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INTERACTION IN CHEMISTRY AND MEDICINE BETWEEN INDIA AND EUROPE IN 18th–19th CENTURY

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From prehistoric times, the curiosity of man, the *Homo sapiens*, has continuously led to accumulation of knowledge and power in human societies encompassed by geographical or political frontiers. Knowledge and power conjointly lead to the development of Science. "Man" has learnt a lot from "Nature". Nature to be commanded must be obeyed ; that which in contemplation is the cause, that in operation is the rule. This has been the underlying principle of scientific inventions and their utilisation into the development of various technologies for welfare or warfare.

Scientific knowledge developed in a particular country has traversed over a period of centuries to far distant lands, only to come back to the lend of its origin where it was eclipsed. Knowledge of astronomy, mathematics, laws of matter and energy, biology and reproduction, chemistry and medicine, developed in ancient India as early as the pre-Aryan period, gradually diffused into the civilisations of Babylonia, Mesopotamia, Greece and Rome in the Pre-Christian and later to the Arabs through whom the Indian Science reached Europe in the Post-Renaissance period, only to come back to India, of course modified and some times enriched, through our political interactions with the Portugese, French and English colonial powers during the eighteenth nineteenth centuries.

Studies on Modern chemistry or the *Rasāyanea* as the Hindus called it and *Khymiya* of the Arabs and Alchemy of the Greeks and Romans were essentially motivated by the desire to acquire superior metals for warfare, currency and ornamenents ; search for Philosopher's Stone which would turn base mètals into gold and 'Elixir of Life' for longevity and eternal youth. Therefore, the contention of this paper is to present the inter-actions between India and Europe during the 18th-19th century in the chemistry of metals, fermentation, medicinal plants, natural and synthetic dyes. It will also be our endeavour to trace the influence of these developments in India during the 18th-19th centuries on our present day attitude, in scientific research and management.

METALS

As early as the Pre-Harappan period (4000—2000 B.C.) and during the Indus Valley Civilisation, the Indians had developed skills to purify copper to the extent of 96.67%, casting and forging of metals and the use of copper-arsenic alloy as substitute for bronze and the use of gold, silver and gold-silver alloy. Later, during the Vedic period, the use of iron, *kṛṣṇaya*, was developed. By the end of the fifteenth century, chemical technologies for the production of copper, gold. silver, mercury, lead, tin, antimony, zinc, iron and their various alloys, alkali and salts and oxides of these metals and their use in medicine were prevalent in India[1]. In Europe. "platinum" was discovered in 1750 by Watson and chromium in 1797 by Vaquelin, although the use of other metals and their compounds as known to the Indians, was also prevalent. In the nineteenth century, Davy discovered sodium, potassium, calcium, strontium, barium, magnesium and boron (during 1803-1808). Later many metals were discovered in Europe during the nineteenth century and their chemistry was studied.

In 1766, Cavendish was the first to identify hydrogen as a definite substance and called it "Phlogiston". In 1783 Lavoisier named this gas as hydrogen. During the second half of the nineteenth century Lord Rayleigh and Sir William Ramsay discovered the inert gases : helium, neon, argon, krypton and xenon. In 1894 Lord Rayleigh obtained nitrogen from air, as well as from the oxides of nitrogen and from urea by the action of hypobromate.

These researches in Europe initiated a phenomenal development of organic, inorganic and physical chemistry which indirectly influenced India. Dedicated persons who were the pioneers in developing science in India went to Britain to learn chemistry. Aghore Nath Chattopadhyay, (the father of the Nightingale of India, Mrs. Sarojini Naidu) and Acharya Sir P. C. Ray received D. Sc. degrees in chemistry from the University of Edinburgh in 1875 and 1887 respectively. Dr. Aghore Nath Chattopadhyay after his return to India, joined the education department of the Nizam of Hyderabad and did not take up any significant part in research. However, it was left to Acharya P. C. Ray who dedicated his life for the cause of science to plant the sapling of chemical research and industry in India during the last phase of nineteenth century. Throughout his life he nurtured this sapling which has now grown into a banyan tree, whose prop root has developed into a big tree *"Quot Rami Tot Arbores"*.

