Iatrochemical and Alchemical Knowledge in Medieval India

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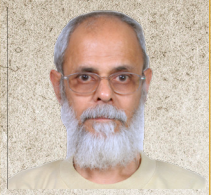

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In this essay, I describe very briefly, the pursuit of chemical knowledge in India until the period of the early eighteenth century. The attempt is not to discuss in any exhaustive way various strands of chemical practices from the antiquity till the late seventeenth century but to offer a glimpse of a variety of chemical endeavours, in different geographical locations of India, visualized from iatrochemical, alchemical and chemical industry perspectives. The first two perspectives also seem to suggest a strong theoretical backdrop of the relevant practices. However, it historically remains an open question how the theory and the practices informed each other if at all it actually happened. The motivation for organizing this essay in the way I have arises from two distinct ideas. The first is to revisit the historiographic insights that late Professor Prafulla Chandra Ray brought to bear in writing a remarkable two volume book titled A History of Hindu Chemistry. I will explain that in a bit more detail below. Second, in engaging with the primarily textual accounts of chemical practices in Ancient and Medieveal India, I stay true to the view that Chemistry is both a science (a body of knowledge about some aspects of nature or the material world) and an art, a set of practices which have a bearing on the kind of knowledge these practices produce including making new materials with interesting functions and properties. Indeed there has been a great deal of interest to review our understanding of Chemistry given that Chemistry is involved in making new materials and molecules. This synthetic and preparative aspect of chemistry (see e.g., Schummer (1997), opens up new historiographical directions to write history of chemistry.[1] I will have a bit more to say about what historiographical repercussion this view has and how I employ it below.

The word Chemistry is translated differently in different languages that are accepted as national languages of India. While most of the languages in India translate the word Chemistry as Rasāyana, interestingly in Tamil the relevant word is Vetiyiyal. For the purposes of this essay, I will stay close to the word Rasāyana, although in Malayalam, the word is Rasatantram. The phrase *tantram* vis-vis śāstra is an important indicator for the subject matter of chemistry (Rasāyana) in India as it evolved for at least twenty five hundred years.

The general framework of this essay has several aspects. First, to paraphrase Thomas Kuhn, an adequate history of chemical practices in India needs to embrace a perspective that underscores what it was like to think chemically in a period when the canons of chemical thought were very different from those current today.[2] Second, the separation of the theoretical and practical seems to be a reasonable construct given the socially, politically, economically and culturally stratified society in India in the ancient and the medieval periods. (This stratification is still quite prevalent in the modern India but that is a different matter). Although it will be a reasonable question to ask how the separation was viewed and addressed it would be extremely difficult to hazard a guess at this point of time when the intricacies of the social, economic, political and cultural positions of various groups of practitioners in those periods remain quite unaddressed even today. Third, the subject matter of pursuit of chemical investigation was to be the material structure of the world and the causes of material transformation. And (chemical) practitioners engaged primarily in practical manner and at times in a theoretical manner.

For chemical knowledge to be useful as a practical art, a specific methodology needed to be used to organize and tabulate the observations of chemical phenomena, so that the general rules could be arrived at for subsequent use. These rules would legitimize the inquiry concerning the nature of chemical operations and also the nature of the objects of chemical investigations.[3] And the content of these rules would be to lay down the procedures which could be employed in actual practical context and often be couched in terms of 'powers'. Suppose we want to know how a specific medicine works. We need to disclose the powers of the ingredients of the medicine upon which the specific powers of the medicine depend. Thus, it is necessary that analysis of that medicine be a process of reduction of that medicine into its parts, of the separation of the contents and the identification and establishment of their specific powers by the investigator.

Medical Knowledge Systems and Rasāyana

Given the picture above, there are many important features that follow. I will illustrate this very briefly in the context of two seminal medical texts, ***Caraka Samhitā*** (hereafter CS)[4,5] (a text from probably the late BCE era approximately third century) and ***Suśruta Samhitā*** (hereafter SS) (a text from probably the third or the fourth century CE era).[6,7] The reason for looking at these texts is that these provide us with textual support for a strand of chemical practices – the iatrochemical practices. One could say that these two texts offer a glimpse of scientific practices in Ancient India. One should recognize that the textual accounts of CS and SS were influenced by the didactic enterprise of the authors and their roles as physicians. The fact that they wanted medical (including iatrochemical) knowledge to be understandable and useful to various members of their audience, which included students aspiring to be physicians, and thereby students of practical chemical arts, and probably some traders, led to the detailed discussion of various kinds of substances and operations. A brief summary of some of the salient features of CS and SS follow to highlight the empirical basis both in terms of observations and in terms of interventions (active engagements) that underlie this body of medical and to a lesser extent iatrochemical knowledge. It also brings out clearly that there is no mention of Mercury (male principle) and Sulphur (female principle) as a part of an over-arching Theory as one comes across in later alchemical texts quite often. This is not to deny that mercury or sulphur might have been employed for specific medicinal purposes.

A list of medications and procedures show that there are twenty four types of gruel preparations consisting mainly of plants although in some there is presence of animal parts, thirty two powders and pastes based on plants. There is mention of six hundred evacuative drugs which are derived from the latex, root, bark, leaf, flowers and fruit of plant drugs:

There are 133 formulations of (madan) phala, 39 of devadālī, 45 of kaṭutumbī, 60 of dhāmārgava, 18 of kuṭaja, 60 of kośātakī, 110 of śyāmā and tṛivṛt, 12 of āragvadha, 16 of lodhra, 20 of snuhī, 39 of saptalā and śaṅkhinī and 48 of dantī and dravantī. These are six hundred evacuatives. (CS, Bk.I. Ch. IV, Verse 4)

There are ten groups of major decoctions (mahākaṣāya); each is constituted by a varying number of kaśāyayonaya, totalling fifty. These kaśāyanas each is constitutive of ten plants, the total number of plants being 500. (CS, Bk. I. Ch. IV, Verses 8 – 18; and 21 – 22)

Plant substances are divided into fifty groups according to the physiological actions of their decoctions. There are 177 medicinal substances of animal origin, 341 medicinal plants and plant products, 64 mineral substances of mineral origins, 44 physico-chemical operations, and 25 physical operations.[8]

The Medical texts of ***Āyurveda***, (CS) and (SS) also deal with Vājikarana (increasing virile power) and Rasāyana (increasing longevity). A number of compositions and practical procedures are mentioned in both texts. The elixirs are produced by elaborate methods and largely herbal.

