवलु धृतादेशाः सनादिसम्बन्धः उपयें भुनुषुभेशानातः लविन्त भविष्य-
पारस्तः बहुदेशाः भुनुषुभेशानातः वहनावयानोऽध्याविकः। चतो नियतः स्थानः
अनुनादायुः।

(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 Nyāya 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 Nyāya then proceeds to show how an Upádhi is established, or how disproved by observation:—

सि या:धृतेऽवनस्य चित्ता पूण्यो धृतोऽवकोपार्थी दक्षिणातः शार्वेवायोधः
यस्य यूनोऽध्याविकः। न यु धृताविद्या इति निचिदा:। पूण्यविद्येष्वस् हि चित्ता
वष्टिन्तः भुनुषुभेशाः, उपवयाने दस्यं भुनुषुभेशानस्य बहरानायं प्रवाहाभावाम्,
विविष्यस्त्वभावस्य श शान्तस्य भुनुषुभेशान्यं भुनुषुभेशाम्, वहनायं श चतिः-
प्रवाहाम् प्रदशाः प्रनुषुभेशाः। स्थानाविकः: स्मं: प्रत्याविकः।

(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: चर्चा प्रकाशणे या साध्यसत्यार्थ: उच्चते स उपाधिरूपम्।
Hence, to avoid an Upádhi (which is साध्यसत्यार्थः), the constant presence of anything relevant other than the sign and the signate in the positive instances (of agreement in presence, चर्चा), and the constant absence of any such thing in the negative instances (of agreement in absence, अनिलेक) must be safeguarded against. This amounts to Mill's Joint Method.

(f) Suspicion of non-perceptible Upádhi—Limits of legitimate doubt:

न च चर्चा प्रकाशणे दृष्ट्यान् मृत्युः साध्यसत्यार्थार्थेन सैद्धं सम्बन्धः अंतः च अधिकारं प्रतिपद्ध्यादि हि सान्तत:।
चर्चा प्रकाशणे अभिविक्षेपं नियमसत्यसत्यार्थार्थेन सैद्धं सम्बन्धः अतः च अधिकारं प्रतिपद्ध्यादि।
चर्चा प्रकाशणे अभिविक्षेपं नियमसत्यसत्यार्थेन सैद्धं सम्बन्धः अतः च अधिकारं प्रतिपद्ध्यादि।

(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 (सत्यसत्यसम्बन्धः), as well as in the principle of Causality (सत्यसत्यसम्बन्धः), is generated in the mind, a belief which has evidential value and validity. It is not
intuition (न मानन) but a mental pre-disposition based on uniform and uninterrupted experience (भूयोद्योगमनित-संस्कारसहितम् इत्यादे खानाहिकसम्यवाहे—यथा भूयोद्योगम् चताधारकम्
इति प्रमादानां भास्म्). 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 cir-
stances, 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 cir-
stances 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 (तबो, तजः)
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.—सामाजतत्त्र धार्मिकरा देव: खसाधेन, यदि
साधनसत्त्राय भवेन: खसाधेन प्रच्छेरित्तित तत्वसहित: चनिनसाध्वाहित—
रेव दृष्टिश्वेति व दृष्टि चसाध्व राधानं स्पोष्यन हाने।—Váchaspati, I.,
1, Sútra 5; cf. also I., 1, Sútra 40: तजः वारकारोकपक्षा
सम्भवेन हाने। काराभास्मचे ब्यायेस्य चताधानः।

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
(सदृष्टिस्त) nor under Identity of Essence (तादायः).
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.

_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 (कारकसमग्र)
and the sum of effects (कायपेदावली). For example, fire requires green-wood to complete the sum of causal conditions to give rise to smoke with some particular marks (प्रमिस्थोपत्तममार्गादिशसे दिशाः, Jayanta, II.; compare Gaṅgesa, पुज्याबधमभवस्थनान्य मयुक्तार्धर्मानयं नयुक्तार्धर्मानयं सिद्धांसि। —Chintámání, Anumana, Viruddha-Siddhánta). Here, between an effect and a single condition (termed a cause) there is a relation of Vyápti. The effect is Vyápya or Gamaka (the sign or mark); the cause (or condition) is Vyápaka or Gamya (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 Vyápti 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 (नामेवेल्हलक्ष or नामेभेद indicating नामेवेल्हलक्ष or नामेभेद). 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)—कारणपैमाबार् कारणपैमाबम्। But the Nyāya 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 Nyāya as well as of the Buddhists, as we have seen; but the later Nyāya 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 Vyāpya) of any one of the causes in particular. Accordingly, some adherents of the later Nyāya 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 Vyāpya) 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 (कार्यात्मक), we are told that it is one-or-otherwise (समानता), 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 (धातिलक्ष्ण), or a common "form" (धातिलक्ष्ण), which accounts for the production of a common effect. The latter is therefore a sign or mark of this power (शक्ति) or this form (धातिलक्ष्ण), which is manifested by each of the causal aggregates. This hypothesis (विभाषा), they hold, is simpler and more plausible than the hypothesis of specific differences latent in the apparently identical effect of a plurality of causes (कार्यविभाषाः कामेर्च्यानतः).

