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 (युगविवेचनम् yuga-vivechana). But even this is real only for our empirical (relative) consciousness (अनुस्थितत्वम् anusuchitavatmam), which intuits the relation of antecedence and sequence into the evolving Reals (Gunas), in the stage of ‘empirical intuition’ (भविष्यति निर्विभावयता). The ‘intellectual intuition’ (विभिन्नतप्रयतन्) on the other hand, apprehends the Reals as they are, without the empirical imported 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 (मूल्य) regarded as the unit of change in the phenomenal or causal series (पञ्चाशुक्ल) or वृत्तार्थार्थवेण बलवत्वनाद—शीर्षादिक, Sutra 51, Pada III). Spatial position (Dik) results only from the different relations in which the all-pervasive A'kāsa stands to the various finite (or bounded) objects. On the other hand, Space as extension or locus of a finite body, Desa (रेष: दिशावार:), has an ultimate unit, being analysable into the infinitesimal extensive quantity inherent in the Reals (Gunas) of Prakṛiti. (गुणप्रकटि-रसपरिषान:—शीर्षादिक: पृथिवी दिनपित विभाग्यको आक्षारता, आमार्थी निद्याध्यायारामारामारा। पुर्यादिभावहारन हिगुपाध्यायको सम्बन्धात् आमार्थी: काफिलुद्धारासंकायिन आक्षारादिव तदुपपतिः। कालात दिनकार विषिव: गन्त बाह्य: चरणप्रण प्रबरते, दिनकु त समयात वेषते।

The Casual 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. (काल्यिकारपार्थाशालामो: ज्योतिर्दासाम्—शीर्षादिक, Sutra 51, Pada III).
The dissipation of Energy (and of Mass)—their dissolution into the formless Prakṛiti:—Cosmic Evolution (परिप्रेक्ष्य) is a two-fold process, creative as well as destructive, dissimilative as well as assimilative, katabolic as well as anabolic (वशुवनिःसर्ग and विद्युवनिःसर्ग, विद्युतविद्युतपरिप्रेक्ष्य and शवश्वपरिप्रेक्ष्य). 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 (विद्युतिर्विद्युत, विद्युतिर्विद्युतमभवं, विद्युतिर्विद्युतमभवं) in what is essentially an incoherent indeterminate homogeneous whole (भविक). 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 (शंगपरिबाच), 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 sublatent, 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 Prakṛiti, its unknowable source and ground (साक्ष्य and बौधेन).

The Evolution of matter (साक्ष्यविश कमि) :-

The ultimate constitution of Matter is a question of the profoundest interest in the Sāṅkhya-Pātañ-
jala 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 (सूतादि—
नामात्रारूपम्), (2) The infra-atomic unit potentials,
charged with different kinds of Energy, which re-
sult from the action of Energy on the original units
of Mass, (लक्ष्मा), and (3) the five different classes
of atoms, the minutest divisions of which gross
matter is capable, but which are themselves complex
Tanmātric systems (तन्मत्रस्यपरनामः).

The first stadium Bhūtādi is absolutely homogene-
ous and absolutely inert, being devoid of all physi-
cal and chemical characters (क्यादिमिरच्यून) except
quantum or mass (परिणिष्ठव, परिसारः); and this
admits neither of addition nor of subtraction,
can neither be created nor destroyed. The second
stadium Tanmātra represents subtle matter, vibra-
tory, impinging, radiant, etc., instinct with potential
energy. These potentials arise from the unequal
aggregation of the original mass-units in differ-
ent proportions and collocations with an unequal
distribution of the original Energy (Rajas). (लक्ष्मा
वादी: यदि कार्यमुदित चेत खाकार्यक्रमायां गृहाभिनिपातेन अयोभ
प्रति वायुनिष्ठस्य परादिना भविष्यस्यादिष्य च युक्त:)
The Tanmātras possess something more than
quantum of Mass and Energy. They possess
physical characters, some of them penetrability
(शब्दावली), 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 subtle matter they are devoid of the peculiar forms (विशेष) which these potentials assume in particles of gross matter like the atoms and their aggregates. In other words, the potentials lodged in subtle matter must undergo peculiar transformations by new groupings or collocations to be classed among sensory stimuli,—gross matter being supposed to be matter endowed with properties of the class of sensory stimuli, though in the minutest particles thereof the sensory stimuli may be infra-sensible (चरीक्षय बुद्धिस्ति), (बचेत्वाकंतु लक्ष्यः)। ते च पदार्थः प्राचार्यतः प्राचार्यःः श्रुतिभेतः सदन्तः महादिविभिषेषः यथा एकधर्मान। तथा च मानादिविभिषेषसहस्त्रिति नातितिथ्य कुमारास महादिविभिषेषः।

The Tanmātras, then, are infraatomic particles charged with specific potential energies,—first, the potential of the sound stimulus is lodged in one class of particles, Tanmātras which possess the physical energy of vibration (परिवर्त) and serve to form the radicle of the ether atom (शास्त्रमहानाष्ठ), 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 gas atom (Váyu Paramánu); —next, the potential of the colour stimulus is lodged in a third class of Tanmátrás, 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 Tanmátrás, 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 Tanmátrás, 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.

HINDU CHEMISTRY

चक्षुबिशेषः तपशा महद्यकाञ्च आर्यस्वमां दण्डकाञ्च मस्तक्काञ्च सम्बन्धस्य दार्शीचित्रितं कुक्षिपुष्टिका: प्रदेशेण प्रदिशिष्टः । आवस्मां, Sutra 19 Pada II महद्यकाञ्च महद्यकाञ्च सम्बन्धस्य दार्शीचित्रितं कुक्षिपुष्टिका: संवयो यथा संरक्षितः एवंस्मिर एकाकुशिता तपशाय तस्यसे ( विश्लेषणाय—Sutra 62, Chap. I ).

महद्यकाञ्च मूर्तिमाज्ञानीयोऽगः परिवामः प्रविष्टपरिकाष्ठः तपशाय: । भूताकरणम् श्रव श्रेतीयाः श्रवयात्निस्तादेशः चवादय वानांमु एकविद्यार्थ्यः समायितः । ( आवस्मां, Sutra 14. Pada IV.) तपशा: महद्यकाञ्च वानांमु एकविद्यार्थ्यः उष्णायतीश्चादान्
Before explaining the genesis of atoms, it is necessary to say something about A’kása, which is the link between the infra-atomic particles (Tanmátras), and atoms (Paramánus). A’kása corresponds, in some respects to the ether of the physicists and in others to what may be called proto-atom (protyle). In one respect A’kása is all-pervasive (मध्य), and devoid of the property of impenetrability which characterises even the infra-atomic potential units (Tanmátras), In another aspect, A’kása is described as having originated out of the mass or inertia in Prakrití (Bhútádi) when the latter became charged with the first potential vibration (the sound-potential). Vijñána-bhiksnu in the Yoga-Vártika boldly tackles the difficulty. A’kása, he explains, has two forms, original and derivative, non-atomic and atomic. The original A’kása is the undifferentiated formless Tamas (mass in Prakrití, matter-rudiment—Bhútádi) which is devoid of all potentials, and is merely the all-pervasive seat or vehicle of the ubiquitous original Energy (Rajas). This A’kása
must not be confounded with vacuum, which is merely negative (आखर्यांक—un-occupiedness), though it must be conceived as all pervasive, occupying the same space as the various forms of gross matter (अज्ञानशर्म—अज्ञानशर्म—अयािक्ष—यथासंविष), and therefore devoid of the property of impenetrability (वृद्धिश्चल—यथासंविष) which characterises atomic matter. But when the original equilibrium (सामान्यता) comes to an end, unequal aggregations form collocations in different groups and proportions of the three Gunas (यस्ते अश्वस्वप्नात्मकं शरणं संधि, शंकरं—विष्णुस्वप्न, प्रतीतम्य एव यथासंविष). The transformation of Energy now begins,—working on a collocation of mass (with Essence) (यथार्थीयीय—सम्बन्धसंधि, संधिसंधि—विष्णुस्वप्न, यथासंविष); it first gives rise to the sound potential (समस्याभासविश्वसंधि—विष्णुस्वप्न एव यथासंविष) and the atomic A’kāsa (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 (आखर्यांक) is integrated, limited (परिभक्त) and as such cannot occupy the same space with other (subsequently integrated) atoms. But this proto-atomic integration of A’kāsa (आखर्यांक) is formed everywhere, and itself residing in the ubiquitous non-atomic A’kāsa (आखर्यांक—अयािक्ष—अयािक्ष) forms the universal medium in which air or gas atoms, light and heat corpuscles, and other atoms move and float about. (आयुर्विक्ष) यदि हि अवबिश्वसंधि ‘आयुर्विक्ष
The genesis of the infra-atomic unit-potentials (Tanmātras) and of the atoms.

