expression (12) for the hardness of diatomic molecules in terms of the electronegativities of the constituent atoms rather than their hardness values. The molecular-hardness values for several diatomic molecules (considered in Table 1) have been calculated using equation (12) and have been reported in Table 3. It provides a new method for calculating the η values for diatomic molecules, and the values compare favourably with other calculated values available[23].

In conclusion, I have attempted estimation of different molecular properties from electronegativities, a widely shared goal of chemists, with better electronegativity values, and these show good agreement. I have also reported improved atomic hardness values, which may be used for calculation of other related properties and in developing[26] the chemical concept of hardness from a more rigorous footing. The near-constancy of λ values for elements of the same group in the periodic table may lend additional insight into the chemical-structure theory of elements.

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RESEARCH COMMUNICATIONS

Do objects in friezes of Somnathpur temple (1268 AD) in South India represent maize ears?

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Spindle-shaped structures in the hands of human figures in friezes in the Somnathpur temple (1268 AD) and other Hoysala temples (eleventh to thirteenth centuries AD) of South India have a striking similarity to maize ears, and hence have been viewed as evidence of cultivation of maize in India in pre-Columbian (before 1492 AD) times. This interpretation has implications for the existence of trans-oceanic trade contacts between the Old World and the New World before Columbus. But the basic assumption that maize ears served as the model for sculpturing these 'maize-like structures' (MLS) has frequently been questioned. We have compared qualitative and measurable features of MLS of Somnathpur temple with those of maize ears. Our data suggest that MLS at Somnathpur temple do not represent maize ears.

Maize is known to have originated in Mexico[1,2] and then to have spread to the Old World following Columbus' voyage to America in 1492 AD. Nevertheless, a few reports propose that maize was being cultivated in the Old World before Columbus[3–8]. These reports have served as a source of the long-standing controversy and 'emotionally charged vehement arguments'[2] regarding the origin and spread of maize. After a critical analysis, Mangelsdorf[2] argued that these evidences were not unequivocal and 'there is no tangible evidence of any kind—botanical, archaeological, ethnographic, linguistic, ideographic, pictorial or historical—of the existence of maize in any part of the Old World before 1492 AD'.

It is in this context that Johannessen and associates[9,10] have suggested that 'maize-like structures' (MLS) in the hands of human figures in friezes in several Hoysala temples of South India are probable evidence of pre-Columbian existence and cultivation of maize in India. Johannessen and Parker[10] conclude, on the basis of several intricate details, including kernel-like carvings, that these structures morphologically represent the maize ear. Their conclusions are, however, based mostly on gross comparisons of MLS and maize ear, for qualitative traits such as shape of MLS and kernels, curving at the tip of MLS, and arrangement of kernels. Most of the characters for which they made comparisons are subjective and not quantifiable, and hence not amenable to statistical analysis. Indeed, in the only quantitative trait they recorded (width/thickness ratio for the bead-like structures or 'kernels' of MLS), MLS were significantly different from maize ears. Payak and Sachan[11] examined 50 friezes in Somnathpur and concluded that the objects resemble some kind of beaded ornamentation characteristic of the Hoysala tradition and that they do not represent maize ears. However, their conclusions also are not based on any quantitative data. Hence the present study.

We recorded length (L) and diameter (D); number of rows (number of horizontal arrangements of bead-like structures or 'kernels') and width (W) and thickness (T) of bead-like structures ($n = 5$ for each MLS); and shape (conical, spindle, cylindrical) of 74 MLS at Somnathpur temple. We recorded similar data for ears of various strains of maize ($n=66$) using photoprints from Mangelsdorf[2], Singh[12] and Wellhausen *et al.*[13] and also for a few specimens of present-day maize. The D/L and W/T ratios for MLS and maize were computed. The means and frequency distributions of the quantitative data were compared using Student's t and Kolmogorov–Smirnov tests respectively; frequencies of shapes were analysed using a chi-square test.

MLS had significantly fewer rows, higher D/L ratio, and lower W/T ratio compared to maize ears (Table 1). The frequency distributions of D/L ratio and W/T ratio of MLS also differed significantly from those of maize (D_{max} for D/L$=0.73$, $P < 0.01$; D_{max} for W/L$=0.31$, $P < 0.01$).

Johannessen and Parker[10] also showed that the Somnathpur MLS have significantly lower W/T ratio than maize ears. They however argued that this might be because the MLS at Somnathpur probably represent ancient maize, whose W/T ratio might be lower than that of present-day maize. In support of this assumption, that W/T ratio of maize kernels has been increasing with time, they provided data on kernels from different strata from the Bat Caves of Mexico. Our analysis of the data, however, indicates that kernel W/T ratio has not increased with time ($b=0.063$; H_0: $b_0=0$; not significant). Thus the claim of Johannessen and Parker that MLS represent maize ears does not seem to hold true on the basis of quantitative analysis.