It also needs to be mentioned that the practitioners of medicine in India continued to develop use of newer herbs, drugs and techniques and formulations. Sharma (1981) argues that in the northern India "there was a cultural upheaval starting from the Gupta period and culminating in the late medieval period in which ancient atharvans, buddhists, saivas, saktas and alchemists joined together and formed a tantrik culture" which had a significant impact on the medical field.[9] "A new branch, now known as 'Rasa – śāstra' was developing during this period in which mercury and its various combinations with other metals began to be used as drugs in various disorders."[10] Sāraṅgadhara in the thirteenth century A.D. combines the older traditions of drugs with the new metallic combinations. His ***Sāraṅgadhara Samhitā*** although preceded by Sodhala's work (***Gadanigraha***, Vol. I, Chowkhamba Sanskrit Series, Varanasi,1938) of the twelfth century C. E. in the same direcion, remains a significant improvement on the materia medica and pharmacy of that time. The improvements include introduction of new indigenous plants as drugs,[11] introduction of new therapeutic uses of indigenous drugs,[12] propagation of locally available herbs in rural areas for medicinal purposes in those areas,[13] use of animal products,[14] formulation of new group of drugs,[15] introduction of poison and psychotropic drugs,[16] and in the use of metallic and mercurial preparations by including brass which was later replaced by Zinc.[17] His contribution to systematization of medieval pharmaceutics is recognized as the model that is worth emulating.[18] During the medieval period, a large number of Āyurvedic texts were available which introduced a large number of drugs that are not described in the earlier Āyurvedic texts. For details about these texts and the specific drugs see e.g., Sharma and Sharma,[19] Chauhan and Singh,[20] and Chopra.[21]. This

gives us good reason to believe that the medicinal explorations and alchemical explorations benefitted from each other through this interaction. White similarly mentions that Rasaśāstra continues as a subfield of of Āyrurveda even today and has incorporated many of the old alchemical formulations, procedures, apparatuses, and nomenclatures into its production of plant based and mineral based pharmaceuticals for therapeutic use.[22]

These medical and alchemical texts were written for a diverse audience. The audience consisted of patrons, apothecaries, merchants, and students who were interested in a career in medicine or other branches of practical knowledge. These texts therefore had to serve several functions. These included discussion of speculative and theoretical principles, as well as detailed accounts of various physical and chemical operations suited to merchants, to apothecaries, and to other groups. These texts include very detailed accounts of instruments such as furnaces, vessels etc. that are to be used for various specific chemical operations. What is important is that the theoretical account of the subject matter occupies a very small part of these texts. The percentage of the text devoted to the theoretical part is probably around ten percent.

The detailed enumerations of the processes, the outcomes of those processes, were a summary of chemical investigations and a guide to future research and commercial exploitation – especially in various chemical industries including those involving metallurgical processes, but primarily in medicine. An important example of alchemical investigation being useful for industrial purposes is Zinc extraction in the medieval period. A substantial reorganization of chemical operations had taken place over the millennia. Medical and alchemical knowledge were responding to various kinds of audiences. Besides 'philosophical / theoretical aspects of knowledge', there were other conceptions of rasāyana specific to specific groups of people. These can be categorized as applied chemical (rasāyana) knowledge, commercial chemical (rasāyana) knowledge which involved the use of earlier knowledge and sometimes theoretical knowledge to support, and improve trades, and other economic activities. These required application of these above mentioned branches to the particular uses of different groups. Rasāyana (Chemistry) therefore needs to be conceived also in relation to its social and economical role.

The ancient and the medieval period in India has been of less interest to historians of chemistry in India than the succeeding era of the emergence of "modern" chemistry, with its familiar chemical elements, compounds, structures , syntheses, and equations. Recent research, although extremely limited and sketchy,[23] has underscored that this period (although spanning at least two thousand years) in the history of chemistry in India deserves a very thorough investigation in its own right.

An Historiographical Outline

In the Indian context, the first and still the most influential writing has been ***A Concise History of Science in India***, published in 1971 and reprinted in 1996.[24] The book still remains an important sourcebook for the history of various scientific disciplines in India (from Antiquity to the Modern period). The relevant entries for the History of Chemistry are B. V. Subbrayappa's (on Physical World Views and Concepts which include Atomism of Kanāda as well as on Chemical Practices and Alchemy) and R. C. Majumdar's (on Medicine). However, prior to that there is the two volume books by Professor Prafulla Chandra Ray titled ***A History of Hindu Chemistry.***[25] Subsequently a redacted version of the two volume book was authored by Priyadaranjan Ray and published in 1956 with a title ***History of Chemistry in Ancient and Medieval India.***[26] The focus of these two books had been to bring to the notice of all (including the International historians and practicing chemists) that Indian chemical knowledge in the past had been substantial especially in the iatrochemical tradition, alchemical tradition, and industries. There are several important historiographical studies on Ray's seminal contribution to History of Indian Chemistry (See e.g., Chatterjee and Sen;[27] Raina[28] and Raina.[29]

Taking a cue from Ray's life as a chemist and his substantial work, this essay explores primarily two of the three strands of Indian chemical knowledge – iatrochemical knowledge, alchemical knowledge and chemical industries e.g. metallurgical, glass, dye, rockets etc. The idea of a chemical industry in the Ancient and Medieval period would be quite different from what we may have of the same in the twentieth and twenty-first centuries. A few observations will be made later when we look at a very restricted example set of chemical industries of the ancient and medieval periods. This historical research on chemical knowledge in the Ancient and the Medieval periods attempts to eschew the progressivist and the presentist perspectives. The attempt, taking a cue from Ray's own work, is to engage in a serious and sympathetic study and assessment of these domains.