The subject of the genesis and the structure of the Tanmātras and the Paramāṇus 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 Purāṇa, Parāśara, Patañjali and a certain School of Vedantists reported in the Tattvābhidhā.

1. A famous passage in the Vishnu Purāṇa explains the genesis and the structure of the Tanmātras and of the Bhūtas (Paramāṇus) in the following manner:—

The first Tanmātra originated from the rudiment-matter (Bhūtādi), the individuated but still indeterminate potential-less Mass in Prakṛiti under the action of Energy (धर्मपद: परभस्यमण्डलमपयम: Sutra 66, Ch. I.) by a process of disintegration and emanation (विभवमं: विभवमण्डलमाय: विभवमाय: Sutra 14. Pada IV. विभवमाय: विभवमण्डलामाय: आधिपत्या चति.,
याबल, बोगबारिंक on Patañjali's Sutra.—सनीयदिविविकरणभाव: etc.) in the menstruum, or surrounding medium of the unindividuated Cosmic Mass (Mahat) (सचेष तानत:).

This first subtle matter, the first result of ‘Mass disintegration’ and Energy-transformation, is charged with the sound-potential, the potential of vibration or oscillation (परिस्थिति). It is called the sound-potential (शब्दसंरक्ष).

This is typical of the genesis (and structure) of the other Tanmátras (kinds of subtle matter). In each of the remaining cases, an atomic Mass charged with actual specific energies (सूतपर्वतासु) disintegrates and emanates, and thus evolves a form of subtle 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 subtle matter becomes charged with a new potential in addition to the potentials already evolved. The genesis of an atom, Bhúta-Paramánu, is a quite different process. Here the unit potential (Tanmátra) receives an accretion of Mass, and by a sort of condensation and collocation evolves an atom (Bhúta-Paramánu).

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

1. The super-subtile individuated Mass (rudiment matter (Bhútádi), under the action of the
original Energy (रेखा:) disintegrates and emanates (विक्षब्धः) in the menstruum or surrounding medium (सन्धिबन्धः) of Mahat, cosmic super-subtile Mass, and evolves a form of subtile matter (तत्त्वः), which becomes charged with the sound-potential (vibration-potential, परिस्फोटः), and is called the unit of sound-potential (वस्तुक्षेत्रः).

2. This subtile matter, the Mass, charged with sound-potential, receives an accretion of Mass from the rudiment matter (भूतादि) and by condensation and collocation evolves the आकाश भूता, the atomic आकाश, the proto-atom charged with the specific energy of the sound stimulus (actual vibratory motion.) (स एव भूतादि: शब्द-तत्त्वावत् सत्तितवात् शब्दयुक्तकम् दार्शनकम् समस्याः तथा च भूतारम्बन्धःतत्त्वाभासः मिलितः बाकाशं चक्षुः,—धीर्यवार्तिक on the Vishnu Purāna passage, Sutra 14, Pada IV).

3. This proto-atom, the atomic आकाश, 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 matterj(Tanmātra) which becomes charged with the touch-potential (the potential of impact or mechanical pressure
(प्राकृतम्, वहुःकीरङम्) in addition to the sound-potential (vibration-potential—परिषात्ते) and is called the unit of touch-potential (अम्लस्मार्थ).

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 (Bhūtādi) and by condensation and collocation, evolves the Vāyu Bhūta, 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 Vāyu, 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—Bhūtādi) and thus evolves another kind of subtile matter (Tanmātrā), which becomes charged with the heat-potential (सीताः—षत—heat-and-light-potential) in addition to the impact-potential and the vibration-potential, and is called the unit of colour-potential (अम्लस्मार्थ).
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 (Bhūtādi), and by condensation and collocation evolves the Tejas Bhūta, 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 (रससम्भाव), 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 subtle 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 summarises the Vishnu Purāna 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 विभिन्नमाय: (the disintegrating process), and the distinction between the genesis of subtile and gross matter (Tanmātra and Bhūta).

श्रद्धाप्राणिनः नक्तः नक्तता च तथावतः।
शून्यविरूपं विभिन्नमायं वरेत तन्मात्रित्वं ततः।
11. A famous passage in Parásara takes another view of the genesis and structure of the Tanmátras and the Bhúta-Paramáusus. Krishnápáda, in the दक्षिणवष्टस, represents the scheme as follows:

The Tanmátras originate from one another in one linear series, and each Bhúta originates in a separate line from its own Tanmátra. —

मूखादि (Bhútádi)

चक्रस्माक Sound-Tanmátra—as a radicle or centre surrounded or encircled by Bhútádi generates A'kása.

अवस्थानमाक Touch-Tanmátra—as a radicle or centre encircled by Sound-Tanmátra with A'kása-atom as a help generates Váyu—

रसस्माक Colour-Tanmátra—as a radicle or centre encircled by Touch-Tanmátra with Váyu-atom as a help generates Tejas—

रसस्माक Taste-Tanmátra—as a radicle or centre encircled by Colour-Tanmátra with Tejas-atom as a help generates Ap—

स्मृतमाक Smell-Tanmátra—as a radicle or centre encircled by Taste-Tanmátra 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 Tanmātras of the immediately higher order in the medium of its own Bhūta.

Thus an atom of A’kāsa has the following structure:—

An atom of A’kāsa

Sb = S’abda-Tanmātra (vibration-potential)
Bh = (Bhútádi)
An atom of Váyu is constituted as follows:—
This takes place within the surrounding medium of A'kasa.

An atom of Váyu
Sp = Sparsa-Tanmátra (impact-potential)
Sb = S'abda-Tanmátra (vibration-potential)
An atom of Tejas—heat-and-light corpuscle—has the following structure:—
An atom of Tejas

\[ R_p = \text{Rūpa-Tanmātra (light-potential)} \]
\[ S_p = \text{Sparsa-Tanmātra (impact-potential)} \]
and so on.

A Chemist will be disposed to push his chemical processes into the region of subtile matter. He may translate श्वत्र as a menstruum, and सर्वावक as a catalytic agent. In this case, an atom of Vāyu will be considered as generated from the impact-Tanmātra as a radicle, in the menstruum of vibration-Tanmātra, with A'kāsa-atoms as a catalytic agent.

A slight variation of the above view is ascribed to a certain school of Vedāntists in the तद्विद्रवयः.

The scheme may be represented as follows:—

A Bhūta-atom is evolved by integration (condensation and collocation, खूबायङ्कः) from the corresponding Tanmātra (subtile matter). This is the same view as that of the Vishnu purāna.
The Tanmátras again evolve from one another in a lineal series as in Parásara’s view. But the process of this generation is somewhat more complex. A Tanmátra first disintegrates and emanates in a surrounding medium (a menstruum) of the Tanmátra just preceding it in the order of genesis and with the help of its own Sthúla Bhúta as a sort of catalytic, generates the Tanmátra next in order; e.g., the infra-atomic impact particles (अर्धनाभ) disintegrate or emanate, in a surrounding ‘atmosphere’ of the vibratory subtile matter (अभ्यदन) and then with the help of their own atomic integration Váyu, gas, generate the Tanmátra next in order, the subtile matter of radiant light-and-heat (शक्ति).

III. Patañjali’s view, as expounded in the आज्ञातिकः and वीरज्ञानिकः is as follows:—

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

(1) Bhútádi, the rudiment-matter, original Mass, acted on by Raja, Energy, produces the sound-potential (vibration-potential) वर्माण्याय ब्रह्माण्याय वस्त्राणामि राजशाहीवीरिणिका वस्त्राणीमिका।

(2) This subtile vibration-potential, as a radiicle, with accretion of rudiment-matter
(Bhūtādi) condensing and collocating, and acted on by Rajas, generates the subtile touch-potential (impact-potential) which is impingent as well as vibratory (oscillating).

