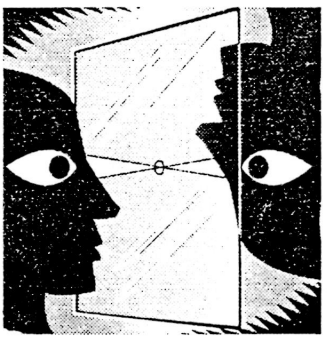
Monumental Marvels

Science Through the Looking Glass

By J V Narlikar

The episode of Mayasura in the *Mahabharata* tells us of the magnificent palace built by this remarkable architect for the Pandava princes. The palace was reputed to contain several marvels, and more importantly, optical illusions. There is the story of Duryodhana being shown around the palace and falling into a pool of water mistaking it to be solid ground. Likewise there were examples of solid floors being mistaken for water pools.

Such illusions are created by cleverly incorporating the optical phenomena of reflection and refraction into architecture. Myths apart, there are real relics that tell us about the maturity of a civilisation through its scientific content. These can be of many types and find expression through optical and acoustical effects as well as other subtleties built into architecture and landscaping. The science may also have a utilitarian aspect. The drainage system of the Harappan civilisation, for example, shows a certain level of advance on the ladder of practical engineering. A mature level of metallurgy is likewise indicated by the non-rusting alloy used in the iron pillar near the Qutub Minar in Delhi.



The principle of the pinhole camera is used in the Virupaksha temple. Here the light rays going through a tiny orifice and falling on a wall produce an inverted image of the light source on the wall. This method is seen in operation when the image of the *gopuram* of the temple falls inverted on one of the walls of the main temple 100 feet away. Another well-known optical effect is seen on the face of the Buddha statue in an Ajanta cave: The carved expression on the face indicates different moods depending on the location of external light falling on it. Was the statue designed that way, or did this happen by chance? Use of mirrors in lighting the underground chambers or other interiors of the fort in Gwalior is another clever optical arrangement. Likewise, in the fort of Chittorgarh, you can see a demonstration of how Padmini's face was shown reflected to Allauddin Khilji to satisfy his curiosity, without letting him actually see her.

Many science museums proudly exhibit whispering galleries where whispers carry across several metres, provided the source and receiver are properly placed, e.g., at the focal points of two parallel curved reflectors. A much more impressive demonstration of the same effect is found in the circular gallery of the Gol Gumbad at Bijapur. In spite of a general high level of noise raised by crowds of tourists, I was able to pick up words spoken softly from a diametrically opposite point.

The signalling system at the Golconda Fort near Hyderabad uses a similar acoustic effect. A clap produced at the main entrance gate can be heard at the top of the fort a kilometre away. This facility was no doubt as useful in conveying messages those days, as a mobile telephone is today. The Vitthal temple at Hampi has musical pillars. They produce pure musical notes of the *sargam* when tapped. These use the principle of resonance similar to that used in a sitar. Clearly those who designed these pillars were familiar with the working of musical instruments.

What were the motivations for the creators of these monuments in incorporating these effects? Was this done on purpose or did it just happen accidentally? Looking at the precision of these examples, the latter alternative seems less probable. It is not necessary, however, for them to have known the fundamentals of the science of sound, namely that it travels in longitudinal waves, that its speed is determined by a formula using the elasticity and density of the medium, that resonance can be an important effect in amplifying sound, and so on. Many of these properties can be discovered empirically, through trial and error. That is how musical instruments in common use were made and perfected. The pair of shaking minarets in Ahmedabad is another demonstration of resonance. Why does one minaret vibrate when the other is shaken by hand? Again, the effect is startling even if you know the scientific explanation. Those who have read Jerome K Jerome's *Three Men in a Boat* would know about the maze at the Hampton Court Palace on river Thames, west of London. The maze landscaped into the gardens of the palace is a popular tourist attraction. It is easy to get lost in it and difficult to come out if you do not know the trick. We have replicated it in the science park at our centre at IUCAA in Pune.

Mazes have existed in India too. The famous *chakravyuha* in the Mahabharata war which Arjuna's son Abhimanyu could enter but not get out of, is a maze that is technically called a labyrinth. I was shown how to draw it by my mother and later was interested to find that the map resembles exactly the Cretan maze of ancient Greece. In a labyrinth there is only one winding route towards the specified target.

The Archaeological Survey of India and UNESCO sponsored a workshop recently in Delhi organised by the Surabhi Foundation to collect together such remarkable instances of science peeping through monuments. It was felt that a deeper study of such monuments is needed, not only to understand the science behind them but also the motivation of their creators in having incorporated them in the first place. For, it may throw some light on the scientific ethos of those times.