P. C. Ray and his work may be profitably understood as exemplifying three strands of intellectual engagement. The first is of course his pioneering work in several areas of modern chemistry. A quick summary of his work one can find in James Poskett's recent book titled Horizons[30] (See also Raina[31] and Chatterjee and Sen[32]) He established the very first School of Chemistry in India and successfully supervised research in chemistry in Calcutta University. His collaborators and students went on to contribute in teaching and research in twentieth century chemistry and build a vibrant chemical community with the participation of others across India. This was Ray and his connection with modern science. But Ray was also a historian and an industrialist. He worked for fifteen years alongside his teaching and pursuing research in chemistry to produce two volume work on ***A History of Hindu Chemistry*** (vol. I, in 1902, and vol. II, in 1909). The scholars have suggested that Ray's investigations in the history of chemical work in India might have influenced his choosing a problem related to the synthesis of mercurous nitrite. His establishment of Bengal Chemical and Pharmecutical Works Ltd., was an attempt to develop chemical industry in India and employ among other ideas the chemical insights from the ancient and medieval chemical knowledge claims especially iatrochemical ideas. Raina[33] suggests that Ray pioneered a new historiography of science and was probably the first to develop the language of social history of Indian science. Ray's several years long epistolary exchanges with the French chemist and historian of chemistry Marcelin Berthelot (Ray dedicated his second volume of the History of Chemistry to Berthelot) seem to bring out that Ray was not a revivalist wanting to highlight and bring back the golden age of Hindu India. Suffices it to mention that Ray also published "Chemical Knowledge of the Hindus" in ***Isis*** (the only journal of history of science published from Boston with George Sarton being the editor) in 1911[34]. To employ Kulkarni's classification, Ray was straddling between suggesting that pre-British India had a thriving science and technology tradition although lost its way about because of debilitating casteist society and initiating an Indian tradition of modern science and technology.[35]

The iatrochemical and alchemical scholarship of the past forty years has started to undermine the traditional perspectives leading to search for those items which can be read off or can be read into the modern chemical knowledge. (The presentist strategy) Instead it has begun to widen its inquiry to include iatrochemical and alchemical practices and knowledge to highlight how these practices were intertwined. White suggests that "Indian Alchemy was a body of religious practices and techniques" but

"linked to a number of scientific disciplines – metallurgy, traditional Indian medicines, iatrochemistry (rasa śāstra, the science of essential substances), rejuvenation therapy (rasāyana, the path of essential substance), transmutational alchemy (dhātuvāda, the doctrine of the elements), elixir alchemy (dehavāda, the doctrine of the body)."[36] Indeed as mentioned above rasāyana historically arose from the medical delineation between curing a disease and rejuvenating the human body. The latter is the purview of rasāyana / rasaśāstra. The meaning of the term rasāyana underwent change and the term also evolved as rasaśāstra with the attendant change in how to practice the same and the place of minerals and metallic substances in such practices. The idea of rejuvenation applied to human body (a part of nature) opened up the possibility of transmutation of base metals to gold. This will suggest that iatrochemical and alchemical traditions need to be relooked including the work on chemistry of materials. Hence, the meaning of 'alchemy' is open to review. And an alchemist is now probably to be viewed as an artisanal expert. The alchemists played a significant role in generating and disseminating relevant knowledge claims in diverse domains of plants, minerals, and metals and ways of preparing diverse kinds of materials for medical and other purposes including metallurgy, sustenance of healthy body, and even perfumery. The chemistry of the medieval period was a technoscience (to borrow a terminology from the twenty first century), a hybrid of science and technology that engendered a host of instrumental, and experimental endeavour.

White's suggestion is that the alchemists worked out an operational view of their work based on some aspects of Sānkhya philosophy. The present world is a result of disintegration of the Universe into twenty five categories (tattvas). These can be reintegrated back into their higher evolutes. Thus, earth, the lowest of the five gross elements (mahābhutās) has the potential to be reintegrated into ether, the highest element in the series through the intermediate elements, water, air and fire. This same capacity applies to the hierarchical elements (dhātus) of alchemy. Thus, in the alchemical text, ***Rasahṛdaya Tantra*** (hereafter RT; Author Govinda, 10th C.E.) one finds claims like the following: "Woody plants are absorbed into lead, lead into tin, and tin likewise into copper. Copper [is absorbed] into silver, silver into gold, and gold is absorbed into mercury". (Ch. I, verse 12)

A complementary interpretation of the relation between the alchemical tradition and the Sānkhya philosophy is, however, available. It holds that the alchemical work and texts arose in the Tantrik tradition. This tradition was supposed to be more socially inclusive unlike the traditional caste hierarchies in the Indian society. It was committed to the principle of the unity of humans and nature. This notion of unity is cashed out in terms of the view that the human body is to be conceived as a microcosm of the universe. There are therefore two aspects of the Tantrik world view. One concerns the external aspect towards the universe and the other the internal aspect and is connected with the human body. Both the medical and the alchemical traditions focused on the latter in terms of making the body disease free and the seat of enlightenment. In the medical tradition, it acknowledged that knowledge of human body and the external material world is a sine qua non for an adequate understanding of the functioning of a human body. And this knowledge is about the material principles (the pañca-bhūtas: earth, water, air, fire and ākāśa) that constitute the human body and the external world and the process of material transformation. A corollary that is drawn from this view and that everything in nature is made up of these five principles although in different proportions, is the thesis that in medicine "There is no substance in the world which cannot be used for some medicinal purpose."[37] There is a long list of animate and inanimate substances and their products that are recommended for various medical purposes.[38] At the end of the list, the text points out that it is impossible to enumerate exhaustively. Hence, the physician needs to judge an entity, that (s)he has not come across thus far, by its qualities and also take into account local wisdom where such substances are found.[39] This lends credence to the view that the practitioners were open to new knowledge to be gathered through engagement with the world. The Tantrik tradition consisted of both "occult practices and practices that are supposed to help attain the perfect and enlightened state of body and mind (siddhi)."[40] Ingestion of compositions (elixirs or rejuvenators) constituted of mercury, sulphur, mica and other ingredients was supposed to help attain siddhi.