(3) This subtile impact-potential again, as a radicle, with accretion of rudiment-matter (Bhūtādi) condensing and collocating, and acted on by Rajas, generates the subtile light-and-heat potential (क्षरस्वर) which radiates light-and-heat, in addition to being impingent and vibratory.

(4) Next, the light-and-heat potential, as a radicle, with accretion of rudiment-matter, (Bhūtādi) condensing and collocating as before, generates the subtile taste-potential, which is charged with the potential of the taste-energy, and of viscous attraction, in addition to being vibratory, impingent and radiant.

(5) Lastly, the subtile taste-potential as a radicle, with accretion of rudiment-matter as before, condensing and collocating, generates the subtile smell-potential, which is charged with the potential of the smell-energy, and also of cohesive attraction, in addition to being vibratory, impingent and radiant.
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 A’kása-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 A’kása-atom possesses penetrability, the Váyu-atom impact or mechanical pressure, the Tejas-atom, radiant heat-and light, the Ap-atom, viscous attraction, and the Earth-atom, cohesive attraction.
Vijñāna-bhikshu in one passage gives the following scheme of the genesis of the Bhūtas:—


of A'kāsa = Bh(Sb)
of Vāyu = { Bh(Sb) } (Sp)
of Tejas = { Bh(Sb) } (Sp) Rp

where Bh = सृष्टिः, Sb = विकृत्तिः, Sp = अभिवृत्तिः, Rp = ध्वनिः, 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 Sāṅkhyaśa 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 A'kāsa (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 A'kāsa-atom—आकाशात्मक) 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 (अर्धस्वरूपाचार्य) combining with the vibration-potentials (A'kāsa 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 Tanmātras (अर्ध-स्वरूपाचार्य) combining with the potentials (Tanmātras) of vibration and impact, produced a new kind of atom—the tri-Tanmātric 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
Tanmātras, 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-stimulas. These Tanmātras (तन्मात्राः) combining with the three previous ones, gave rise to another class of atoms, the tetra-Tanmātric Ap-atom, and the flaming gases were thus precipitated into cosmic masses of viscous fluid matters (Ap). Finally appeared the fifth class of Tanmātras 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 Tanmātras (तन्मात्राः) uniting with the other four kinds or infra-atomic subtile particles, formed another class of atoms, the penta-Tanmātric Earth-atom. Thus the viscous fluid matters were condensed and transformed into the Earth-Bhūta, comprising the majority of the so-called elements of chemistry.

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

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Examples of the different Bhūtas:—

1. A'kāsa:—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 A'kāsa. But they have either suffered a fresh transformation into substances of a more complex atomic structure, or have dissipated into the mono-Tanmātric A'kāsa, out of which they took their rise. The one familiar example now surviving is atmospheric air. Water-vapour (वाष्प) is but water (Ap), and smoke, fumes, etc. but earth-particles in gaseous diffusion.

3. Tejas:—Various classes of Tejas corpuscles,—substances with tri-Tanmātric atomic structure, i.e. two grades subtler
than the ordinary elements of chemistry (which are of a pentad-Tanmätric structure),—are even now known. (तेजो भौमार्थिको में देन ब्रह्मिष्य। घीमें दिम्यं चौदीम्य मादेंग—सर्वसेवुपूर्वण,—तस्बर्मायाऽष.)

First, there is fire, or the light-and-heat emitted by the burning log of wood or lamp (चंपः—द्वैपः—गौमं लेजः). Now it is important to note that the flame of a burning log of wood (च्यागं) or 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 pentad-Tanmätric substance) acted on by Energy; and then the Tejas corpuscles, light-and-heat particles which are latent (absorbed) therein, come forth as flame (पार्श्वसेवकेश तद्दग्नतान्त तेजः: भविष्मंति—विभागमिः—प्रवचनाऽषयः. Sūtra 110, Chap. V). Then there is the light of the sun and the stars (दिम्यं चौदीम्य ब्रह्मिष्य) which are flaming masses of molten viscous matters (सति मादेंशकं तेजः: दिम्यं तस क्यांदिः,—तस्बर्मायाऽष, भविष्मंबर्भ) or of molten earthy matters सत्यान्तोति चर्मेन तेजः अर्यं न्यायिकायाऽष—विभागमिः. प्रवचनाऽषय, Sūtra 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 (जौदळे). 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 (स्वर्णऽविकोष शेतासाः द्रव्याणाः—विमात्रनिघ, गवशनमाय, सूत्र 19, Chap. III). Aniruddha, a late Sāṅkhya commentator, notes in reference to 'igneous bodies' that the greater part of their mass is derived from the Earth-Bhūta, 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.

तथ धातु (तैत्रेये वरीषे धातु) । सहारारतिः सामसारमत्वादमा, प्रसन्ने चाकुण्डोमात् । (पलिपमात्यात—Sūtra 112, Chap. V.)

4. Ap. This viscous fluid of a tetra-Tanmātric 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-Bhūta, the hard full-formed matter, with its penta-Tanmātric atoms, comprises by far the majority of the so-called chemical elements.

The question is,—how does one and the same Bhūta, 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 manifest in the particular collocations of the three Guṇas,—Mass, Energy and Essence; and a tri-Tanmātric, or a penta-Tanmātric atom, i.e. an atom composed of three or of five kinds of Tanmātras may differ from another of the same class, in respect of the number of constituent Tanmātras of any particular kind, as also of their collocation or grouping, and therefore in mass as well as in generic and specific characters.

The Saṅkhya-Pātañjala conceives the properties (or energies) of substances to result from the grouping or the quanta of the Tanmātras, 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 (अष्ट) and not of their components, for components they have none.

As a typical and familiar instance of the variety of characteristic properties (or energies) that may result from variations in accompaniment or grouping, the Sāṅkhya-Pātañjala points to the various kinds of fruit acids and juices, all originating from one and the same Bhūta (water) with different accretions of earthy matters (जूबक्षारः). 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 Guṇas, which underlie Tanmātra and atom alike (सतरसनमव भकवशालापवः संवात: परमाशुद्धिति—आयश्वरिक, तथीतकर, reporting the Sāṅkhya view : प्रस्थवस्त्रावस्त्रवः संवात: परमाशुद्धिति—आयश्वर्य, Sūtra 44, Pada III.—परमापु: सामांवशिष्यांस्क शस्त्रवख्यवस्थेदाटुगतः श्युदाय:—आयश्वर्य, Sūtra 44, Pada IV,—सम्भलाराज्ञ्रा धार्मिक: धार्मिकत्र धर्मोः (ibid., Sūtra 14, Pada III.) ये धर्मोः अतुपाती सामांव-विष्याको सीयस्य धर्मोः (ibid., Sūtra 14, Pada III.).

आदित्य—कथा एकपाशा गुणां शनिक्रान्तमाप्ति:-
द्रव्य भाग परिवातः विक्रिया। यथा शान्तिविशमुखतं उदरं एकरं धिष्ठि विविश्वामाय शास्य शान्तिव-माध्य-विल.
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If we take a unit of rudiment-matter (Bhútádi) for the unit of mass (cf. the mass of an electron with a charge of motion etc.), and represent the first Tanmátra by \( t_1 \) such units, and if further, \( t_2, t_3, t_4, t_5 \) units of mass (Bhútádi) be successively added at each accretion to form a fresh Tanmátra, then the second, third, fourth and fifth Tanmátras will respectively contain \( t_1 + t_2, t_1 + t_2 + t_3, t_1 + t_2 + t_3 + t_4, \) and \( t_1 + t_2 + t_3 + t_4 + t_5 \) units of mass.

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

If \( t \) units of mass be added to the first Tanmátra to form the atom of A'kása, 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 Sāṅkhya-Pātañjala were asked to account for differences among Paramánus of the same Bhúta class, he would perhaps suppose \( t_1 \) 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 \( 2\alpha_1 + t, \ 2\alpha_1 + 1 + t, \ 2\alpha_1 + 2 + t, \ldots \ldots \ldots \ldots 2\beta_1 + t, \) 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 Tejas-atoms of the different possible Tejas substances would be represented by the series, \( 3\alpha_3 + 2\alpha_2 + \alpha_3, \ 3\alpha_1 + 2\alpha_2 + \alpha_3 + 1, \ldots \ldots 3\beta_1 + 2\beta_2 + \beta_3, \) increasing in A. P. by unity as common difference, then being \( 3(\beta_1 - \alpha_3) + 2(\beta_2 - \alpha_2) + (\beta_1 - \alpha_3) + 1, \) Tejas substances possible.

