Stent paints a nostalgic picture of science and comradeship in Delbrück's research group in the postwar years, and at the Cold Spring Harbor Laboratory, where the geneticists met each summer and where Stent embarked on yet another ill-starred romance.

He does not dwell much on his work in phage genetics, which was then at the forefront of genetic research. He became a prominent figure in the field, although in the words of one of his friends, "Gunter is almost always wrong, but he is always interesting" (as he was in his widely read book, *The Coming of the Golden Age*, in which he asserted that molecular biology had passed its zenith and was now entering a state of stasis and tranquil satiety). In this, as in much else, he was a true follower of his adored patron Delbrück, who seems to have been repeatedly wrong in his scientific judgements, but whose rigorous and ascetic scepticism exerted an influence on genetics that led him eventually to a Nobel prize (which he shared with Salvador Luria and, according to Stent, accepted only after a struggle with his conscience).

Stent owns that he was never driven by any lofty urge to lay bare the secrets of nature. He enjoyed science for what Robert Oppenheimer called "the life it brings" — for the companionship and the give-and-take of debate that can be such a felicitous part of daily life in the laboratory. Were he alone on a desert island, he tells us, he would not bother with research. He is an astute observer of human foibles, and his concluding chapters are rich in anecdotes and vignettes of the great, the merely famous and the infamous; and over all hovers the brooding shade of Saint Max.

The most remarkable feature of Stent's book, aside from an engaging style, a pleasant wit, an amiable line in self-deprecation and an acute sense of history, is his extraordinary candour about his love affairs, his moral failures and the prosaic motives behind his science. Why has he so bared his soul to public view? I can only surmise that this is his way of exorcizing demons that have gnawed at his conscience since the days of his profligate youth. Stent introduces himself as a widower in his seventies and he draws a veil over his life after 1950, when his narrative ends. One must hope that he eventually found in his family life the serenity of mind that had for so long eluded him. ■

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Other memoirs

The Angry Genie: One Man's Walk through the Nuclear Age

by Karl Z. Morgan and Ken M. Peterson
University of Oklahoma Press, \$24.95

Science in culture

Animal arts

Martin Kemp

As soon as ancient philosophers attempted to differentiate human from animal intelligence, a few celebrated cases of 'animal geometers' attracted avid attention. The webs of spiders, the honeycombs of bees and the spiral shells of molluscs are the classic examples, to stand alongside the six-cornered snowflake and phyllotaxis. They testified to what Johannes Kepler called "Nature's formative virtue", the "*facultas formatrix*", through which God insinuated "world-building figures" into matter.

The building bee is eulogized in Kepler's *The Six-Cornered Snowflake* (1611): "the architecture is such that any cell shares not only six walls with the six cells in the same row, but also three plane surfaces on the base with three other cells from the contrary row". He compares this symmetrical packing to the seeds in a pomegranate, and attributes it to the same necessity as operates when pellets are systematically compressed in a round vessel.

The outline of the basic solution to the geometry of the walls was proposed by the fourth-century Greek mathematician Pappus of Alexandria. The preface to Book V of his *Collection* is devoted to "the Sagacity of Bees", to introduce "a problem of wider extent, namely that, in all equilateral and equiangular plane figures having an equal perimeter, that which has the greater number of angles is always greater". While bees are not accorded the reason needed to formulate such a general case, God has "granted that each of them should, by virtue of a certain natural instinct, obtain just so much as is needful to support life". Thus the bees "would necessarily think that the figures must be ... contiguous with each other ... in order that no foreign matter could enter ... and defile the purity of their produce".

Pappus knew that only three rectilinear, equiangular figures would fill the space: the triangle, the square and the hexagon. For their part, the bees, "by reason of their instinctive wisdom chose ... the figure which has the most angles because they conceived it would contain more honey".

But despite sustained attention from Kepler's successors, the full proof of why the hexagon delivers the maximum area for the minimum perimeter, compared to all other possible combinations of packed figures, remained elusive. The bees seemed to know more about the

isoperimetric problem than did mathematicians, including Sir Christopher Wren. The conundrum still warranted a substantial historical review by D'Arcy Wentworth Thompson in *On Growth and Form* in 1917 (Cambridge Univ. Press, 1992). Most recently, a proof of mighty dimensions, occupying 19 pages on the web, has been offered by Thomas Hales of the University of Michigan, an expert in geometrical packing (see www.math.lsa.umich.edu/~hales).

The effort needed to emulate the humble bee, brings us back to the question of animal intelligence with even greater force. To express the problem in modern terms, are the architectural bees obeying a genetic predisposition, or is the regularity the outcome of the self-organizing principles of packing? The wonderfully precise assembly of the thin cell walls at 60°-angles from tiny pellets of wax, to minute tolerances of 0.002 mm, excludes self-organization as the immediate mechanism. However, geometrical packing, like that of bubbles in foam, is as much a 'cause' of the configuration as genetic predisposition.

We can now see how Kepler's "formative virtue" elided two distinct but complementary processes. One is the kind of physical self-organization he observed in snowflakes, while the other is the instinctual programme that permits the bees to carry out such symmetrical acts of waxy engineering within the physical parameters of their world. It seems to me that the relative weights accorded to either of the interlocked processes in each complex instance of animal and vegetable artistry need to be argued case-by-case, even if the roles of geometry and genes now seem to be susceptible to clear definition in the long-running case of the honeycomb.

It is hardly surprising that such wondrous masterpieces of design have inspired artists and architects, no less than mathematicians. For Susan Derges, whose work is illustrated here — and can be seen in the book *Susan Derges, Liquid Form* (Michael Hue-Williams, 1999) — the honeycomb not only embodies the principles of natural order, but also encodes patterns of thought as the bees weave the tapestry of their industrious motions across the geometrical network. ■

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