The Alchemical Tradition

Rasāyana is a rejuvenation therapy which, includes the internal use of elixirs, affords long life. Thus it is claimed in the ***Caraka Samhitā***:"Long life, heightened memory and intelligence, freedom from disease, a healthy glow, good complexion, a deep, powerful voice, great bodily and sensory powers, the capacity to see one's pronouncements realized, respectability, beauty-all these does one obtain from rasāyana. It is called rasāyana because it is a means to replenishing the rasa and other dhātus of the body."[41]

In the Āyurvedic context, the rasāyanas are the elixirs the physician employs in rasāyana therapy and the term rasāyana emerged as a term for alchemy. This "way of rasa" was a mercurial path since rasa, was identified with mercury, the transmuting element par excellence. White also considers another possibility for the "alchemical" use of the term rasāyana. This was the compound rasa-rasāyana, which was employed, in Hindu and Buddhist sources alike, as far back as the second century CE., to signify the supernatural power (siddhi) of alchemical transmutation and bodily transubstantiation.[42] Subsequently, with the alchemical Tantras of the ninth - tenth century C.E., the "laboratory methods for transmutation first come to be discussed systematically, under the heading of rasāyana". It is also in this later period that there are references to alchemical practitioners as Rasa Siddhas and to the alchemical doctrine that Madhava terms "Raseśvara Darśana".[43]

Roy has brought out a tentative list of various rasaśāstra texts, in Sanskrit language, that are available in diverse collections India wide. The list has approximately forty entries. She mentions that there are several Sanskrit texts with title like Pārada, Gandhaka, Dhātu, Dhātuśuddhi, Jārana, Yantra etc. which have not been included in the list. Besides there are several texts in Vernacular literature like Bengali, Gujrati, Oriya, Malayalam, Marathi, Tamil, and Telugu. Also, some Tantrik alchemical treatises have been translated in Tibetan scriptures ***Kanjur*** and ***Tanjur***, and in the Tamil composition of Sittars (the Sanskrit word is Siddha the alchemy practitioners).[44]

A few well known and translated (either in English or in another Indian language) rasaśāstra texts are mentioned below with their approximate date when they became available for either circulation or at least for some kind of didactic purposes. ***Rasendra Mangala*** (8th century C. E.; hereafter RM); ***Rasārnava*** (10th century C. E.; some scholars date it to 12th century C.E.; hereafter RA); ***Rasa Hṛdaya Tantra*** (12th century C. E.; hereafter RHT); ***Rasa Ratnākara*** (12th century C. E.; hereafter RR); ***Rasopaniṣad*** (12th century C.E.; hereafter RP); ***Rasendra Cūdāmani*** (12th / 13th century C. E.; hereafter RC); ***Rasaprakāśa Sudhākara*** (13th century C. E.; hereafter RPS); ***Rasa Ratna Samuccaya*** (13th century C. E.; hereafter RRS); ***Rasendra Sāra Samgraha*** (15th century C. E.; hereafter RSS); and ***Rasa Taranginī*** (20th century C. E.; hereafter RT). The alchemical texts mentioned above can be grouped as early texts (e.g. ***Rasārnava***; RA; ***Rasa Hṛdaya Tantra;*** RHT); texts that are dated to be from 12th century / early 13th century C. E. (e.g. ***Rasa Ratnākara;*** RR;

Rasendra Cūdāmani; RC); *Rasaprakāśa Sudhākara;* RPS); and texts that are dated from the latter half of the 13th century C. E. (e.g. *Rasa Ratna Samuccaya;* RRS; *Rasendra Chintāmani*, RCH) Although there is disagreement among scholars about the exact dating of these texts, it is agreed upon by most scholars that RA and RHT are from earlier group of texts, while RC and RPS follow the early group and RRS follows RC and RPS. This agreement is based on the best textual and literary evidence. A few of the above texts will be employed to develop a better understanding of alchemical / chemical practices

In most of these above mentioned texts, there is a mention of sixteen principal mineral reagents which are generally divided into eight mahārasas and eight uparasas. These contribute to the transformative powers of mercury. *Rasendra Cūdāmani* (RC) also provides an Āyurvedic usage of the compound rasa-rasāyana, which it uses to designate a mercurial elixir that is highly effective both therapeutically and alchemically.[45] This is another example of the Āyurveda and rasa-śāstra practices influencing each other especially during the medieval period.

Most of the rasasāśtra texts mentioned above introduce two important terms. These are lohāvedha, the doctrine that deals with purely alchemical work such as transmutation of lower metals into higher metals and dehavedha, the doctrine of the iatrochemical preparations for therapeutic purposes. White correctly brings out the insight that the lohāvedha aspect of alchemy, is "propaedeutic to dehavada alchemy, the alchemy of elixirs of bodily immonality".[46] The textual support for such a view is available in several treatises. "As in metal, so in the body. Mercury ought always to be employed in this way. When it penetrates a metal and the body, [mercury] behaves in an identical way. First test mercury on a metal, then use it on the body. " (RA, *Rasārṇava* 17.165: yathā lohe tathā dehe kartavyaḥ sūtakaḥ sadā) [47] The RRA (*Rasa Ratnākara* of Nityanātha) explains rasendra, the "lord of rasas" (one of the five names for mercury), in similar fashion: "It is called rasendra because through its proper use, both metals and the body become possessed of rasa."[48]

For reasons unknown to us there was, in the north Indian heartland at any rate, a gradual shift of emphasis, from the thirteenth century onwards, away from the goal of bodily immortality and towards a more therapeutic use of mercurials and other "elixir" preparations. Here, rasaśāstra ("mercurial science") came to apply the scientific discoveries and techniques of tantric alchemy to the Ayurvedic discipline. So it is that the internal application of mercury and other mineral and metallic rasas would come to constitute a subdivision of Ayurvedic rasāyana. It is in this subordinate form, as Ayurvedic pharmacy, that tantric alchemy-which gave up nearly all pretension, by the fourteenth century, to being a path to immortality-has persisted over the centuries and continues to thrive down to the present day throughout India.[49] Joshi makes essentially the same observation in the introduction to his translation of the text *Rasaprakāśa Sudhākara*.[50]

All these texts have something in common. As mentioned above, all draw distinctions between lohāvedha and dehavedha. However, while for the early texts the focus is primarily on lohāvedha, the middle era texts focus on both lohāvedha and dehavedha. The texts from the period of late thirteenth century, e.g., RRS focuses in a limited way on lohāvedha and primarily upon dehavedha thereby signalling a clear shift to iatrochemical practices. And this focus remains unchanged till the twentieth century text (RT). An exception to this general trend of the alchemical texts focusing both on lohāvedha and dehavedha, there is *Rasopaniṣad*, a text probably written between 11th and 13th century C.E., which focuses only on transmutation of metals. It is one of the largest texts on alchemy during the medieval period.[51]

A little digression on the issue of transmutation of metals is in order just to provide a glimpse of the techniques, processes and the materials employed to transform base metals to higher metals according to the alchemists. Joseph Needham had studied Chinese alchemy extensively and had identified the gold-making (or aurifaction to use his terminology) in different categories according to the processes involved in them.[52] These are:

Uniform substrate alloys
Surface layer enrichment by addition
Surface layer enrichment by withdrawal
Surface film formation
Some other special cases