MLS and maize ears also differ significantly in their shapes (Table 2; $\chi^2=488.87$, $P < 0.0001$). The majority of MLS of Somnathpur are spindle-shaped (70.27%), and rarely cylindrical (1.35%), while the maize ears we examined were mostly cylindrical (66.15%) and rarely spindle-shaped (6.15%). Thus MLS of Somnathpur differ significantly from maize ears in both qualitative and quantitative features.

Chronologically tracing the probable source of MLS of Hoysala temples, we found that such structures are available in Jaina icons in North India of periods as early as the eighth century (e.g. Kubera statue in the temple at Ramanilaya, Chittorgarh district of Rajasthan[14,15]). Jainism originated in North India and slowly spread to South India prior to the fourth century. However, a few Jaina rulers of the Hoysala dynasty converted to Vaishnavism owing to Ramanujacharya's influence[16,17]. Vishnuvardhana (1111–1141) was one such convertee from Jainism to Vaishnavism, and the Somnathpur temple was built under the rule of his dynasty in 1268 (refs. 16, 17). Hence we propose that MLS in South Indian Hoysala temples represent a relic of an unknown cult structure (model/icon) of Jaina sculptures. They perhaps represent the *Kalpa Vriksha* (Figure 1), an important element

Table 1. Comparison of MLS and maize ears for three quantitative characters.

	Maize ears			MLS			
Character	n	Mean	SE of mean	n	Mean	SE of mean	P
D/L ratio	66	0.331	0.02	75	0.542	0.011	0.0001
Number of rows*	50	29.66	1.564	69	12.89	0.47	0.0001
W/T ratio	258	1.587	0.039	365	1.327	0.016	0.0001

*Number of horizontal arrangements of bead-like structures or kernels.

Table 2. Frequencies of different shapes of MLS and maize ears.

	Frequency*	
Shape	Maize Ears	MLS
Cylindrical	43 (66.15)	1 (1.35)
Spindle	4 (6.15)	52 (70.27)
Conical	18 (27.69)	21 (28.38)
n	65	74

$\chi^2 = 488.87$; $P < 0.0001$

*Numbers in parenthesis are percentages.

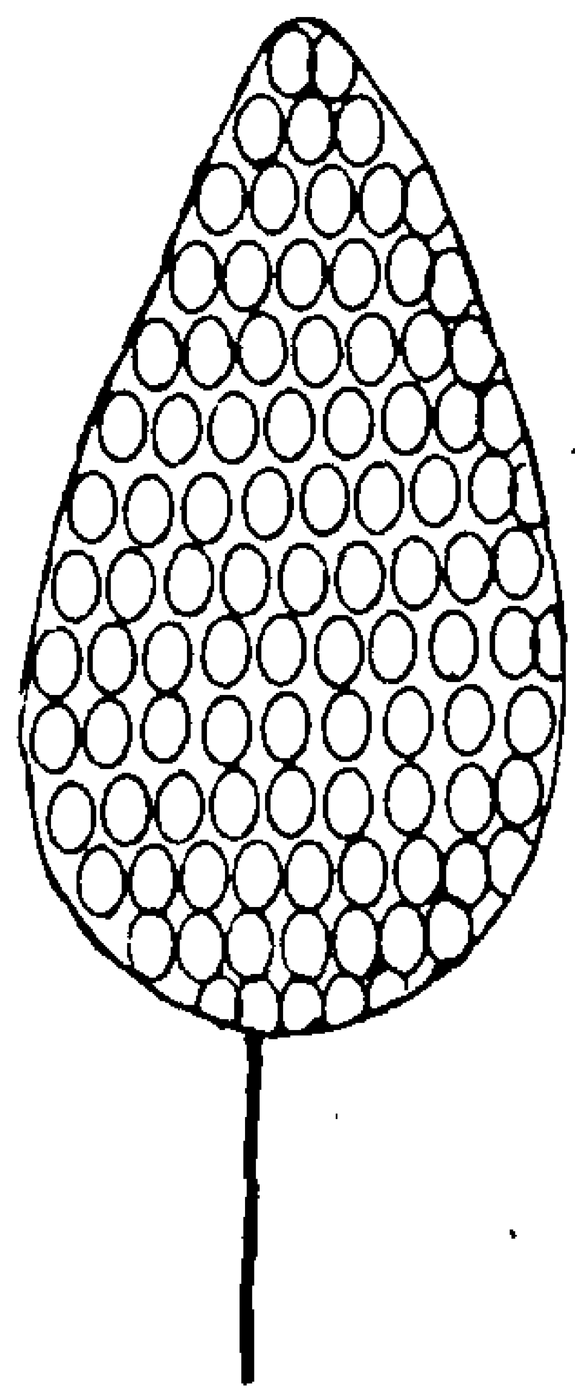

Figure 1. Pen sketch of Jaina *Kalpa Vriksha* copied from Ravikumar (ref. 18).

of Jaina cosmology[18], which has a similar structure. This, however, could not be tested because of lack of sufficient samples. Figure 2 shows chronological changes in D/L ratio of MLS from second-century (Jaina) to thirteenth-century (Hoysala) temples. It can be seen that this ratio has drastically decreased over a period of time. We propose that these MLS represent an entirely different model of Jaina culture whose D/L ratio was high. When this cult structure from North India was copied in South Indian temples (probably as a result of some Jaina kings converting to Vaishnavism) a 'copy error' was probably incorporated over a period of time, leading to a resemblance to maize ears.