The worthy students of the worthy 'master,' Acharya P. C. Ray assisted their teacher with their untiring efforts to develop various branches in the School of Chemistry. Amongst them the names of Professor Nil Ratan Dhar, Sir J. C. Ghosh and Dr. J. N. Mukherjee deserve mention. In 1891-92 Dr. P. C. Ray, started the "Pharmaceutical Industry" later known as "The Bengal Chemical and Pharmaceutical Works." with the preparation of sulphate of iron from scrap iron and sulphuric acid. This chemical (sulphuric acid) had just begun to be manufactured in Cossipore (near Calcutta), by D. Waldie and Co. Daird Waldie was born in Linlethgow, Scotland and was associated with the discovery in 1847 of the anaesthetic properties of chloroform, and had come to Calcutta in 1853. The production of other items which Ray took up were Phosphate of Soda and Super Phosphate of lime, Potas Nitrates, syrup Ferri Iodidi, Liquor Arsenicalis, Liquor Bismuth etc., extracts of *kalamegh* (*Andrographis paniculata*), *kurchi* (*Holarrhena antidysentrica*), syrup of *Vāsaka* (*Adhatoda vasiea*) and *Ajowan* water (*Aqua Ptychotis*) etc. Thus the Bengal Chemical and Pharmaceutical Works, Calcutta which is a living testimony to the industrial foresight symbolising the patriotism of Acharya P. C. Ray came into existence. Similarly the establishment of Tata Iron and Steel Company by Sir Jamshed Jee Tata, and a series of collieries were the initiation factors in the process of industrialisation now functioning in India.

FERMENTATION

There is sufficent evidence to prove that the art of brewing and fermentation was highly developed in India during the Vedic age. Fermented drinks *Gouri* prepared from sugar-juice, *Madvi* from the sweet flowers of *Bassia latifolia* and *Paiṣṭi* from rice and barely cakes, had been popular in India. In the *Ṛgveda* references to the use of fermented beverage *Soma*, prepared from juice of *Soma* plants are well known. In *Suśruta Saṃhitā*, the word *Kohala* has been used for an alcoholic beverage made from powdered barley. Arabic term *Al-kohala* and the modern term alcohol seem to be of the same origin as the sanskrit word *Kohala*[2]. The use of curds, or fermented milk, involving lactic acid production, as we understand today, was also common in India, but it seems that the use of fermented drinks from grapes became popular only after India came in direct contact with the Greeks. However, when Europe came into power, the use of fermented drinks prepared according to indigenous technologies, was relegated to lower strata of the Indian Society. The kings, and their nobles started the drinking of imported wines, beers and spirits. This had a hampering effect on the Indian Economy.

Indian System of Medicine and Plant Chemistry

From the times of Āyurveda upto the Arab invasion the Hindu System of Medicine flourished in India and permeated far and wide into Egypt, Greece and Rome. Later during centuries of our interaction with the Arab civilisation, the Hindu Medicine influenced that system of medicine which was later called the Tibb or Unani system. By the end of the sixteenth century both the Āyurvedic and Unani systems had interactions and were, being liberally used for the health needs of the Indian people. With the development of pharmacological and pharmacognostic sciences in Europe in the nineteenth century, the therapeutic efficacy of many plant extracts used in the Indian system of Medicine and in folk-lore medicine of other 'Colonies' of the European powers was established, e.g. presence of pharmacologically active alkaloids in several species of *Rauwolfia* was observed by Greshoff[3]. *Cinchona* preparations were introduced into medical use in Europe, through the efforts of Countess of Chinchon, wife of Spanish Viceroy in Peru, who in 1638 was successfully treated for malaria by administration of Cinchona extract. The great demand for *Cinchona* alkaloids in Europe resulted in extensive and successful cultivation and breeding of *Cinchona* in India.

This gave impetus to isolation of chemically pure and crystalline alkaloids with distinct therapeutic activity. The pain killing principle of opium namely morphine was isolated by Thrommsdroff[4]. It will be pertinent to mention, here that, opium, the crude extract of *Papaver somniferum* (*Khas Khas*) was being used for centuries in India as medicine and intoxicant. Almost all the Moghul Emperors, with the exception of Aurangzeb, were in the habit of drinking wines mixed with opium. Intensive chemical investigations by Gomes in Portugal in 1810 and by Pelletier and Caventon[5] led to the isolation of pure quinine and cinchonine.