In *Rasārnavakalpa*, the processes involve making uniform alloy or the formation of gold-coloured films on other metals or alloys. Processes of Gold and Copper alloy are mentioned in verses 599 and 762. Processes of preparation of Gold, Silver and Copper alloy is mentioned in verse 81. Processes of making copper and silver alloy are mentioned in verse 473 and those of making gold and lead alloy are mentioned in verse 184. Similarly various aurifaction processes used in *Rasārnavakalpa* are documented in Deshpande.[53]

Keeping in mind that all these texts hold that mercury is an important component in preparing the elixirs which when ingested lead to siddhi, there is an emphasis of making various preparations using mercury, gandhaka (sulphur), abhraka (mica) etc. Subbrayappa holds that these texts signify "a systematic treatment of new knowledge of rasa (mercury) and other substances and their iatrochemical aspects. Same is the case with tamil siddha (sittar) texts".[54] The materials used in alchemical practices include minerals (gems and metals are subclasses), a large variety of plants, and animal products. More than two hundred names of plants are mentioned in various texts. The roots, leaves or seeds are used for the material digestion process. Among the animal products, the flesh, excreta, and some parts of their bodies are mentioned across various texts.[55] The use of plant products and animal products resonates with the medicinal formulations that one sees prescribed in the CS and the SS. Metals were called dhātus with mercury being an exception. It was called by various names like pārada, sita, rasendra etc.

The alchemists held that minerals and metals would not acquire the desired iatorchemical properties or transmuting powers unless these were treated with medicinal plants. Even mercury had to be treated with a variety of plants. But more importantly, mercury needs to be freed from doṣas (imperfections) for it to be ready to perform its chemical work in either context. And for that mercury needs to be treated with mahārasas. In *Rasārnava*, there is a list of eight mahārasas – abhra (mica); vaikrānta (kinberlite dust); māksikā (pyrites); vimalā (chalco-pyrites); adrija (bitumen); sasyaka (copper sulphate or a compund of copper); and capala (zinc carbonate).[56] The rasa-śāstras also mention what are known as uparasas. These are also employed to remove doṣa from mercury. These are again primarily minerals. These include gandhaka (sulphur), gairica (haematite and red ochre), kāsīsa (iron compound), kāṅkṣi or tuttha (alum), tālaka (orpiment or arsenic trisulphide), añjana (stibnite or antimony compound), śilā (realgar) and kāṅkuṣṭha (rhubarb). In some texts, the last one is not included.

Mercury was subjected to eighteen kinds of samskāras or processing so that it would become free from imperfection and would be highly potentiated to perform the lohāvedha or dehavedha actions. A brief description of the alchemical samskāras are as follows:[57]

These eight samskāras serve to purify and detoxify mercury such that it may be used internally in the treatment of diseases.

Indeed RRS being a text primarily of the iatrochemical group highlights these eight samskāras. What we find is that in the earlier texts the following eight samskāras are also mentioned. Thus, RA or RC or RPS devotes substantial discussion on the next eight samskāras which

1. Svedana literally means "sweating".	It involves heating mercury in a water bath together with plant and mineral substances.
2. Mardana literally means "rubbing,"	It involves grinding, of steamed mercury in a mortar, together with plant and acidic substances.
3. Murcchana literally means "fainting"	It involves grinding mercury, in a mortar together with vegetable matter, until it loses certain naturally occurring toxins, impurities, and defects.
4. Utthāpana literally means "resurrection"	It involves steaming of murcchita mercury with alkalis, salts, and plant matter and by rubbing it in the open air. And mercury recovers the brilliance, etc. it had lost in step 3.
5. Pātana, literally means "distillation"	It involves "distillation" of mercury obtained in step 4.
6. Bodhana, literally means "awakening,"	It involves restoration of its "virility" (virya) through irrigation in a salt bath.
7. Niyamāna, literally means"regulation"	It involves reducing the motility of mercury raising its temperature of evaporation and rendering it lustrous in appearance. This is done by soaking mercury, in a bath of alkaline and herbal substances and then steaming it.
8. Dīpana, literally means "kindling"	It involves enhancing mercury's potency and luster through steaming in an alkaline bath. This operation is said to kindle mercury's desire to "consume" other metals.

potentiate mercury to transmute metals and to transform a human body into an alchemical body through the last two samskāras.[58]

Gold, silver, copper, and iron were considered as pure metals while tin and lead were considered odorous (pūti) and inferior. The alloys used were bronze, brass and bell metal. All the known gems were employed. *Rasārnavakalpa* describes forty different types of transmutation processes and also the same number of longevity compositions. The text also describes 29 kalpas, where kalpa means 'that which is capable of performance by its own potency'.[57] The text describes 29 kalpas: two deal with sulphur and arsenic sulphide; the rest are description of the efficacy of about a hundred plants. These plants are classified as divyauṣadhi and trṇauṣadhis or adivyā.

The alchemists were experimentalists with skills to use known processes and develop new processes. They had expertise in handling metals, minerals and plants. Since their work involved a variety of processes, they were adept in setting up rasaśālās or laboratories. A number of apparatuses, instruments have been mentioned in the texts. The processes include heating, steaming, distilling, triturating etc. Dolā yantra and swedanī yantra are appartuses used for heating chemical substances.

Similalry, Distillations were performed by various apparatuses.