Cf. Dinakari on the Siddhānta-Muktavali: केवलु वर्ति नवश्चारसंस्थानासंगाते नवश्चारसंज्ञानावस्थेष्य कारणस्ता वापरिस्णेत्य सबभवात् धातिलक्ष्णबिलक्ष्णः। न च नवश्चारसंगाते वर्ती नवश्चारसंज्ञानावस्थेष्य कारणस्ता वापरिस्णेत्य सबभवात् धातिलक्ष्णबिलक्ष्णः। न च नवश्चारसंगाते राज्यादिकर्मणां सम्बन्धस्य सम्बन्धस्य राज्यादिकर्मणां सम्बन्धस्य राज्यादिकर्मणां सम्बन्धस्य राज्यादिकर्मणां सम्बन्धस्य राज्यादिकर्मणां सम्बन्धस्य। तत्रतस्मात्स्वदेशसंपादनार्थ राज्यादिकर्मणेऽर्थात्यब्धात्यविनिमयप्रस्त्वतः तत्सम्बन्धस्य राज्यादिकर्मणेऽर्थात्यब्धात्यविनिमयप्रस्त्वतः तत्सम्बन्धस्य राज्यादिकर्मणेऽर्थात्यब्धात्यविनिमयप्रस्त्वतः तत्सम्बन्धस्य राज्यादिकर्मणेऽर्थात्यब्धात्यविनिमयप्रस्त्वतः। तत्र च सम्बन्धस्य वार्मात्मकाभावतु।...चरु रु पुरुषार्धसम्बन्धार्थिनार्थसंगातेऽर्थात्यब्धात्यविनिमयप्रस्त्वतः चरु रु पुरुषार्धसम्बन्धार्थिनार्थसंगातेऽर्थात्यब्धात्यविनिमयप्रस्त्वतः।...स्लोक 2; cf. also, गुर्जाराविनिमयस्य स्वरूपत्वादिकर्मणे विनिमयार्थात्यब्धात्यविनिमयप्रस्त्वतः।