Isolation of pure compounds, having distinct and definite therapeutic activity, and elucidation of their chemical structures invariably led to their partial or total synthesis. Introduction of synthetic drugs in the market, automatically affected adversely the requirement of medicinal plants or their extracts and thus started an era of dependence of India on Europe and America for drugs. A list of Indian medicinal plants (not exhaustive) is presented in Table 1. Active principles of some of these plants were isolated by the end of the nineteenth century while those of the others had to wait until the present times. The point to be emphasised here is that traditionally accepted therapeutic values of Indian medicinal plants and their confirmation by modern pharmacological and chemical methods, stimulated intensive research on plant chemistry in Europe, India and elsewhere during eighteenth-nineteenth centuries and the following period.

Certain parts of many Indian plants, have been traditionally used as spices, condiments, colouring and flavouring agents in Indian dieteries as well as in some of the preparations used in the indigenous systems of Medicine. The quest for the "land of spices" was one of the dominant factors in the exploration of the "New World". Trade in spices led to colonisation of tropical and sub-tropical countries by European powers, viz. Spanish, Portugese, Dutch and British. Although, the active principles of spices might not have been isolated so far, their chemistry had attracted considerable attention during the nineteenth century and the following years, while essential oils or extracts of many of the spices find use in many commercial preparations in Europe and India. A list is given in Table 2.

Dyes and Clouring Matters

The history of dyes would run parallel to that of spices. Portugese, Dutch and British, since happy at sea, brought a number of oriental products to the European market in the thirteenth to sixteenth centuries. The most common dyeing materials were obtained from *Quercus fenestrata, Rubia cordifolia, Indigofera tinctoria, Alkanet tinctoria, Cessalpinis sappan, Lawsonia inermis, Gamboge* (plants of *Garcinia* spp.), *Cutch* (plants of *Acacia* spp.), saffron and turmeric. Some of the plants were used in combination, e. g. *Butea frondosa* with *Nyctanthis arbotristis*, and *Bixa orellena* and *Caesalpinia sappan.* The history of dyes will not be complete if the 'King of dye stuffs', viz. Indigo from *Indigofera tinctoria* is not discussed. It is more so because the cultivation of Indigo was stretched in 48750 acres in Saran[6], 60000 acres in Champaran[7] and 1500 acres in Monghyr districts in and around 1880-1881[8]. The cultivation was controlled by the East India Company, exploiting the local labour and earning more than £100,000 per year. With the discovery of synthetic indigo by Huemann in 1890, the indigo cultivation in India collapsed and was subsquently stopped. That the Indian products were of considerable importance were shown by the fact that in 1631 about 333,000 lbs of indigo were exported to Holland from India equivalent to 3/4th million dollars. The indigo was in competition with woad (*Isatic tinctoria*) and the influential lobby of woad observed that the use of indigo was prohibited over the entire European continent for over a century. It may be quoted here from a promulgation of 1577 in England, concerning indigo... "prohibited under the severest penalties in the newly invented harmful, balefully devouring, pernicious, deceitful, eating and corrosive dyes known as the devil's dye...used instead of woad".[9] A local law in Neuremburg required dyers to take an annual oath that they would not use indigo. Yet, because of its merits and in spite of all attempts to discourage its use, by the middle of the seventeenth century indigo had become the most popular dye. Indigo is thus one of the examples which clearly showed that the colonists were never interested in the development of indigenous materials. What they could not achieve in the agriculture sector, finally succeeded in synthesising in laboratories. Until 1884 there was no synthetic dye which could be used for dyeing cotton. The synthesis of indigo by Heumann in 1890, alizarin by Graebe and Liebermann in 1860, Congo red by Bottinger in 1883 and mauvinee by Perkin in 1873 (Table III) revolutionised the whole dye industry and almost replaced the natural dyes.

Socio Political Conditions

During the first half of the eighteenth century, the Mughal Monolyth of power was shattered. Regional Rajas, Nawabs and the European traders were fighting and intriguing against each other for achieving the trade monopoly in the subcontinent. However, inspite of this chaos, the Indian system of Education, through the *Maktabs*, *Gurukuls*, and *Pathshalas* remained intact. Education was more widespread than in the twentieth century[10].

The *Hākims* and *Vaidyas* and the *Maulavis* and *Paṇḍits* had access to repositories of our heritage in science and medicine, through their knowledge of Sanskrit, Persian and Arabic. The priests of village temples were capable of looking after the health of poorest of the poor. Even then surgeons of the East India Comany were not hesitant to learn surgery from their Indian counterparts[11]. India had a flourishing trade in spices, essential oils, indigo and crude drugs.