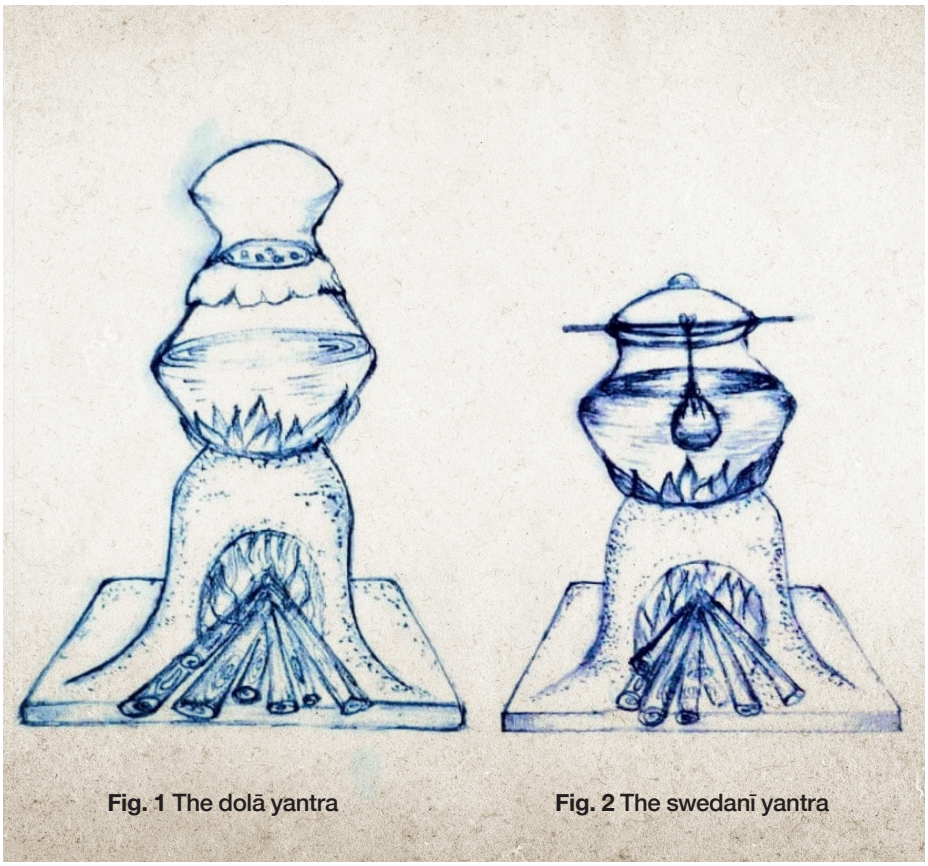


Fig. 1 The dolā yantra

Fig. 2 The swedanī yantra

The apparatuses were made of clay material, though some apparatus made of iron and glass have also been mentioned in the literature. These processes were used for both lohāvedha and dehavedha purposes and also for preparing the starting ingredients for the processes that are to be employed for lohāvedha and dehavedha purposes. The Figures are inspired by secondary source materials.[60]

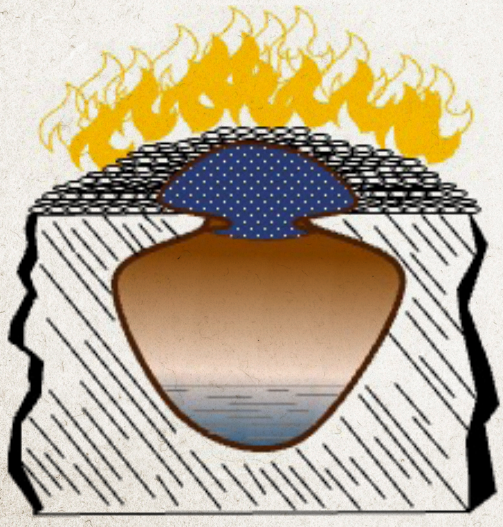


Fig. 3 The ardhapātana yantra

Fig.4 The Tiryakpātana yantra

I end this section with the observations that it would be quite unhelpful to employ the modern categories of chemical science to try to even sympathetically understand the large body of knowledge and practices that the alchemists produced, validated, and disseminated. Instead, it will be helpful to know "how alchemical knowledge was gained, lost, preserved, and circulated". Consider the eight mahārasas that were mentioned in all the alchemical texts. A list from the text *Rasārnava* was mentioned above. Joshi[61] has given us a very useful table in which he lists around twelve minerals and shows that the different texts enumerate a different list of mahārasas. The list from one text is slightly different from the next. This shows that there was no single paradigm which connected the knowledge claims of diverse practitioners. A part of the diversity may be explained in terms of the milieu temporal, spatial and otherwise. But this only shows that knowledge was fluid, open to change and there was both loss and gain of practical insights. Consider also the text RC. Written during the 12th and early 13th century C. E., it includes a chapter on initiation of student. This explicit attempt suggests that dissemination of knowledge was an important consideration within the alchemical community of practitioners. This chapter brings out the financial difficulty an alchemical practitioner will face in pursuing this artisanal trade. Since this tradition is based on employing mercury as the chief material actor, and India does not have a ready supply of mercury and it has to be imported, the economic cost of learning and subsequent pursuing is high. The RRS suggests how the students should choose their teachers who can properly initiate them to the tradition. The treatises also seem to suggest that alchemical knowledge was treated as a set of skills and procedures that required specific kinds of artifacts such as instruments and substances that gained prominence over time and might have lost part of that prominence as well over time. This is because knowledge need not always be something that represents the world but arises as a result of something the artisans do or did. From this perspective, history of alchemical knowledge is a history of the material culture of that time. The number of substances in the plant domain, or in the mineral domain were overwhelmingly large and their use in experiments and the kind of experiments the alchemists actually did to manipulate them are therefore not just a handful. For example, in RPS, the whole of chapter 8 is devoted in describing 103 distinct operations with the detailed descriptions of the ingredients and the methods of preparation of *rasayogas* (the herbal medications for a variety of diseases). The chapter 9 of RPS lists 64 herbal plants or parts of plants, Divyauṣadhis, which are to be used for bandhana (solidification) of mercury. There is a list of 68 Rasauṣadhis, herbal plants or their parts which are to be employed for the māraṇa, jāraṇa, and niyāmana samskāra of mercury. A list of 68 Mahauṣadhis, herbal plants or parts of plants, which are to be employed for the sūta bandhana and māraṇa processes of mercury, Finally, in the same chapter, there is a list of 68 Siddhauṣadhis which ensure success in mercurial operations. This is a very extended list of herbs available in the plant kingdom. The list is much longer when one consults RRS. For example, it lists 325 herbal drugs for therapeutic purposes. Therefore, there is the expanding array of substances and compounds. And herbs might have to be sourced (sometimes through buying) and therefore would have to be sold by reliable suppliers in the service of alchemical knowledge. It should be remembered that from practical engagement point of view minimally the goal of alchemical practices were therapeutic. And hence servicing such social and cultural goals through preparing and administering medication would require both the practitioners and the recipient of the results of the practice or being a part of the network of health providing practice recognize that the substances and the instruments used to study and manipulate them are also objects of society, culture, and commerce besides being objects of nature.