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

Size (परिमाण).—As to size or volume, the Sāṅkhya accepts only two kinds,—the infinitesimal, which is also without parts (चतुर्भूज—निर्गत्व) and the non-infinitesimal, which consists of parts (चतुर्भूज—वायुचक). The latter varies from the excessively small (the so-called Azus, Tanmātras and Paramānus) to the indefinitely great (परसमयत्र—विशु,—e.g.—A’kāsa).

The Gunas alone are infinitesimal, with the exception of those ubiquitous ones that evolve into A’kāsa-atoms and Mind-stuff (अक्षामाणि तथा अन्न:करण) :—all the rest of the evolved products (whether subtile or gross matter) are non-infinitesimal.

Vijñānabhikshu 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 A’kāsa and Mind-stuff, must be held to be ubiquitous, and this will suffice for the ubiquity of Prakriti,
Chemical analysis and Synthesis—Elements and Compounds.

What then is the equivalent in the Sāṅkhya-Pātañjala of the distinction between a chemical element and a chemical compound, or is there none? Did or did not this elaborate 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 of chemical physics and physical chemistry.

Aggregates (समूहः) 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 (समूहसिद्धान्तः समूहः) ; and (2) mechanical aggregates, or collocations of distinct and independent parts (समूहसिद्धान्तः समूहः).

A substance is an aggregate of the former kind, and may be divided into two classes, (1) the Bhūtas and their ‘isomeric’ modifications भूत, भूतनिदिह और भूतनिदिहारम्) ; and (2) chemical compounds (स्पष्टिनिदिहः,
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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 (समानोबीतिक ), in the second case, between heterogeneous or 'polymeric' atoms (विउरीतिक ). The first contact leads to intimate union (सङ्ग-संबंध: व: संबंधरिक; तेनं व्रजती बिकारो भविष्य —विज्ञानिक संस्करणा: ) : the isomeric atoms by a peculiar liberation of Energy (समानोबीतिक संस्करण—=the action of similars on similars) are attracted towards one another, and being riveted as it were, form the so-called material cause (संपाद्य कारण ) of the compound product. The second kind of contact (that between unlike or 'polymeric' atoms of heterogeneous Bhūtas) begins with a liberation of Energy (चरण ), which breaks up each of the Bhūtas, and taking particles (or atoms) of one as nuclei or radicles groups 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 cause (संपाद्य कारण ), and the others, which by their collocation cause the liberation of Energy (चरण, तत्त्व or विचर ).
are called efficient causes —प्रभाव गुणमात्रिकाः परिपातेऽद्वारा अपराधानुत्तमः परिधानमेतेकान् प्रवर्तयति —वाष्पति, वौजय्यि on Kārika 16. The illustration 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 भाष्यारिकाः चलिः पतिः गोपाययूम् चं नक्षत्रयान् भाष्यारिकाः (१७५.१७५). —तथ वधिप (तेजश्वी मल्लिकर्णिनी वधिप) बहुतपार्श्वारिकाः सादृश्यायूम् १०२५.२०५ (वधिप on Sūtra 112, Chap. V.), भाष्यारिकाः आत्मार्मणं भाष्यारिकाः सादृश्यायूम् भाष्यारिकाः मल्लिकर्णिनी वधिप (वधिप २०५.२०५).

Aniruddha goes so far as to hold that both ‘isomeric’ and ‘polymeric’ (or ‘heterogenic’) combinations are real cases of constitutive contact, (अर्थात् सिद्धान्त, e.g. मौतिलियारीकाः परिधानम् —परिधान on Sūtra 113, Chap. V.) But in the later Sāṅkhya-Pātañjala the current teaching denied this—समन्तासुपादायाबोधायाम् (Sūtra 102, Chap V), when विद्यासागर notes—वह हरि मनतीयायां कोषांर्थात् न हस्तनिर्देशणे मनतीयायाम्। समन्तान समन्तासुपादायां

But besides these transformations of substance—(समन्तान—परिधान) 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. (वर्णतथा-सारस्यापरिप्रेषणः न प्रभावजनः ।—यथा एक रेखा प्रत्येकानै मर्त
दशस्याने दशा, एकायोगस्याने, यथा पदार्थेण सी माता चोपते दुहिता च खल चंति,—शुभिगिनिधिवंगमि गुणं, न विशदवेदिक्ष्यते—आश्चर्य, सूत्राः 13, पदा 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."

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

तत्सार्यवाक्यार्यसिद्धार्थीमेवते मण्डलत: ।
वर्णद्वृद्धानन्दोऽसोंता लघुवचारिज्जीवीः ॥

and Udayana, who wrote the Parisuddhi on the Tātparyyāta-likā of Vāchāspati, could not have been a contemporary of the latter, as will also appear from the invocation to Sarasvatī in the opening lines of the Parisuddhi. Vāchāspati then proceeded Udayana by 142 years, and must have been himself preceded by the author of the Vyāsa-Bhāshya by a
Now the question is—in these mixed substances does the fusion take place by Paramánus or by larger masses (or lumps)? Now a Paramánu 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 therefore not indivisible. It is subject to disintegration. In a Bhúta or its isomeric modification, the Paramánu, the smallest homogeneous component particle, is unmixed, and therefore corresponds to the atom of modern chemistry. In a mixed substance (संयुक्तसूत्रम्) whether it is an ‘isomeric’ or a ‘polymeric’ compound, the qualities are due to the mixture, and therefore its Paramánu, the smallest homogeneous particle possessing its characteristic qualities, must result from the mixture of the Paramánus (in smaller or larger numbers as the case may be) of the component substances. The Para-

longer interval still, for Váchaspati ascribes the Bháshya to Veda-Vyáasa himself (वेदव्यासो भाष्याचे भाष्य अव्याख्याते). The internal evidence also points to the conclusion that the Bháshya cannot have been composed later than the sixth century,—cf. the quotations from Pañchasikha, Várabhagavána, and the Sháshti-Tantra-Sástra, without a single reference to Īṣvara-Krítsha—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.
mánu of a mixed substance therefore corresponds to what we now call molecule. (ध्वनि, प्रत्यय्यमान मानामयति—आचार्या। सीढ़ा रि द्विब्रह्मात्मक विकाराय संकल्पतम् अभित्तेति हु।) प्रत्यय्यमान परमाणुः—वाचस्यति—वाचस्यार्थी—Sūtra 52, Pada III.—साधुतिविना न निषार्गल। प्रद्धिव्यपाशुः अवसप्ताःप्रश्विरिकालिकाभवारसु प्रविशिवादीनामपरमाणकारात्मकासामामात्राश्रेष्ठ। विश्राम-प्रियासु,—प्रियासु, Sūtra 88, Chap. V.)—That the Paramáñus form molecules (राजुष) in forming substances, is acknowledged by the Sánkhyaś as will appear from Gaudapáda,—तथा बाणोवा राजुषा हारुषवहुहुः। (जीठपाठ, on Kārikā 12). Even the Vaiseshikas, with their prejudice against ‘polymeric’ or ‘heterogenic’ combination, acknowledge that in ‘polymeric’ compounds the different Bhúta substances unite by their Paramáñus (or atoms), though they rigidly insist that in such cases only one atom should be regarded as the ‘radicle’ (ध्वनि, प्रत्यय्यमान मानामयति) and the others as co-efficient causes (निषार्गल—ध्वनि, e. g. प्रविशिवादी—प्रक्षेप द्वपुर्वोऽद्विस्ये नवस्ये नवस्ये नवस्ये, निषार्गल—ध्वनि, where S'rídhara notes परिवा नम्बर्व्या तज्ज्ञान तज्ज्ञान—where Udayana notes परिवा नम्बर्व्या तज्ज्ञान तज्ज्ञान—where Udayana notes परिवा नम्बर्व्या तज्ज्ञान तज्ज्ञान हिर्यत्वम’ विविषितं.)
It is only in the medieval Sāṇkhya-Pātañjala that under the influence of the Nyāya-Vaiseshika 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 (or 'polymeric') atoms. In the former case, there was believed to take place intimate union (जोडः), in the latter case, only a grouping of comparatively free or loosely attached atoms round a radicle atom (मूर्त्त), with liberation of Energy (उपेत, विषयादित्य—or विशय) and the setting up of unequal stress and strain (चक्षुषश्चिन्द्रेण—वहरण). At the same time, it was of course admitted that this distinction does not apply to the forms of subtle matter (Tanmātra—शृङ्खल) which could unite in intimate fusion, whether homogeneous or heterogeneous. For example, the subtle body (शरीर) which is supposed to be the seat or vehicle of the conscious principle is acknowledged by Vijñāna-bhikshu to be penta-Bhautic (पञ्चभूतिः); in other words, all the five Tanmātras serve as material causes, though the gross body (the animal organism) is stated to be only a 'polymeric' compound with the Earth-Bhūta as radicle or base. जातिर्दशा सुशास्त्रां विश्वासां न ज्ञाते। वपुष्पार्जय वन्द सुसुग्धस्य विपत्तिः संहतिः। शृङ्खलादयं यथा शृङ्खलां विश्वासां पत्रोपल् (पञ्चभूतिः—Sūtras
11 and 12, Chap. III.—सूत्रासौर वार्तिष्ठिसै च विनियोग तन्त्रासौर (ibid. Sūtra 19, Chap. III.)