Implantation of Western Science and Education

In 1833, the British Parliament made the East India Company responsible for all aspects of government and administration on behalf of the Parliament. The famous controversy between the orientalists represented by Sir William Jones and anglicists represented by Lord Macaulay and Raja Ram Mohan Roy, about the system of education to be adopted in the Indian domains of the Company ensued. Ultimately the English system of education came into force in India. The Hindu College was established in Calcutta in 1835 for "teaching European languages and science". St. Joseph's College, Tiruchirapalli (1844) and St. John's College, Agra (1850) were started by the Christian Missionaries. In 1854 the Agra Medical School came into being.

The last attempt of India to throw the British Yoke in "1857" failed. As if, it were a mockery of circumstances, that in 1857, three Indian Universities were established at Calcutta, Madras and Bombay to provide *"a regular and liberal course of education by conferring academic degrees as evidences of attainments in different branches of art and science"*. Later in 1882 the Punjab University was established at Lahore and the University of Allahabad, at Allahabad in 1887. The Plague Research Laboratory (later to be known as the famous Haffkine Institute) was started in Bombay in 1886.

Thus European science was transplanted in India during the nineteenth century. Macaulay's pious expression of good will towards the Indian subjects of the British Crown apparently materialised, but in reality both the Government of England and of India, "had taken every means in their powers of breaking to the heart the words of promise they had uttered to the ear".[12] Simultaneous with the creation of these government sponsored scientific institutions, the pioneers of Indian Renaissance—dedicated and proud of cultural and scientific heritage of India, made sustained efforts for creation of scientific institutions with national outlook. In 1876. Dr. Mahendra Lal Sarkar, with the help of the rich citizens of Bengal, started the Indian Association for the Cultivation of Science in Calcutta. The great reformist and educationist, Sir Syed Ahmad Khan, a contemporary and friend of Ghalib, was responsible for the creation of the Muhammadan Anglo Oriental College, Aligarh in the year 1875.

The idea of establishing the Tata Institute, Bangalore (now known as the Indian Institute of Science) was conceived by Sir Jamshed Jee Tata in 1898, for fundamental research on various disciplines and their applications for the benefit of the people at large, the Institute ultimately came into being in 1909.

Retrospection and Perspectives

In spite of interactions in science between India and Europe during the eighteenth-nineteenth centuries, the present day infrastructure of science in India is not in continuity with the cultural heritage of our country. It is a transplant from Europe. It is not possible at this stage to evaluate the benefit arising out of these interactions. During eighteenth and nineteenth centuries, India was under the grip of corrupt feudal and colonial systems of government. But the then scientists of our country were free from corruption and their thoughts and ideas penetrated deep into our culture which infused in them missionary zeal, and social commitment. Hence, the achievements of Bose and Ghosh, Ramanujan and Raman, Saha, Sahni and Mitra in tbe twentiteh century were possible. Feudal and bueraucratic values have crept very much in the science of post independence era. Therefore, the future of Science in India will depend upon how far the Indian Scientists are able to get rid of the adverse effects arising thereby.

TABLE I

Some Important Plants That Are Used By Those Practising Āyurveda and Unani System of Medicine

Name of the Plant	*Active Constituent*	*Reference*
1. *Ammi visnaga*	Khellin	Fieser and Fieser. *Organic Chemistry*. Reinhold Publishing Corpn. 1956. pp. 818
2. *Atropa belladona*	Atropine	Ladenburg, *Ber. 12*, 941 (1876)
3. *Cannabis sativa*	Cannabinol, Cannabinin	Chopra, *Glossary of Indian Medicinal Plants*, CSIR, 1956 pp. 48.
4. *Cassia angustifolia*	Sennosides	Dragendorff and Kubly, *Z. Chem.* 411 (1866).
5. *Coptis teeta*	Berberine	*Wealth of India. Raw Materials.* CSIR, II, 322. (1950).
6. *Cinchona succirubra* *Cinchona ledgeriana*	Chinchonine	Hess, *Ann,* 205, 322 (1880) ; *Ber, 28*, 1301 (1895).
7. *Datura stramonium*	Hyoscyine	Ladenburg, *Ber. 12*, 941 (1876).
8. *Digitalis lanata*	Digitoxigenin	Jacobs and Gustus. *J. Biol. Chem. 78*, 573 (1928).
9. *Ephedra vulgainsris*	Ephedrine	Ladenburg and Oelschlagel *Ber, 22*, 1823 (1889).
10. *Erythoxylum coca*	Cocaine	Nuemann, *J. Prod. Pharm, 9*, 489 (1860).
11. Ergot (Parasitic fungus)	Lysergic acid	Jacob, Ph.D. Thesis Rockfeller Institute, Berlin, 1883.
12. *Holarrhena antidysentrica*	Steroid alkaloids	Favere, Haworth, Mckenna, Powell and Whitefield. *J. Chem. Soc.* 1115 (1953).
13. *Cephaelis ipecacuanha* (Ipecac root)	Emetine	Pelletier and Megendia, *Chem. Phys. 4*, 172 (1817).
14. *Papaver somniferum*	Morphine, Codeine and Thebaine	Gulland and Robinson, *J. Chem. Soc. 123*. 980 (1928).

