Nature's shapes

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What Shape is a Snowflake?

by Ian Stewart

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It is always good to broaden our horizons beyond our primary field of interest, and popular science books serve this purpose quite well, even for scientists. Choosing such a treatise is often the hard part, as the bookshop shelves are full of examples competing for our attention. Gorgeous illustrations, an intriguing title and a well-known author are strong attractants, all of which make Ian Stewart's *What Shape is a Snowflake?* an appealing choice. Stewart, a professor of mathematics at the University of Warwick, is better known as a prolific author of science books, a regular contributor to *New Scientist* and *Scientific American* and the 1995 recipient of the Royal Society's Faraday Medal for his contribution to the public understanding of science. In his latest book, Stewart takes the reader on a fascinating voyage through nature, during which he describes a multitude of shapes and patterns and explains how they are generated.

The book's leitmotif is the shape of a snowflake. In this, Stewart follows the example of German astronomer Johannes Kepler, who, in 1611, explained the origin of the 6-fold symmetry of snowflakes in his book *On the Six-Cornered Snowflake*. But Stewart sets himself the

much more ambitious task of completely understanding a snowflake's shape as well as such other disparate patterns in nature as the stripes of zebras, the shape of complex soap bubbles and the spiral structure of galaxies. Clearly, the four centuries of scientific progress since Kepler's time has aided the explanation of many natural shapes. But, surprisingly, understanding a snowflake is still not straightforward and relies on such involved concepts as chaos, fractals and complex systems, all of which I found entertainingly described.

The voyage with Stewart was indeed interesting, largely because he enlivens the presentation by recounting short anecdotes about the scientists involved. For example, if it seems that the retraction of papers is a present-day phenomenon caused by the enormous pressure to publish, the tale of King Oscar II of Sweden and the French mathematician, astronomer and philosopher Henri Poincaré is enlightening. In 1887, Oscar offered a prize of 2500 crowns for a mathematical solution to the question 'Is the solar system stable?'—as opposed to the unstable situation where planets could change their orbits, collide with each other or even escape. Poincaré set to work on the problem, reduced its complexity and submitted a manuscript containing the putative proof that a solar system composed of just three bodies would always follow a regular path. He claimed the prize, only to notice somewhat later that he had made a fundamental mistake. By this time, his memoir had been printed but, fortunately, not yet distributed. Desperate to erase his mistake, a corrected version of the 'prized' work was published, costing Poincaré much more than the original prize he had won. Nevertheless, it was worth it; the corrected version spawned the field of deterministic chaos, since Poincaré was the first to demonstrate that a relatively simple system governed by simple deterministic equations could behave in an apparently random manner. Stewart does not state whether Poincaré gave back Oscar's prize, but it is clear that serious scientific mistakes resulting from a tight

schedule are nothing new. Of course, Stewart also brings us up to date on the current understanding of the stability of our solar system: Mercury will slowly increase its distance from the Sun until it approaches Venus, whereupon one of the two planets will be ejected from the solar system. Luckily—or unluckily if your scientific curiosity is very strong—this will only happen in about a billion years from now.

On the negative side, the book has several obvious deficiencies, especially when Stewart enters the realm of biology. For example, he states that prokaryotes lack not only a nuclear membrane but also a cellular membrane. How a cell's content is held together in such a scenario is not explained. In dealing with another fundamental point, Stewart writes: 'A cell ... has genetic equipment which it keeps inside the nucleus when not actively in use.' It is a pity that Stewart did not consult a biologist, who would have explained to him that actively transcribed DNA still rests within the nucleus. I was, however, especially disturbed by Stewart's discussion of the asymmetry of the human face. He used a photo of Einstein that was taken slightly in profile to mirror duplicate the left and right sides of the face. The resulting two pictures are then very different in a caricatural way, but the whole asymmetry arises from the fact that Einstein was not directly facing the camera in the original picture. Yes, there is an asymmetry in the human face, but it does not serve the public understanding of science to artificially increase the magnitude of this asymmetry in order to make the effect more striking.

These annoyances aside, Stewart's book is a visually compelling guide to the links between mathematics and the natural world and clearly demonstrates that a small snowflake can take us a long way towards understanding many of Nature's shapes.

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