panding or contracting, whereas the general theory of relativity did not naturally produce a static universe. To keep the universe static, Einstein added a constant to his equations, (the 'cosmological constant'), whose value was chosen such as to balance things out and keep the universe static. Shortly thereafter, however, observations established that the universe was, in fact, expanding, and that the cosmological constant was not necessary. Astrophysicists have, ever since regarded the cosmological constant ('Einstein's biggest blunder') as an embarrassment at best and 'theoretical poison ivy' at worst. But the universe is, as Kirshner says, an extravagant place, stranger than our wildest dreams. It turns out that to produce an accelerating universe one does require a cosmological constant, or something very much like it. Excepting, this time, the value of the constant is such that instead of keeping things static, it speeds up the expansion. Of course, to be certain that what the observations point to is a cosmological constant, one needs to understand supernovae~Ia well. Perhaps, there is no cosmological constant, but instead distant supernovae are just different (and dimmer) from nearby ones. Perhaps, there is some obscuring material between them and us which makes the supernovae appear dimmer. Or perhaps, with your distaste for philately, you have got supernovae of different types (and hence different intrinsic brightness) adulterating your sample. Kirshner's book gives a cogent and interesting account of why it is unlikely that the data are affected by issues of this sort.

In his *Hitchhiker's Guide to the Galaxy* trilogy, Douglas Adams suggests that every major culture goes through three distinct and recognizable phases; those of survival, inquiry and sophistication, otherwise known as the how, why and where phases. For instance, the first phase is characterized by the question, 'How can we eat?', the second by 'Why do we eat?', and the last by 'Where do we have lunch?'. In this scheme, the subculture of popular science aficionados should surely be classified as having reached the sophistication phase. One needs to go beyond describing natural phenomena and offering explanations in accessible terms. Recognizing this, Kirshner, throughout the book, but more so in the latter half, writes also about the real politik of modern astronomy. What happens when two major groups decide to work on the same project? Particularly, when the leader of one group is on the advisory board of the other?

Kirshner leads us through the feints and thrusts of conference talks and referee reports. The subtle and not-so-subtle put-downs at seminars. Issues of priority and credit. The agony and the ecstasy of deciding between whether to rush into print (and risk the danger of being wrong) or to wait for more confirming data (and risk the danger of being scooped). But through all this hurly-burly, it is clear that Kirshner has had a great deal of fun with this project, and that comes through in the book. The prose is vigorous, the tone is lively, the style is amusing. Go read it.

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**A History of Hindu Chemistry. Vol. I and II, Centenary Edition.** Acharya Prafullachandra Ray. Somnath Bal, 86/1 Mahatma Gandhi Road, Kolkata 700 009. 2002. 152 pp. Price: Rs 1050.50.

There is a verse in the *Chandyogya Upanishad* (IV, 17, 7) which states: 'As one binds gold by *lavana* (borax), silver by gold, tin by silver, lead by tin, iron by lead and wood by iron and also by leather… .' The verse is indicative of the status of materials science of the Hindus even in the days of the *Chandyogya Upanishad*, which belongs to the 8th/7th Century BC (at the latest). Several scientific works of this period, such as *Rasaratnakara*, *Rasarnava*, *Rasaratnasamuchchaya*, *Kakachandeswari*, *Rasendrachudamani* and *Rasaprakasasudakara*, describe the practical expertise of the Hindus in such aspects of materials science as calcination, sublimation, distillation, steaming, fixation, etc. *Rasarnava* describes different *yantrams* (instruments) for these operations. The Hindus were also aware of alkaline and acidic materials and that on mixing, they get neutralized. *Rasarnava* mentions a mixture called *Vidas*, which has the property of the aqua regia!

The material prosperity of the Hindus would not have been possible without centuries of development in materials science (chemistry in particular, although not in the way the subject is understood today), even before the Buddhist era. Among the metallurgical skills of the Hindus may be mentioned tempering of steel in a manner worthy of advanced metallurgy and forging a bar wrought-iron pillar (which is close to Kutab Minar, AD 400) larger than any that had been forged even in Europe up to a very late date. Pliny is reported to have stated that the best glass ever made in those days was Indian glass.

In the book under review, the author Acharya Prafullachandra Ray refers to an interesting method of characterization of metals in those days, copper by blue flame, tin by pigeon-coloured, lead by pale tinted, iron by tawny, peacock ore (*sasyaka*) by red (cf. the flame test of present-day analytical chemistry).

The central theme in this book is to establish that the developments in materials science (chemistry) and also in medicine in Hindu India were indigenous. Ray lists a number of works on the subject by Charaka, Sasruta, Vagbhata and others of the pre-Buddhistic era, which have been translated for the Caliphs of Baghdad around the 8th Century. Charaka occupied a place of honour in the library of a cultured Arab. Ray mentions that several Hindus were induced to reside at the court of the Caliphs, as their instructors. Mussalman students, in turn, flocked to the centres of learning in India.

A point of great importance, that Ray makes, is that 'between the period of the *Atharva Veda* and the days of Charaka, there must have been composed several medicinal treatise. Charaka represents only a more or less final development'. At the time of Charaka there existed at least six standard works of Agnivesa, Bhela, Jatukarna, Parasara, Harita, and Ksharapani.