But in the original Sāṅkhya-Pātañjala it appears that the production of a new substance by mixture of unlike Bhūtas (विनियोगसौर) was conceded as freely as in the Vedānta, and was conceived as 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 (or 'polymeric') atoms. At bottom they are all collocations of the Gunas. Even Vijñāna-bhikshu who, as one of the latest expounders of the Sāṅkhya-Pātañjala, has been most affected by the Vaiseshika prejudice against 'polymeric' combination (विनियोगसौर) urges that the qualities of a compound substance are not necessarily the result of similar qualities in the component elements. (सांख्य-कार्यानुसार व्याख्या प्रारम्भता द्वितीय तृतीया (वार्तिष्ठिसौर) विषय न निर्देश:।)

Elsewhere he explains that 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

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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:—( ज्ञातिसाध्याः पञ्चाशसदी-
पलात्, प्रामाण्यवस्तु पद्यकरिति द्वन्द्वः पद्धति पक्षाशुमी-
पावने पद्यवन्माति—प्रवचनमहाय, Sūtra 32, Chap. II). In the middle of the ninth century, we find Vāchaspati instancing some 'heterogenic' or 'polymeric' compositions as typical examples of evolutionary change ( परिवर्त्त ) and unhesitatingly accepting the substantive character of the products. In the Kaumudī he describes the various acids and juices of fruits as modifications of the same original water in the presence of different kinds of earthy accretions. The process is peculiar. The water-particle (or atom) serves as a radicle or centre of a system, and the different kinds of the Earth-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. यथा बारिष्ठविशुद्धशुमुदकं
पक्षरसमपि तत्र-सूतविकाराद्वृत्ता भाष्यवा बारिष्ठविशुद्धवन्नाशी-विशुद्ध-वाक्ष्यादि-
रसयथा परिणामात् मधुराक्षविशुद्धवन्नाशीकृतकथमात् विकाले। इति
विवेकगुरुसम्बन्धात् मधुराक्षो भारिष्ठा अप्रभावशुमा: परिवर्त्तकेत्राय:
परस्यंवसितं। ( बौद्धि 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.
(परिशासेकलं वहनासपि एकं परिषासं हुदं। तद्वचा गवाश्र-
सिद्धासाहसंहि इमानिद्रितानि प्रकाशलमकालोपचनां
परिषासं, विरिलासाहि स प्रदीप धति।—सत्स्यादि on ब्रह्मसाहि, Pada
IV. Sūtra 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 com-
ounds of water and earth substances, in the shape
of saps, acids and juices, are found in plants in
their different parts (जलसूक्ष्मं परिषासीकं रसादिवैयुक्तं
व्यासश्रवाय तद्भवं।). In other words, bi-Bhautic compounds
are here placed in the same category as 'isomeric'
compounds of substances of the same Bhūta class,
for here the particles of both the Bhūtas are
regarded as forming the matter (material cause—
चक्रादातीतत्व) 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 Sāṅkhyas 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 Varahamihira’s Vṛihat Samhitā. (पद्म: पद्मः [तम्मावेमः] यत्संहस्यमूलं भवति। तेभः मरीरिष्ण मरीराच्यः। यस्त: पद्मदन्दसूतसत्सापि मरीराच्यः। Utpala, Chap. I, Słoika 7).

Chemistry in the medical schools of ancient India:—As a matter of fact, long before the fifth century, probably as early as the first century A. D., the prevailing schools of medicine and surgery which were based on the Sāṅkhya teaching with a methodology derived from the Nyāya-Vaiseshika doctrine (cf. Charaka, Sārīrásthāna, Chap. I, Vīmānasthāna, Chap. VIII—also Susruta, Sārīrásthāna, Chap. I) had founded an elaborate theory of inorganic and organic compounds, which equally admitted iso-Bhaustic and hetero-Bhaustic combinations. Like the Vedantists, Charaka held that each of the gross Bhūtas (Mahābhūtas) is a peculiar ultra-chemical compound of five original subtile Bhūtas. In this sense, every substance is penta-Bhaustic, but for purposes of chemical analysis and synthesis, i. e. considered with reference to the Mahābhūtas, 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 Bhūtas, 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 Bhūtas:—The prevailing physical characters of the different Bhūtas 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, subtle, light, dry, clear, rarefied, and luminous.

Vāyu-substances—Light, cold, dry, transparent, rarefied, impinging.

Aṅkāsa-substances—Imponderable (or light), rarefied, elastic, capable of sound (vibrations).

(वृद्धिकटात्विपरिवर्तनसः-संततिविकल्पसः प्रकारस्यस्य संरचना अर्थातः। रा्जस्वितांश्च, वृद्धिविवर्तनस्याद्विकल्पसः प्रकारस्य। मयाः प्राणस्य-वृद्धिविवर्तनस्याद्विकल्पसः आयनवातः। अयोध्यायथः प्राणविवर्तनसः अर्थातः।)
Charaka points out that the primary qualities or specific physical characters of the five Bhūtās 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 A'kasa.

(Charaka-S'ārīrasthāna, Chap. I.)

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

The Mahā-Bhūtās—mechanical mixtures:—

Suṣruta notes that each of the gross Bhūtās (Mahā-bhūtās) is found mixed up with the other Bhūtās;—e. g., the Mahābhūta A'kasa 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 Tejās, of earth-particles in the shape of smoke, and also water-vapour.
Mono-Bhautic Earth-substances:—Charaka and Susruta regard the following as Earth-substances—Gold, the five Lohas (silver, copper, lead, iron and tin) and their ‘rust’, arsenic, orpiment, various mineral earths and salts, sand, precious stones, (Charaka, Sūtrasthāna, Chap. I. Cf. also Susruta, Sūtrasthāna, Chap. I—पाठिवा: स्वाष्ट्रसंविभूताम्:—श्रियांवतपायास्य:। स्वाष्ट्रं इत्यापर्यंवनिविक्रिययात् वृहलक्षाधिविभूतानाः:। धूमे आदिध्रुवनान् सीडेषिक्रियमादिस्विधायारंवतास्य—नैरिकर्थ्यायम्:—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 (चोरिरं पाषाणश्च वज्तासून्नम्: सेरम्:).

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 (चक्षुसि: ) (Chikitsāsthāna, Chap. 10). These metallic salts are therefore mono-Bhautic Earth-compounds. Susruta also gives the preparation of mild and caustic alkalis. (Sūtrasthāna, Chap. 11.)
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—वैचित्री ग्रहावसापानम् वैचित्री मुखः खमावत्—Utpala notes,—रजःपलं प्राणं: जाःसारिण ).

Ap-substances, simple and compound:—

Susruta, following Charaka, enumerates various classes of Ap substances (रब्रह्म) 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, pun-
gent; with Mahábhútás Váyu and A'kása predominating, bitter; and with Mahábhútás Váyu and Earth predominating, astringent (Charaka, Sútrasthána, Chap. 26,—cf. Susruta, Sútrasthána, Chap. 42).