One interesting issue that arises in the context of looking at only texts to get a sense of alchemical practices is that these texts are written in Sanskrit, the language of the upper caste and literate. The most of the practitioners of alchemical work did not come from this group. Their lingua franca would

probably have been Prakrit, Apabhramsa, Pali (a language in which several alchemical texts were translated and were available in present day Tibet), to name a few, in the northern part of India. In the southern part of India, by the medieval period, the language spoken by people at large would be vernacular (Tamil, Kannada, Telugu, Malayalam etc.). It therefore raises the question about the nature of the interaction between the alchemists and the physicians and the others and the locus standi of the texts among the practitioners.

Theoretical issues concerning the nature and hierarchy of material substances range from the challenges of identifying relevant substances derived from the venerable texts in the earlier era to delineating the natures of the tangible materials used in the laboratory and in commerce. The role of instruments for studying and manipulating chemical substances is of significant importance. Of particular note are the dynamic interactions between the artisanal craftsmen of these instruments and the rasavadins who commission and employ them. Equally interesting will be to attend to the laboratory or rasaśālā as described in the texts. The rasaśālā is organized in a particular way. However, there are differences between the descriptions in two texts separated by a century or so. This leads one to recognize that there are significant learning and dissemination of artisanal knowledge as well as bringing in change. Thus, in RC the rasaśālā is organized in the following way: A statue of Lord of rasaśāstra is to be installed on the east side.[62] Processes involving the use of fire will be performed in the south-west side. Processes involving poisonous drugs will be performed in the south side. Cutting herbs etc. will be performed in the south-east side. Drying will be performed in north-west side. Transmutation will be performed in the north side. Collection and Preservation of final products and raw material will be in the north-east side. In RRS, (see Figure 5) there are a few instructions of setting up a rasaśālā and some of these do not overlap with the ideas described in RC. In RRS, the furnace etc. is on the north-west side (unlike the suggestion in RC). The stone instruments are to be located in the south. However, RC suggests that poisonous drugs related work should be in the south side. These differences suggest a new set of ideas of constructing a rasaśālā has slowly emerged. Some of the old ideas have been forgotten or eschewed. The artisanal knowledge has evolved. We do not have any detail about whether any reason was offered for the interesting changes suggested for the construction of the rasaśālā.

The issue of alchemical pedagogy, academic and artisanal, naturally leads to the consideration of the construction and delineation of an "authority" or "expert," and who was recognized or certified as the authoritative possessor and imparter of chemical knowledge, both natural knowledge (and practice) and artisanal knowledge. The term like "expert" is of recent origin, at least in English. A term like 'authority' probably would be more in tune with the milieu of the medieval period. In fact the term that is often employed while addressing some of the authors of the texts or the 'experts' mentioned in the texts is Āchāryā. An Āchāryā is not merely an adept or an 'expert' but is also a wise person. Since an alchemist is also a physician or at least a producer of substances for therapeutic purposes, the responsibility for producing drugs with therapeutic efficacy needs to be felt by the actor and act accordingly. The success bestows authority on the alchemist and this authority is ethically imbued. The question will be can we recognize our alchemical actors as mere experts or being different like a wise interlocutor with nature and people. Who would be considered an authority or an Āchārya and why requires more engagement and elaboration.

Conclusion:

There were varieties of chemical industries across different parts of India and at different times. Thus, glass production units producing mostly beads were known to be quite numerous being as many as 123 sites between 300 BCE and 400 CE and 72 sites between 400 C.E. and 1300 C. E.[63] War rockets Technology depended upon a superior knowledge of gun power and a good

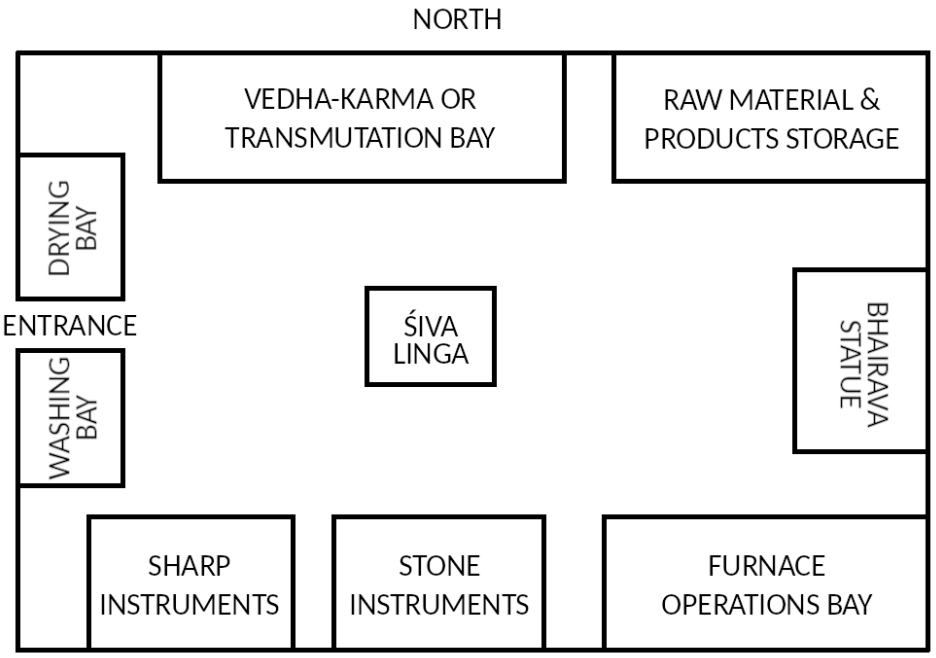


Fig. 5 Diagram of the Rasaśāla suggested by the text Rasa Ratna Samuccaya

With permission from Indian Journal of History of Science. Biswas, A. K., (1987), Rasa Ratna Samuccaya and Mineral Processing State - of - Art in the 13 Century A.D India, Indian Journal of History of Science, 22 (1), 29 – 49. p. 44.