Cf. Udayana, Kusumāṇjali, Stavaka 1: कर्थ ताह्य गुर्जाराविनिमयाऽर्थात्यब्धात्यविनिमयस्य स्वरूपत्वादिकर्मणे। राज्यादिकर्मणेऽर्थात्यब्धात्यविनिमयाऽर्थात्यब्धात्यविनिमयस्य।...स्लोक 2 गुर्जाराविनिमयाऽर्थात्यब्धात्यविनिमयस्य।...स्लोक 2 गुर्जाराविनिमयाऽर्थात्यब्धात्यविनिमयस्य।...स्लोक 2 गुर्जाराविनिमयाऽर्थात्यब्धात्यविनिमयस्य।...स्लोक 2 गुर्जाराविनिमयाऽर्थात्यब्धात्यविनिमयस्य।...स्लोक 2 गुर्जाराविनिमयाऽर्थात्यब्धात्यविनिमयस्य।...स्लोक 2 गुर्जाराविनिमयाऽर्थात्यब्धात्यविनिमयस्य।...स्लोक 2 गुर्जाराविनिमयाऽर्थात्यब्धात्यविनिमयस्य।...स्लोक 2 गुर्जाराविनिमयाऽर्थात्यब्धात्यविनिमयस्य।...स्लोक 2 गुर्जाराविनिमयाऽर्थात्यब्धात्यविनिमयस्य।...स्लोक 2 गुर्जाराविनिमयाऽर्थात्यब्धात्यविनिमयस्य।...स्लोक 2 गुर्जाराविनिमयाऽर्थात्यब्धात्यविनिमयस्य।...स्लोक 2 गुर्जाराविनिमयाऽर्थात्यब्धात्यविनिमयस्य।...स्लोक 2 गुर्जाराविनिमयाऽर्थात्यब्धात्यविनिमयस्य।...स्लोक 2 गुर्जाराविनिमयाऽर्थात्यब्धात्यविनिमयस्य।...स्लोक 2 गुर्जाराविनिमयाऽर्थात्यब्धात्यविनिमयस्य।...स्लोक 2 गुर्जाराविनिमयाऽर्थात्यब्धात्यविनिमयस्य।...स्लोक 2 गुर्जाराविनिमयाऽर्थात्यब्धात्यविनिमयस्य।...स्लोक 2 गुर्जाराविनिमयाऽर्थात्यब्धात्यविनिमयस्य।...स्लोक 2 गुर्जाराविनिमयाऽर्थात्यब्धात्यविनिमयस्य।...स्लोक 2 गुर्जाराविनिमयाऽर्थात्यब्धात्यविनिमयस्य।...स्लोक 2 गुर्जाराविनिमयाऽर्थात्यब्धात्यविनिमयस्य।...
The scientific Methods already noticed—the Joint Method of Difference (the Pañchakārāṇi) and the Joint Method of Agreement (Vpāptigrāha with Upādhisanākā-nirasa and Tarka)—are not the only methods of ascertaining causality or concomitance, or establishing a theory (विज्ञान); nor are these Methods always practicable. Very often we reach the explanation of a fact (प्रकाश) by means of a hypothesis (खण्डन) properly tested and verified (निर्देश). A legitimate hypothesis must satisfy the following conditions:—(1) the hypothesis must explain the facts (दृशिति or उपपति); (2) the hypothesis must not be in conflict with any observed facts or established generalisations (दृशियते वि चयुवं वस्तुः, न दृश्यविषय—Jayanta, Nyāya-\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\\---ibid.)}; (4) when two rival hypotheses are in the field, a crucial fact or test (पिनिगमन, ratio sufficiens) is necessary; the absence of such a test (पिनिगमनायर्जन) 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 (खण्डनार्थ वersus खण्डनार्थ); (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 (प्रकृतोपकृतपत्र); (7) a hypothesis that satisfies the above conditions must be capable of verification (निर्देश) before it can be established as a theory (विज्ञान). 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, निष्क्रिय—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 (Vijñāna) or philosophical (Jñāna) (तोड़े पीड़ानम् स्माद विज्ञान प्रस्तावताखानोऽ, 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 स्वपन) or descriptions (by वणलक्ष); and (3) examination and verification (यरििा and निष्क्रिय). Ordinarily the first step, Uddesa, is held to include not mere Enumeration of topics, but Classification or Division proper (सिभाग: उहेङ्यकाशायपापापु उहेङ्य स्वाली | सामान्यसेंग्या कोषेनचुदेष्वा प्रबार्तेदसंहया कोरेन विभाग इति—Jayanta, Mañjari); 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 Pramanás, 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 (सत्यअवलोकन). And the Scientific Methods are merely ancillary to these Pramāṇas 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 Nyāya (न्यायविद्या), which, in spite of its arid dialectics, possesses a three-fold significance in the history of thought: (1) logical, in its conceptions of Avachchhedaka 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 Vyāpti and Upādhi (and of ज्ञानसाधन), 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, Vimánaśthána, 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? Patanjali answers that this is done by an instinctive use (cf. Vachaspati’s भूयोद्वैभविन्यितुस्कारस्य स्नित्वम्) of the Joint Method of Difference (combined Addition and Subtraction), fortified by the Joint Method of Agreement (चत्वारिश्चित्रिते). Patanjali 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—ह्रीयते); 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—उष्णायते); and
that Ati, which is the only "common antecedent" (अन्त्य), is the invariable concomitant of "one agent," which is the only common "consequent" (अन्य). 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 (चन्द्रयाबीरेश्वरी). 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 (चन्द्रयाबीरेश्वरी) 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 हीवते and उपजावते); 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 Prakriti 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.

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 (कर्तव्य साधनम्), end (नित्य), origin (तत्त्व), limit (चालन), substance (पद्ध), 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 (स्थानसम्बन्ध), of causality (कार्यावस्थेकप्रभाव), of inherence (समप्रभाव), of co-inherence (सामान्यविक्रियाप्रभाव), of substance and attribute (विशेषविचित्रप्रभाव), of the sign and the signate (संकायकप्रभाव), of mutual dependence (ग्रहणारण्य)—an entire grammatical (and philological) apparatus, which will serve as a point d'appui for generations of philologists and grammarians to come.