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

Qualities of Compounds.—The isomeric modes of each Mahábhúta have specific colours, tastes etc. due to their structure, i.e. the arrangement of their atoms, and the physico-chemical characters of compounds whether of the same or of different Mahábhútás 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.

Susruta ignores Charaka's distinction between Mahábhútá and subtile Bhúta, and views every
substance as in reality penta-Bhautic and it is only the relative predominance of a particular Bhūta or Bhūtas in any substance that determines its class. (प्रविवासान्यामार्मण्यां समुदायाय द्वारास्थवर्ध्यः। चतुर्योष: पलितत्त्वकी मर्मति यां यापि यां यां धारीं धारीं धारीं तैजसं यां यां वायव्यं यां यां भावायोग्यतः। Susruta, Sūtras-thāna Chap. 41)

The extant Charaka and Susruta—Succession of medical authorities:

The extant Charaka and Susruta, the sources of our present information regarding the progress of scientific knowledge in the medical schools of Ancient India, are both redactions of original authorities. The extant Charaka is a redaction by Dridhabala of the genuine Charaka Samhitā which was itself a redaction by Charaka of the original work of Agnivesa, the disciple of Aṭreyya Punarvasu as distinguished from Krishnāṭreyā and Bhikshu Aṭreyya, also well-known medical authorities. The extant Susruta is a redaction by Nāgārjuna of an original work (Vṛiddha Susruta) by Susruta, the disciple of Dhanvantari. That Charaka preceded Susruta is almost certain. Nāgārjuna 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 redactor himself. The latter was probably identical with the alchemist Nāgārjuna (Siddha Nāgārjuna), the metallurgist Nāgārjuna (author of a treatise on metallurgy, Lohasāstra), and the Buddhist Nāgārjuna, author of the Mādhyamika-sūtravrūtti. Charaka and Susruta continued to receive additions after Drīdhabala and Nāgārjuna, 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 Sārīrasthāna 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 (विष्णुशास्त्र) gave elaborate directions for many metallurgic and chemical processes specially the preparation of the metallic salts, alloys and amalgams, and the extraction, purification and assay-ing 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 Nāgāruja mentions that the chemical process of testing pure iron must be repeated twice before it can be regarded as decisive, where as S'ivadāsa 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 Yogoratnākara-samuchchaya); and (3) Nāgārjuna is quoted in the earlier compilations, Patañjali in the later.

Early in the sixth century, Varāhamihira in the
Vrihat Samhitā 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. (प्रासादकोपथवीविक्ष्यः प्रतिशासु कुष्ठकपेशु सन्नावी दानश्री वर्षकायपवस्यायी। Chapter 56, Ibid.). Varāhamihira also alludes to the experts in machinery (वनविद:, वनवर:) and the professional experts in the composition of dyes and cosmetics (रागमयुक्तिविद्: Ch. 16, also Ch. 15). I would also refer to the interesting Chapter on Perfumery (Ch. 76) where Varāhamihira gives various recipes for artificial imitations of natural flower scents as of the essence of Vakula, Utpala, Champaka, Atimuktaka &c., 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 (साध्यमयासार) 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 (तुबरी नक्सला राजवासन) and other chemical (e.g. sulphate of iron) also cow-dung (cf. the "cowdung substitute", Roscoe); (2) the extraction of the principle of indigotin from the indigo plant by a process which however crude is essentially an anticipation of modern chemical methods; and (3) the tempering of steel in a manner worthy of advanced metallurgy, a process to which the mediæval world owed its Damascus swords. It was this applied chemistry much more than handicraft skill which gave India her premier position in the middle ages and earlier (indeed from Pliny to Tavernier) in exports and manufactures; for in handicraft skill as in design and workmanship, great as were her merits, India came to be surpassed by her disciples China and Japan.

The Vásavadattá and the Daśakumára Charita in the sixth century allude to the preparation of a mass of fixed or coagulated mercury (पारद-पिष्क स्रव बाह्यसाधितः—वासवदत्त); a chemical powder, the inhalation of which would bring on deep sleep or stupor (श्रेयोष्णय—दशकुमारचरित); a chemically prepared stick or wick for producing light without fire (श्रीशर्मशिका—दशकुमारचरित); and a powder which like anaesthetic drugs or curare, paralyses
sensory and motor organs (साधनेन्द्रियांविव रत्निक्यायादृष्ट—वायुवद्धा—प्रीतिवसंसृन्तिद्रियासङ्गिति दर्शनः). Vrinda (circa 950 A.D.) notices the preparation of sulphide of mercury (रक्षसमशुष्क) composed of one part of sulphur, and half its weight of mercury; and also of cuprous sulphide (पघिरिदाम). 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-Bhautic substance.

The Rasaratna-samuchchaya divides the mineral kingdom (Earth-substances, simple and compound) into the following classes:— (1) The eight Rasas, mica, pyrites, bitumen, blue vitriol, calamine, etc. (2) The eight Uparasas (useful in operations of mercury), sulphur, red ochre, green vitriol, alum, orpiment, realgar, collyrium, and medicinal earth, to which may be added the eight Sādhārana Rasas, sal-ammoniac. cowrie, cinnabar, rock vermilion, etc. (3) The gems, diamond, emerald, sapphire, cat’s eye, sun-stone, moon-stone, pearl, etc. (4) The metals,
gold, silver, iron, copper, lead, tin, and the alloys—brass and bell-metal. Other Earth-substances are six salts, three alkalis, mineral earths, and several poisons (cf. vol. I, pp. 32-98).

Chemical compositions and decompositions—metallurgic processes.—In these writings, we frequently come across instances of chemical composition and decomposition, by processes, more or less crude, of calcination, distillation, sublimation, steaming, fixation, etc. (अकीकरण प्रक्रिया, अवक्रिया, स्वरूप, साधन etc.) e.g. the preparation of perchloride of mercury by taking common salt and mercury (रसरुप—पारद्रस्त्र विद्यमान अकीकरण प्रक्रियाः); of sulphide of mercury (विद्यमान) by taking sulphur and mercury; of Sindūra from lead (विद्यमान नागसुधाबचन—Amarakosha sixth century A. D.);—of the medicinal compounds, Svārṇa-sindūra and Rasasindūra, with mercury, sulphur and gold, where gold may have been fancied to influence the resulting compound in some mysterious way, either as a ‘dynamic’ or as a catalytic;—also the extraction by chemical decomposition of mercury from sulphide of mercury (विद्यमान)—vide रसरुपसमुच्चय; of copper from sulphate of copper (विद्यमान) by heating this substance with one-fourth of its weight of borax (Rasaratna-samuchchya,—cf. Bhāvaprakāsa, विद्यमान...
HINDU CHEMISTRY

The various metallurgical 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 (खरपक—मधमपक—and बदुपक),—methods which, if often crude, especially from the absence of independent and isolated mineral acids, were yet in several instances remarkably simple and effective, and which, after all by the use of various Vidas potentially containing mineral acids aqua regia, sulphuric acid, hydrochloric acid, etc.) virtually accomplished the practical ends kept in view. To these were added several special processes for mercury (e.g. fixation), bringing up the number of mercurial operations to nineteen.
It may be noted that the mixtures called Vidas, which potentially contained dilute mineral acids, were regularly employed not only in killing the metals (forming their oxides and chlorides), but—what is of fundamental importance—for purposes of chemical decomposition of metallic salts, etc. and the extraction and purification of metals.

Organic Compounds.—Organic Compounds are either vegetable or animal substances (खाद्य ज्वलन युक्त). 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 (जीवित खाद्य युक्त). 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 (वर्दहीस भ्या नम्ना तेल तुलयमयन्यं). Salt may be either mineral or vegetable salt.

Susruta divides poisons into two classes—Vegetable and animal, but several poisons expressly termed mineral poisons (चावरत्क) 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 Mahá-bhútas.

