volume is that it is one of the first of a new generation of reference books that successfully integrates information generated by the sequencing of the *B. subtilis* genome with the many facets of microbial physiology — including cell architecture, chromosome replication and division, metabolism and its regulation, macromolecular synthesis, and adaptation and differentiation. The challenges of annotation — and interpreting the volume of information generated by genome sequencing — are addressed in a separate chapter, and will serve as a useful reference for any group embarking on a genome project.

In addition to focusing on the genes that have been assigned function on the basis of comparative sequence information, all chapters include an analysis of homologues identified in different bacterial species, providing valuable insight into the evolution of specific genes. For example, the genes involved in endospore formation in the genera *Bacillus* and *Clostridium* are compared by a genome-wide analysis searching for homologues among their constituent species. Whereas some of the key sporulation genes — including transcription factors and their regulators — are conserved across *Bacillus* and *Clostridium*, which are both endospore-forming genera, other genes are not. The phospho-relay system that activates *spoOA* — the master regulator of sporulation in *B. subtilis* — in response to the metabolic condition of the cell, the state of chromosomal replication and cell density, is absent in *Clostridium*. This analysis has also shown that homologues of many of the sporulation genes, such as *spoIIIE*, are also found in bacteria that do not form spores, including *Escherichia coli*. These genes are postulated to have evolved a new function in endospore-forming bacteria.

There is much in this reference for researchers working on genes that originated in prokaryotes. I focused on chapters dealing with stress tolerance, and cell signalling through the histidine kinase phospho-relay cascade, and found a wealth of information that can be applied to many biological systems, such as stress tolerance in plants.

Although each chapter has been written by a different group of authors, a common thread and uniformity of style runs through the book. In spite of its size and breadth of scope, this is a very readable book. Explanations are solidly grounded on experimental data and references. The referencing cannot be faulted and includes a combination of classical and current references. Bacillus subtilis *and its Closest Relatives* sets a new high standard for physiology and biochemistry texts, and is an essential reference for researchers, university libraries and both undergraduate and graduate students. ■

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Science in culture

The Kings' comet

Giotto, Halley and the art of observation.

Martin Kemp

According to legend, it was 11 days after Christmas, on Epiphany, that the Kings brought their gifts to Christ. They arrived at precisely the right spot courtesy of a guiding star, whose behaviour differentiated it clearly from those normally visible in the night sky. If it was a star outside the normal run, what did it look like?

For most medieval artists, the conventional pointed star did the job well enough, hovering above the stable in which Christ had been born. But not so for Giotto di Bondone, the great early-fourteenth-century pioneer of naturalism. In his lucid and eloquent image of the *Adoration of the Magi* in the Arena Chapel in Padua, Giotto characterizes the Kings' guiding light as a flaming ball streaking across the heavens. The eight-pointed star at the centre of the array dissolves at its rear into a trailing tail of streaky fire. Less prominent than when first painted, through losing some of its painted gold, it still has a striking effect, unparalleled in earlier representations. It is easy to believe that Giotto had witnessed the advent of a comet. But which one?

By far the best candidate is Halley's comet, which was visible from mid-September to November in 1301. The date works well enough, for Giotto painted his image in the years immediately preceding 1305. The comet's visit was noted in various written records, and one Italian chronicler described it as having "great rays of smoke behind it".

Giotto's ability to depict the comet so convincingly was due to his innovative naturalism. More than a century before the invention of linear perspective, he had experimentally determined how to create the effect of solid forms, overlapping in space, with simple architectural features slanted back into the picture. One important tool was his use of a consistently directional light, described as coming from a large window on the west wall of the chapel. Not only does Giotto use this light to sculpt the figures, but he also plots its passage on the stable, as the diagonal beams of the roof fall systematically into shade on its far side.

It is in this context that the comet declares itself in the spectator's mind as an observed phenomenon rather than a conventional pictorial symbol. Embedded precociously in Giotto's image is the as-yet unrecognized potential for the use of empirical science in the naturalistic techniques forged by the artists of the fourteenth and fifteenth centuries.

Giotto's portrayal of the appearance of a 'real star' could not be more fitting for Epiphany, given that the Greek *epi* means 'around' or 'over' and *phainein* 'appearance' or 'manifestation'. It was also a happy choice to name the spacecraft launched in 1986 to investigate Halley's comet after the great Italian artist. ■

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