The truth is that till pseudo-Basil Valentine (ca. AD 1600) very little scientific progress was achieved in Europe. On the other hand, the Hindus had the concept of atoms (*anus*) from the early days. Materials were considered as aggregates of *anus*. Kanada maintained the eternity of the *anus*. Ray has an intriguing discussion on *Parimandalya*, a term which indicates a spherical shape (vol. 1, p. 211).

Hindus had expert knowledge in dyes, cosmetics and perfumery; in the preparation of fast dyes for textile fabric by treatment of natural dyes like *manjishtha* with alum.

In the tantric period (AD 1100–1300), chemistry was exploited in magic and in witch-craft. Charms, sorcery, exorcism of diseases by means of amulets were used. Mercury preparations were key tantric medicines. Palming of alloys of base metals, which possess bright yellow lustre, for gold was also prevalent. This according to Ray, has been there in all ages and in all climes.

Hindus reigned supreme in the field of medicine. The popularity of *ayurveda*, the Hindu system of medicine, continues from the days of the *Atharva Veda* to the present. Ray establishes convincingly that before the birth of Hippocrates, the Hindus had elaborated a system of medicine based upon humoral pathology. Some of the legendary names in the Hindu medical field are Charaka, Susruta, Vagbhata, Madhava, Sarngadhara, Vrinda and Chakrapani. *Rasaratnasamuchchaya* was a systematic and comprehensive treatise in materia medica, pharmacy and medicine. The medical works of Vagbhata (2nd Century BC) and Nidhana were translated by the order of the Caliphs of Baghdad in the 8th Century.

I would mention here an interesting medical preparation, an iron tonic. The preparation is interesting because it would suggest to a modern chemist that some metal complexes had been formed to which could be attributed the medicinal property. The procedure is as follows. A thin iron plate is to be made red-hot and plunged into a decoction of the myrobalan, cow's urine, a solution of 'the salts', a solution of the alkalies extracted from the ash of *Butea frondosa* (one of the above liquids at a time). When the iron becomes black like collyrium, it is to be powdered.

The development of chemistry (materials science) in ancient India, perforce, was empirical; by trial and error methods, presumably, monitored for specific performance. The preparation procedures for a drug had strict regimens. Serendipity must have played its role in the discoveries. No characterization of the compounds responsible for an activity, was attempted. It would not have been possible in those days. Perhaps, the very concept of associating a single medicinal property with a single compound was not there. In later years, the Hindus did not persist with their experimentation on the materials science. Their bent of mind was more towards spiritual quest; perhaps, on the realization that material prosperity led nowhere to inner peace.

Ray's book has extensive Sanskrit texts on chemical and medicinal literature, which must have been gathered painstakingly*. His work is indeed a labour of love, love for India's hoary past. Ray, quite often, digresses on the philosophy of the Hindus.

The book includes two articles, by B. N. Seal; one on the mechanical, physical and chemical theories and the other on the scientific methods of the Hindus.

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**Editorial note:* See *Resonance*, 2001, **6**, 97 also available at http:// www.ias.ac.in/resonance/Jan 2001/pdf/Jan 2001 p95-98.pdf


**Imitation in Animals and Artifacts.** K. Dautenhahn and C. L. Nehaniv (eds). The MIT Press, 5 Cambridge Center, Cambridge, MA 02142-1407, USA. 2002. 607 pp. Price not mentioned.

Imitation – the ability to recognize and reproduce others' action – is one of the most important mechanisms whereby knowledge is transferred between individual agents, whether they be animals (including humans), or computational agents and robotic autonomous systems (collectively referred to here as artifacts). Although traditionally, imitation, as a behavioural phenomenon and cognitive process, was largely studied by ethologists interested in animal behaviour, imitation has, of late, been attracting the attention of computer scientists and engineers typically interested in artificial intelligence (AI). Today, spurred on its way by current trends in multidisciplinary research, it is likely to be of interest to psychologists, ethologists, philosophers, linguists, cognitive scientists, computer scientists, mathematicians, biologists, anthropologists and roboticists.

The reason for this paradigm shift is not too difficult to find. Imitation, apparently a simple process when viewed outwardly, involves the interaction of perception, memory and motor control – subsystems that typically utilize very different representations and that must interact to produce and learn novel behaviour patterns. Gaining insight into the mechanisms of imitation thus becomes compelling from the standpoint of AI and the behavioural sciences. Moreover, the propensity to imitate appears to be innate and the mechanism is phylogenetically ancient, although its true and complete form, it is largely believed, is very rare in nature. From the practical standpoint, imitation, even in its simple forms, is a faster and more efficient form of acquiring new behaviours than are traditional classical conditioning and reinforcement learning; in humans, particularly, imitation is critical during development and remains an important aspect of social interaction and adaptation throughout life.

It is precisely for these reasons that this book provides fascinating material for behavioural and computational scientists and some chapters for interested laymen as well. Born out of the 'Imitation in Animals and Artifacts' Symposium, organized by the editors at Edinburgh, Scotland in April 1999, this impressive collection of papers spans a great diversity of subjects and is likely to be of interest to researchers working in the areas of computer science, robotics, software engineering, comparative psychology, neuroscience, primatology and linguistics. In fact, in my opinion, a self-stated function of the book is likely to succeed admirably – it will bring together this diverse group of people and allow them glimpses into why the other roads not taken are equally fascinating and, perhaps more important, contain signposts they can each learn from.

One strategy that the book thus adopts while presenting an integrated interdisciplinary approach to imitation is that it