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 developments of the foetus are further transformations (higher compounds) of these foetal substances. All the component substances of the body are penta-Bhautic compounds, though sometimes they are assigned to the particular Bhútas which predominate in their composition, e.g. bile to Tejas, lymph, chyle, blood, fat, urine, sweat and other secretions to Ap, and skin, flesh, bones, nails, hair, etc. to Earth.
Fetal 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 (स्कलोः), then follow the several tissues (कः), the flesh, the vascular tissue, the fat and marrow, the lymphatic (and glandular) tissue, the intestinal tissues, the biliary and the seminal vessels,—tissues which 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 (पाच्). e.g. chyle is transformed into blood, blood into flesh, flesh into fat, fat into bone, bone into narrow, marrow into sperm-cell. The organs are next formed out of the tissues. The liver, gall-
bladder (श्वेत), spleen and lungs are referred to the blood; the intestines to the blood, lymph and bile; the kidneys to the blood and fat; the testicles to the blood, lymph and fat; the heart to the blood and lymph; and the tongue to the lymph, blood and flesh. Vāyu, with the accompaniment of animal heat, impels the ‘currents’ (स्तोतरिकी) in the system; Vāyu acting on the flesh gives rise to the muscles, and it is Vāyu again, which, with the essence of fat (or marrow), produces the nerves, arteries and tendons. (तद्र खण्डे यक्षौ शिक्षात्मक अभिप्रयोगोपादेश सोस्योत्स यमाण्याय: समस्यां अपानी।—काला: खण्डियां सर खण्डवनी। यथाष्टक वायु: यायू विषयानमूतिः हमावे। तातां यज्ञा नागिग्नका। वातीयां रक्षा। तत्त्वा महोधरा। बलैया यज्ञा। पद्मी प्रारंभिक। या। चित्राया। संभाभू यज्ञा।—संभाभू यक्षुविदानी मेदितजी—et seq. Suṣruta, Sārīrasthāṇa, Chap. IV.—रसाद्वं ततौ मांसे मांसामूद्र: प्रजायते। मेदितजीक्ष ततौ मध्या नरः यज्ञस सम्बन्धः। Sūtrasthāṇa, Chap. XIV.)

The following parts (tissues and organs) in the foetus are in a special sense modifications of the four organic substances 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, of the substances derived from the mother,—skin, blood
flesh, fat, the heart, liver and spleen, kidneys, stomach, intestines, etc. (Charaka, Sārīrasthāna, Chapter III. यानि खस्त्र गम्यं प्रदवनि पिठजानि पिठत: सधयतः: सध्यथोऽस्मयस्तु-सम्य-सम्य-दलास्क्षिणिः-गाय-धसः: गुप्ते-निति पिठजानि। यानि खस्त्र गम्यं साहजानि यानि च महा मात्रतः सधयतः; सध्यथोऽस्मयस्तु—सधयथा लम्भः च जीवितच्च मासः मन्दिर वद्यं च यज्ञुः च श्रीमाः च हस्तो च पुरुषाधारं च दाषामध्यं नमि-माहजानि।)

Chemistry of Digestion—The food we eat contains five classes of penta-Bhautic organic compounds. From their radicles or predominant elements, the substances are named Earth-compounds, Ap-compounds, Tejas-compounds, Vāyu-compounds and A'kāsa-compounds. The Earth-compounds supply the hard formed matter of the body, the Tejas-compounds give the animal heat (or the metabolic heat), the Vāyu-compounds are the sources of the motor force in the organism, the Ap-compounds furnish the watery parts of the organic fluids, and the A'kāsa-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 (heat-producing) and the Vāyu-compounds to the carbo-hydrates (dynamic). The Ap-compounds are the watery parts of food.
and drink. Th. nesh, for example, is a tissue composed principally of the Earth-compounds, the fat of the Earth and Ap compounds, the bones of Earth Vāyu and Tejas compounds. The Tejas compounds predominate in the composition of the blood. For purposes of digestion it is stated that 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 Mahásrotas (the great channel).

The food goes down the gullet by the action of the biomotor force, the Prána-Vāyu.

In the stomach (आमाशय) the food becomes mixed up first with a gelatinous mucus (फेबान्नसन कर) which has a saccharine taste, and then gets aci- dulated by the further chemical action of a digestive juice (विद्याद्धेखस गत) — evidently the | gastric juice is meant. Then the biomotor force, the Samána Vāyu, begins to act and drives down the chyle by means of the Grahani Nádí to the Pittāsaya (duodenum), into which bile comes down from the liver, and thence to the small intestines (the जलपलक्षय). 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 (च्यु), which has at first
a Katu taste (pungency). This chyle contains in a decomposed and metamorphosed condition all the penta-Bhauristic organic compounds, viz. tissue-producing Earth-compounds, water parts or Ap-compounds, heat-producing Tejas-compounds, force-producing Vāyu compounds, and lastly, finer etheric constituents which serve as the vehicle of consciousness. The essence of chyle (हृदमाश) from the small intestines is driven by the biomotor force, the Prāna Vāyu, along a Dhamanī 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 (सूक्ष्मभाष) proceeds along the Dhamanīs, being driven by the biomotor 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 (biomotor force) and Māmsāgni (the flesh-forming metabolio 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 (biomotor current) and the fat-forming metabolic heat (स्वरूपन्य) in the menstruum of lymph (कर्फ्रक्षत्रिय), receives viscosity and whiteness, and produces the fatty tissue, the Earth-compounds and Ap-compounds of the food especially contributing to the product. This fat in the chyle (or blood), or rather the groser 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 (biomotor current) and the marrow-forming metabolic heat, in the menstruum of lymph (कर्फ्रक्षत्रिय), becomes hard (or crystalline), and forms bone, the Earth. Vāyu and Tajas compounds contributing principally to the product. The essence of the fat fills the hollow channels of the bones, and acted on again by biomotor Vāyu and metabolic heat, becomes transformed into the marrow. The marrow is transformed into the semen, which is conveyed down by means of a pair of Dhamanis (ducts) (च रक्षसरे), lodged in its receptacles (श्वचच्चकान—कच्चच्च), and discharged by means of another pair of ducts (च चिन्तनाय). 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-return-
ing circle) of metabolism (पानकविलय चक्रवृत्त। Cf. Charaka and Vagbhata).

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 marrow; and that each preceding element or constituent of the body (प्रात्शरीरसम्प्रत्ति) 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 (विपाताय) which acts on the chyme to produce the chyle, (समप वसूधाष्ठवांश विर्य); and (2) a colouring bile substance in the liver which adds a red pigment to the chyle and transforms it into blood (सम्पकाचं विनम्भ।). Besides, there are three other biles, of which the aqueous humour in the eye is supposed to be one (सास्तिसबिन्दु) helping in the formation of visual images (वायुक्षेत्र।). This is the view of Dhanvantari and his school, but A' treya 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 (च्युले: । भूषणसंसाय—चक्रपाणि, भानुमति, सूत्रस्त्हान, Chap. 14, S’loka 10; also his commentary on Charaka, Sútrasthána, Chap. 28), but my account is based upon the second hypothesis which has the preference of Chakrapáni (चक्रपाणि). It may be added as a curiosity that each element of the body (चातुर्य) under the metabolic heat is supposed to give off a finer essence (नुद्दर्म) which serves as the material of the next succeeding element, and a dross (सब्ल), 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 Váyus (biomotor 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 Dhamanis gets it back transformed into blood, and the Ojas also proceeds from the heart and returns to it along with the chyle and blood. (Cf. Vágbhata—वाग्भट: । बुद्धि: । द्वितीयें । तीसरे: ।
हिन्दु रसिक तत्त्वम: 