Thus it may be inferred that the MLS at Somnathpur do not represent maize ears. Hence the implication drawn thereupon that maize was being cultivated in South India in pre-Columbian times cannot be unequivocally supported on the basis of these structures; nor trans-oceanic trade contacts between the Old World and the New World during pre-Columbian times.

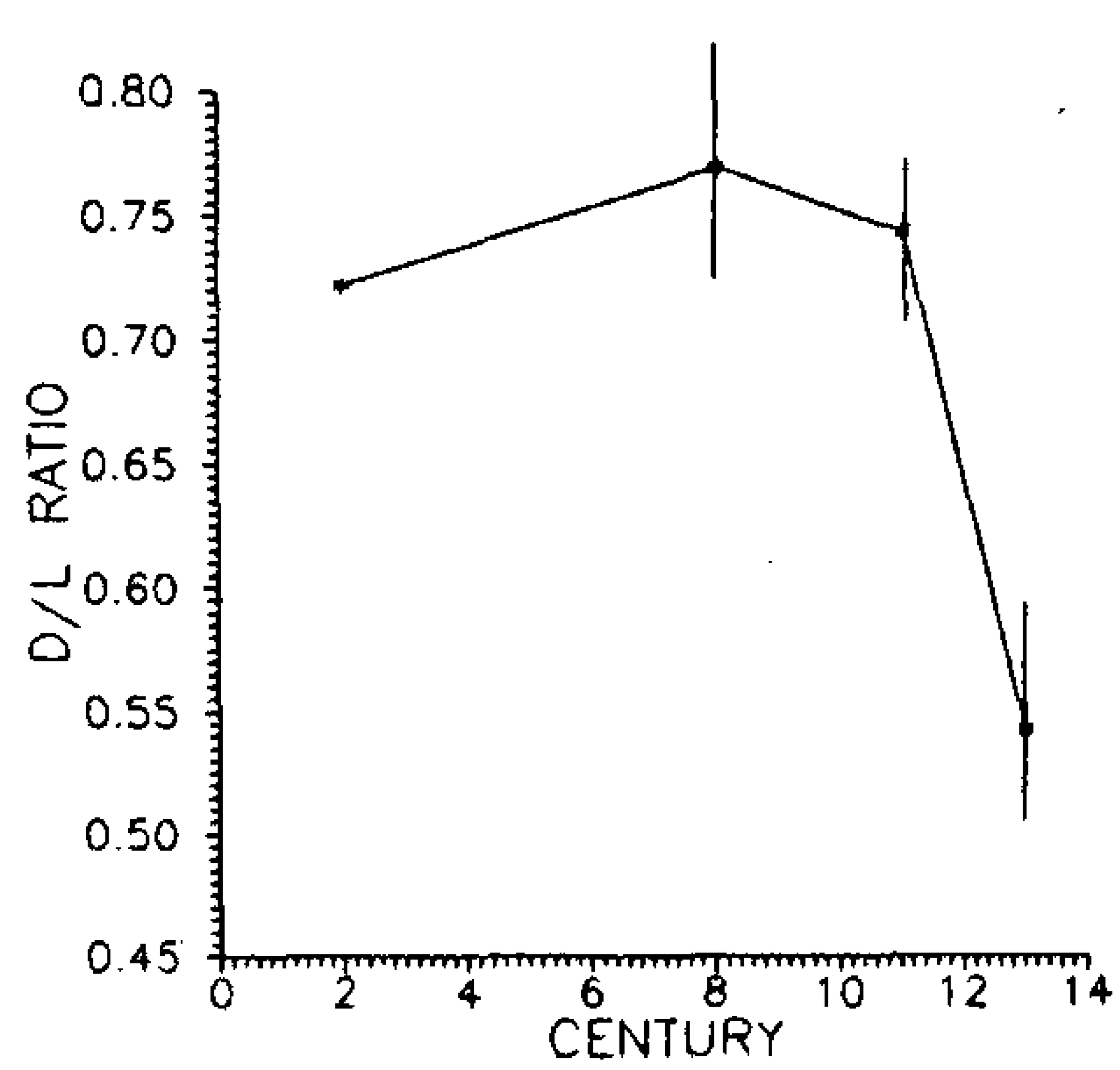

Figure 2. D/L ratios of MLS over centuries. Some of the data for a few centuries have been clubbed. Vertical bars indicate one standard deviation. Sources: second century, ref. 14; eighth century, refs. 14, 15; tenth century, refs. 19, 20; thirteenth century, present work, recorded at Somnathpur temple.

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Symmetry preservation during radiation damage

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An examination of radiation-damage processes consequent to high-energy irradiation in certain ammonium salts studied using ESR of free radicals together with the structural information available from neutron diffraction studies shows that, other factors being equal nearly equal, symmetry-related bonds are preserved in preference to those unrelated to one another by any symmetry.