	Name of the Plant	*Active Constituent*	*Reference*
15.	*Psoralea corylifolia*	Psoralen	Guliand and Robinson *J. Ind. Chem. Soc.* 41 (1933).
16.	*Rauwolfia serpentina*	Reserpine	Wenkert and Bringi, *J. Am. Chem. Soc 81.* 1474 (1952).
17.	*Solanum kharianum*	Steroid alkaloids	Desfosses. *J. Pharm.* 7,414 (1821); Oddo, *Ber*, 62, 267 (1925)
18.	*Strychnos nux-vomica*	Strychnine, Brucine	Robinson, Barkeian Lecture, *Proc. Roy Soc.* (Lond) A130, 430 (1931) *Annual Rev. Bio.*; II, 444 (1933); IV, 497 (1935)
19.	*Vinca rosea*	Vinblastine and Vincristine	Taylor and Farnsworth, *Vinca Alkaloids*, Marcaldekker, Inc. NY. 1973.

TABLE II

Spices And Their Important Constituents

	Name of the Spices	*Constituents*
1.	*Carphyllum aromaticus*	Essential oil, Eugenol
2.	*Cuminum cyaminum*	Essential oil, Cuminol
3.	*Carum carvi*	Essential oi, Carvone
4.	*Carum capticum*	Essential oil, Thymol
5.	*Coriandrum sativum*	Essential oil
6.	*Capsicum annum*	Capsicin, Capsaicin, Solanine
7.	*Curcuma longa*	Curcumin and Essential oil
8.	*Mentha spicata*	Essential oil
9.	*Murraya koenigii*	Essential oil, glucoside
10.	*Papaver somnifernm*	Alkaloids
11.	*Piper nigrum*	Alkaloids and Essential oil
12.	*Pimpinella sativum*	Essential oil and anethole
13.	*Trigonella foenum-graecum*	Saponin and alkaloid
14.	*Zingiber officinale*	Essential oil
15.	*Ferula asafoetida*	Resin

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TABLE III

Synthetic Dyes Discoverd During The Nineteenth Century

	Name of the Dye	*Discoverer*	*Year*
1.	Trypan Red	Ehrlich	1854
2.	Cyanine Dyes	Williams	1856
3.	Pararosaniline	Verguin	1859
4.	Alizarin	Graebe and Liebermann	1860
5.	Phenolpthalein	Baeyer	1871
6.	Mauvine	Perkin	1873
7.	Malachite Green	Fischer	1877
8.	Crystal Violet	Kern	1883
9.	Congo red	Bottinger	1884
10.	Indigo	Heumann	1890

TABLE IV

Educational Institutes That Came Into Existence During Nineteenth Century

	Name of the Institutes	*Year*
1.	Hindu College, Calcutta	1835
2.	St. Joseph's College, Tiruchirapalli	1844
3.	St. John's College Agra	1850
4:	Agra Medical College, Agra	1854
5.	University of Bombay	1857
6.	University of Calcutta	
7.	University of Madras	
8.	Muhammadan Anglo Oriental College, Aligarh	1875
9.	Panjab University, Lahore	1882
10.	University of Allahabad	1887
11.	Indian Association for the Cultivation of Science, Calcutta	1876
12.	Haffkine Institute, Bombay	1896
13.	Indian Institute of Science, Bangalore	(Conceived in 1898) 1909.

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