पञ्चमूलाक इसे जानकर: पाः प्रभासकितविः। विषयः 
पञ्चमूला सम्बन्धितामु खानसम्बिक्येन। सुरुता, सूत्रास्तंबानाः, 
Chap. 46. Cf. also वियतत्पवनजाताम्यां खिड़वाये। मांसः। 
आधृतिवेद मयुरवशः तेन पितसुदीर्घायेः। Ibtd., Chap. 41. 
मीमांकायेष्वावय्याः: पञ्चमे: समासम्यः। पञ्चमोपायमुखानु खानु 
खानु पारथिवादीनु पञ्चमय:। यथार्थ ते स पुष्पिणि पञ्चा सुत- 
गुणानु प्रथमः। पारथिवः: पारथिवानु भेत्य: शेषाव: देशगानु। 
परिविद्धा गुणामि देवस्य: कल्पोंति तु पारथिव:। मेदखपयं सुधासाम 
प्रयोजनितेशकाम्। Charaka, quoted by Dalvana. चाटी 
षड्युक्तमायं भारभूतसमयित्व, पेठीसून चारं यारी बिदायादस्ताय 
तत्। वायुमा समासाम्ये वष्कीर्मिनीने। यस्य पिताधरा भाज 
वा कल्य परिलोकिता। गणपक्षःक्षामः भेशी कालिनवेन। 
शब्दविभागमान्व दयाधातुक्ष्यी मनः। सूक्ष्मासाह्ये वदा या 
विपाखा महाभाषः। बड़ीयवस्ता लक्ष्मणेद्रवेष विमुखितः।...परम 
पहः पितायु पञ्चमाः पुरोहितम्। देशधानुव.सादीसम्बंधियाह- 
वेमाचार्याः। तेजीयाहां सबन्धायां वदुक्तते। पिता ओषध 
वर्णवेष रद्वो रचलस्मारी। वायुप्रितेजसमा जुरां रक्ता मांस- 
वर्णवेष। श्रेष्ठाय व समास्मिष नानां वक्ष्यितुद्वम्, धिरां 
प्रायं शैलं। तेन इनीदिनिणयते। सत्सनामिनवादीनां चनात: 
श्रेष्ठायत:। खरतं मकरीयक्षा जायतेर्भित्य तत्तो ज्ञान:। करोति 
तव हेमिनकाः नभे श्वेतवे। मेदखा वाज गुणोऽसे शेषी 
जला 'तस्त: कृत्वः। तथान्मर्माः ये: शेष: सम वंयाये तत:।
Charaka—Dridhabala Samhitā, quoted by Aruna in his commentary on Vāgbhata. यथा कैदारानिवषत् कुष्चाजलं प्रायाधिन्यो-कैदारीमाजावयवति, तथा रस एव प्रथमं रसं प्रायवयति। तति रसायन-हस्बन्धम् रसस्वप्नं रसायनप्रेणं च श्रन्वयति। रसं च रसस्वप्नस्वतः वसवः स्वस्वयति। तसो रसायनयुपंसमाधारणात्यं, पायुर्मरोगिरेगतात्यं रस एव प्रायवयति। (Chakradatta, Bhānumatī). 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 (तसो रसायनयुपंसमाधारणात्यं, पायुर्मरोगिरेगतात्यं रस एव प्रायवयति) . This will be abundantly clear from the following account of the course of the chyle and the blood:—

तत: सारभूमयायायरकश हो भगी भवतः। खूब: सुस्वय... 
तत: सूची भागः प्रायुपनाम प्रितिए चवतीमारङ्ग श्रीरायायरकश रक्षक खान्य यक्तः प्रोपुयं गन्ता तेन सह सिद्धो भवति। 
तत: प्रायाय-रक्षाती एव तियाति।।।।।।तत: सारभूमयायायायरकश वृक्ष चो भगी भवतः।। खूब: सुस्वय।। सूची भागी रंज- 
कालकेश प्रितेन रक्षीक्षतः: श्रीरायायायरकश रत्नं प्रोपुयं अन-पायुना 
प्रितिए चवतीमालिक: संचरन् सारभूमयायायरकश वृक्ष द्वारा गुप्ततः। 
तत: सूची भागः: अनपायुना प्रितेन चवतीमालिक: विरायाय 
श्रीरायायायरकश मात्सवं गाति। et seq.
This finer essence of chyle which nourishes the flesh must also be carried in the blood, on the 'irrigation channel' hypothesis (श्वासारीक्षणामाभ्). (For diagrams of the central circulation and the sym-pathetic-co-spinal nervous system, vide my Paper on Hindu Anatomy and Physiology. The mechanism of life and the inheritance of specific and other congenital characters are also dealt with in the same paper).

Formation of molecular qualities in chemical compounds:—The Charaka school, which, we have seen, was an offshoot of the Śāṅkhya (cf. Charaka, Vimānaśthāna, Chap. 8, वधा वालिकः पञ्चाशः तथा शास्त्ररूपं प्रवाहिक्षलितं) supplemented the above account of inorganic and organic compounds with a characteristically Śāṅkhya 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. (एवमेयं रसायनं पद्धकुलपपत्रं प्रवाहिक्षालितं विशिष्टं नातासंवल्लं। सूतालिकां खाबशालयानां नातावर्षाकलितं विशेषं। 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 Kaviraja'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 Bhūtas 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 Bhūta) 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, predominant 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 (तीक्ष्ण), 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 (तीखा), 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 termeric 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 (Pātala, 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.
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Parināma-vāda versus Aṛambha-vāda: Charaka's view of the formation of a new quality or a new substance is based on the Sānkhya teaching as to the conservation and transformation of Energy, and brings chemical synthesis in a line with evolutionary change (परिखान). On this view, a new substance may arise by spontaneous or isomeric change, i.e., by the inter-play of Energies within the system of any given substance, in the absence of any action from without. New qualities like new substances are only readjustments of the old, and continual changes are going on by spontaneous disintegration and recombination. Opposed to this evolutional view of chemical synthesis is the Nyāya-Vaiseshika doctrine of Aṛambha-vāda, 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’ (विशिष्टता) 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-Vaiśeshika 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 (विद्यमान, निर्मितिबार्त्त) but it refuses to place
these compounds on the same footing as compounds of isomeric modes of the same Bhúta; and it accepts the 'material' causality, in such cases of only one of the Bhútas, regarding the others as 'co-efficient' (निधिचक्ष).  

The earlier Sáňkhyas including the medical schools of ancient India brushed all this aside as a distinction without a difference. The Vedantists, as we shall presently see, flouted this doctrine of A'rambha-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 Nyáya-vártika, and of Váchaspati Misra in the Tátparyayáti, 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 upholsters of this view would suppose a molecule of the type $E_2A$ (i.e. two atoms of Earth and one of Ap) to explain any bi-Bhautic compound of Earth and Ap (like the plant saps and fruit juices) which exhibits smell in addition to the peculiarities of colour and taste. (Cf. Vāchospati's comment on Udyotyakara's refutation of this view:—

Measure of Time and Space. Size of atoms.

The Siddhānta-Siromani gives the following measures of Time:—

30 Kshanās = 1 day, 2 Ghatikās = 1 Kshana,
30 Kalās = 1 Ghatika, 30 Kāśthās = 1 Kalā,
18 Nimeshas = 1 Kāśthā, 30 Tatparas = 1 Nimesha, and 100 Truti = 1 Tatpara.

This makes a Truti of time equal to $\frac{2}{3}$ of a second, which is nearly the measure of
the Paramánu of time; as given in the Vishnu-
 purána (vide Bháskara’s Siddhánta-Síromani—
 भास्करासिद्धान्तसीरोमनी )

The above measures were in use among the
astronomers, but the physicists computed according
to the following table given both in Udayana’s
Kiranaivali and Srílharā’s Nyāyakandali :- 30
Muhúrtas = 1 day (24 hours ), 30 Kalás = 1 Mu-
húrta, 30 Káshthás=1 Kalí, 18 Nimeshas=1
Kúshthá, 2 Lavas = 1 Nimesha, 2 Kshanás=1 Lava.

अष्टयन्त्र लबः खोपो निमेशसाति जवस्यथम्।
सष्टादन्दिनेशास्त्री। काण्डा विशलनतः लबा।
दिनशौकला दुहर्था स्यान्ति दिनश्चिराधारणी ब तेन।
(Udayana, Kiranaivali).

This makes 1 Kshana of the Nyaya-Vaiseshika
equal to $\frac{2}{3}$ of a second. The Nyāya assumes
that the unit of physical change (or the time
occupied by any single antecedent step in a causal
series before the succeeding step is ushered in)
is equal to a Kshana (or $\frac{2}{3}$ of a second ). The
astronomers were familiar with far smaller mea-
sures of time. The astronomical Trúti of time
measures about the thirty-four-thousandth part
of a second. This is of special value in deter-
mining the exact character of Bháskara’s claim
to be regarded as the precursor of Newton in the
discovery of the principle of the Differential Cal-

culus, 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's to the conception of a rudimentary process of Integration. Bháskara in computing the "instantaneous motion" (तात्कालिक 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 differentia of the planet's longitude, and Bápudeva Sástrí claims that both the conception of the instantaneous motion and the method of determining it plainly show that Bháskara was acquainted with the principle of the Differential Calculus. On the data before him, Mr. Spottiswoode remarks that Bápudeva Sástrí "overstates the case." Bháskara "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