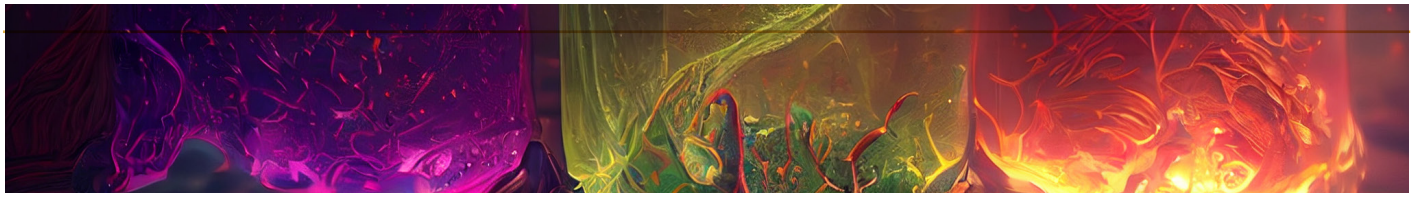
metallurgical background especially in Iron Technology. The oldest rocket that is kept in the Calcutta Museum is dated to be from the Mughal emperor Akbar's time. Interesting aspect of this technology is the confluence of knowledge of two groups of artisans – gun powder producers (more like producers of saltpetre and the metal workers adept in iron technology.[64,65] CS mentions 84 kinds of alcoholic liquors. The process of distillation is also taken up. There is enough evidence to suggest that there were several alcoholic fermentation processes and products available in Ancient and Medieval India.[66,67] There was and continues to be a very widespread dye making and dyeing technologies in India. A preliminary introduction to these processes of dye making and dyeing technologies have been discussed by several authors.[68-72]

There had been smelting technologies for copper, iron, tin, zinc, brass, and bronze material production.[73-78] Biswas suggests that some of the alchemical work like that of the RRS had spilled over to metallurgical industries especially in Zinc manufacturing.[79] Craddock[77] also explores the possibility of there being exchange of ideas between some alchemical texts and the practices in metallurgy. He relies on various examples that P. C. Ray mentions in his two volume books on history of chemistry. Although the evidence at this point is sketchy a more detailed investigation of various metallurgical processes and the processes in the alchemical texts may throw more light on the possibility of interaction or lack of it.

I mention these technologies first for the obvious reason that these involve chemical knowledge although not obviously rasāyana as mentioned in the sections above. However, keeping in mind that these technologies were artisan driven, it would be quite instructive to know and understand how knowledge claims in each of these domains were generated, validated, and disseminated. And whether the artisan groups interacted among themselves in any significant way much like the example of war rocket technology. It would also be important to know what were and are their social and economic classes. That may give us an idea whether the caste structures among the various artisan groups aided or hindered possible interaction. How did they interact with the larger world of commerce, and if such interaction brought about any change in their practices and the attendant body of knowledge. Ethno-archaeological investigations can throw important light on the social and economic contexts of such knowledge production. Since the practitioners were artisans they wuld have been at the lower strata of the society and culturally excluded from the domain of the elites. Thus, as a general methodological insight, Kosambi had suggested at least forty years ago that paying a serious attention to the tribal or similar artisanal groups would help the researchers in understanding both the social organization and the nature of knowledge in that organization.[80] This is also borne out by some archaeologists' comments. Thus, Shrivastava points out that "the pre-historic working still continues in remote parts of the country even today"[81] Prakash makes the point about artisanal classes working out their social and knowledge legitimacy through mythological stories stating their relationship with God from the ancient times.[82] I quote somewhat extensively,

"(S)urvey of the ethnic groups that practice iron smelting which include Munda and Birjiya of Bihar, Mundiya and Agariya of Madhya Pradesh and Bastar, Oraons of Jharkhand and other subgroups settled in other parts of the country seem to show that the ancient iron smelting practice as well as old religious traditions to continue till today. The iron smelting tribes of these regions are Saivaits and they worship Lord Shiva according to the Tantric cult. Indeed there are variations of the stories of the ancestors and their connection to Asura tribes and their specific deities. These stories reflect the various tribes providing a spiritual leading to a social legitimation of their status and their work since they were often outcasts or belonged to the lowest group in the hierarchy."

The artisans often appeal to their specific lineage to Gods and Goddesses through a constructed story to give their artisanal class a social standing and also to establish a class and community identity and thereby help retain the secrets of technological practices and knowledge within the community. This formation, retention, and transmission of local knowledge within a community across various artisanal groups form a basis of chemical practices and knowledge in the Ancient and the Medieval periods. Srinivasan gives the example of Aranmula mirror makers in Kerala who are pursuing their metallurgical work and aesthetic mirror polishing work even today to highlight this point.[83] These examples alert us to the fact that indeed Indian scientific and especially the chemical tradition in the Ancient and the Medieval periods is quite complex and needs to be inquired into.



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41. See Note 4: Bk. 6. Ch. 1. verses 7-8.
42. See Note 22: p. 182.
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46. ***Ibid***.
47. See Note 22, p. 188.
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57. See Note 22, pp. 186 – 188 for more details. What is interesting about the terminology for the smaskāras is that each is a process to make mercury for alive and active. Its living principle is being awakened. It is important to note that that each of these processes is an action that a medical expert or a physician performs on a person who has a disease or a doṣa. And each process is expected to produce some psycho-physiological experience in the patient be it a human being or mercury. The similarity or the sameness with a medical concept is striking and requires a deeper investigation. It probably signals closeness between two modes of thinking – the medical and the alchemical (especially the mercurial, medical, transmutation of metal, and transformation of human body.)
58. ***Ibid***., p. 187. See also Note 50; pp. S29 – S43 for a more detailed and slightly different descriptions of eighteen samskāras. These samskāras are: 9. Grasa māna – adding a measured quantity of essence of abhraka; 10. Cārana, - assimilation by mercury; 11. Garbhadruti, - internal processing; 12. Bāhyadruti, - external processing; 13. Jāraṇa, "digestion" or "assimilation" into mercury. This samskāra is also employed for making herbal medication as well. 14. Rañjaña, "tinting" or "coloration," involves the heating of mercury with "seeds" of gold, silver, copper, sulfur, mica, and salt, such that mercury takes on the natural colors of the minerals it has absorbed or swallowed; 15. Sārana ("flowing"), potentiating mercury in preparation for transmutation, is effected by heating it in oil into which molten "seeds" of metals, diamond, etc. are poured; l6. In Krāmana ("taking hold, "progression"), mercury is smeared with a mineral and herbal paste and heated in a putā such that it becomes capable, as a transmuting agent, of penetrating both metals and bodily tissues. The last two samskāras are: 17. Vedhakarma ("transmutation" of metals); and 18. Sevana ("transformation" of human body),
59. See Note 40, p. 272.
60. See Note 40; Joshi (2001) in Note 50; and https://artsandculture.google.com/story/VAVBaP1RF0y-KQ?hl=en
These figures were redrawn by Ms. Bhagya, Mr. Mohan Pillai, and Dr. Aswathi.
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