Dots, dashes and hydrogen bonds*

Hydrogen bonding is undoubtedly the most widely appreciated non-covalent interaction in chemical and biological systems. Although classified as a 'weak interaction' in textbooks, hydrogen bonding is central to molecular recognition, supramolecular assembly and self-organization in solutions and in crystals. As inveterate readers of the chemical literature, we noticed that there is no uniform notation for representing hydrogen bonds in chemical structures. Publishers like the American Chemical Society, Wiley–VCH, Springer Verlag use a three-dot (···) convention for denoting a hydrogen bond (X–H···Y) in running text. However, some journals and most textbooks do not appear to use this representation, uniformly. Hydrogen bonds appear as solid lines (disguised covalency?) in the *Journal of Chemical Physics*, although another article in the same journal uses the comforting three-dot notation[1,2]. The *Journal of Physical Chemistry* represents hydrogen bonding by three dots in the running text, but succumbs to a single solid line in the title[3]. The *Journal of Biological Chemistry* appears to approve of two dots to represent hydrogen bonds in the running text[4]. Four dot hydrogen bonds appear in the widely used text, *Advanced Organic Chemistry* by March[5], an aberration duly corrected to three dots in the fifth edition of *March's Advanced Organic Chemistry*[6]. *Organic Chemistry* by Finar[7] uses two dashes (– –). In consulting colleagues on the dots, dashes and the significance of their numbers for hydrogen bonds, we realized that this notation may not have been formally used by the International Union of Pure and Applied Chemistry (IUPAC) and that no decrees exist. In reflecting on dots, we note that, two dots vertically arranged represent the covalent bond; a formalism that evolved while G. N. Lewis lectured to undergraduates at Berkeley[8]. Alfred Werner anticipated the three-dot notation, although he used this notation to represent an electrostatic interaction between a proton donor and ammonia, X(H···NH_3)[9]. Maurice Huggins appears to have been among the earliest to use three dots for hydrogen bonds (bridges, at that time)[10]. Two years later, Linus Pauling institutionalized the three-dot representation in his now classic book *The Nature of the Chemical Bond*[11]. Interestingly, many journals and authors appear to have followed this convention (possibly unconsciously), while others seem to have been free to experiment. May be in the not-too-distant future we will see the recommendation of a committee that considers how many dots and dashes make a hydrogen bond.

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Extinction of microbes

The editorial on extinction[1] was both interesting and timely, especially the reference to three microbial pathogens, viz. *Mycobacterium leprae* – the causative agent of obviously the most stigmatized disease in human history, *Helicobacter pylori* – the causative agent of peptic ulcers, and the poxvirus – microbial agent that killed more humans than all the wars put together. Even though microbes are all-pervasive, profoundly affecting humans, animals, plants and the environment, and span the longest history of evolution[2] (more than 3 billion years) among living beings, the principles relating to their evolution (diversification, extinction) are the least understood. It is only in the last decade that we have been able to gauge, with any reasonable accuracy, the magnitude of the diversity of extant microbes. Obviously, the reference here is to the diversity of non-culturable microbes. As regards their nature, all explanations apart, we have no idea if these represent microbes on the verge of extinction. The possible eradication (extinction) of *H. pylori* due to chemotherapy and its effect on the human host cited by Balaram, is only illustrative. The human gut has recently been shown to be the site of several, hitherto unknown, non-culturable forms of bacteria[3]. What effect the widespread chemotherapy currently being practised will have on non-culturable or culturable gut microflora and how it would subsequently impinge on the host need to be investigated. Similarly, the reference to natural extinction of *M. leprae* is also only illustrative. What fate awaits a number of other small-genome microorganisms, viz. rickettsiae, chlamydiae and spirochetes which live obligately in association with eukaryotic hosts also needs to be understood. Recent studies have shown a parallelism between obligatory pathogens and endosymbionts[4]. Bacterial symbiosis is widespread among insects, plants and animals. Endosymbionts are considered key to specialized feeding behaviours and long-term diversification of insects, which constitute the major biota of earth. The association between aphids and an obligate intracellular symbiont *Buchnera aphidicola* has been used as a model system to explore underpinnings of microbial evolution. Using this system, it has recently been shown that genome reduction in such bacteria is degenerative rather than adaptive evolution. This is indicated by erosion of regulatory genes, accumulation of mutations affecting protein stability, pseudogene formation and a continued reduction in replication and repair machinery[5]. The long-term evolutionary consequences of such changes are mutational meltdown and population extinction[5,6]. Studies on comparative genomics of microbes obligately associated with eukaryotic hosts as exemplified above and many more such as mutualistic *Wolbachia* of filarial nematodes, parasitic *Wolbachia* of arthropods, bioluminescent *Vibrio fischeri* of squid host and the classical *Rhizobium* and its ilk may reveal new paradigms of evolution and extinction, and their effects on the hosts. The subject of evolutionary biology of microbes is relatively unexplored and needs further impetus. Thus, it may not only help us to resolve the riddles of the past but also enable us to manage better the future of the biosphere[7].

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Activity index vs standard of science education

Discussions about the standard of Indian journals are not new. In 1990, Ratnakar[1], in his Ph D thesis, analysed the publication policy of Indian physicists such as Raman, Saha, Bose and Krishnan. He found that during 1910–30, most of their findings were published in foreign journals. He also pointed out the problems and suggested solutions to improve the quality of Indian journals[1]. In 1994, Ramaseshan wrote another excellent article[2]. He discussed various issues such as: why do our scientists prefer to publish in foreign journals; why we should not give too much importance to the *SCI*; how we can improve the standard of Indian journals. If the responsible authorities had read these documents and employed the suggestions, most of the later discussions would not have been necessary.

Many articles and letters have been published in previous issues of *Current Science* dealing with the standard of Indian journals and science education in India. I would like to refer to the correspondence by Gupta and Garg showing the activity index (AI) of different countries[3]. With concrete examples from USA and Germany, I would like to show that the Al is not warranted for a good education system at the school level.

The Programme for International Student Assessment (PISA) measures the cumulative educational experience of students from 9th to 12th grade. The programme was designed to measure literacy more broadly, that is, the learning that takes place in and out of school. Out of 30 member countries of the Organisation for Economic Co-operation and Development (OECD), 27 participated in the contest. In 2000, under PISA, 31 evaluated countries also had four non-OECD members, namely Brazil, Latvia, Lichtenstein and the Russian Federation. A table (in: wysisyg://145/http://www.spiegel.de/uni.../0,1518,grossbild-151582-195212,00.html, dated 11 August 2003) shows the ranking of mathematics literacy and science literacy for the 31 countries. In the following discussion the mathematics literacy and science literacy rankings, respectively are given in parentheses. If we compare this study with the AI values given by Gupta and Garg, the following interesting points emerge:

- Though Japanese students are better (ranking 1 and 2) than American (19 and 14) and German (20 and 20) students, yet the AI of all the three countries is nearly the same, i.e. 99, 99 and 98 for Japan, USA and Germany respectively.
- In the case of South Korea (2 and 1) and Australia (5 and 7), the achievements of students and scientists (Al 111 and 101 for Korea and Australia, respectively) are better than those of USA and Germany.
- Though Russian students are worse (22 and 27) than those of USA and Germany, the AI of Russian journals is as good as that of others, i.e., 99.
- AI of Swedish journals is as good as those of USA and Germany, though her students are better (15 and 10).
- Another surprising fact is that a small country – Finland – has the best rank (4 and 3) among European countries.

On the whole, we conclude that the AI does not give the true picture of the education system of a country. It suggests that we need to know more parameters to correlate scientific productivity with the standard of science education.

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