EXHIBITION

Measure for measure

John D. Barrow

Mathematics is more than numbers. It's the collection of all possible patterns, from crazy-paving to crystals, carvings and castles. The exhibition *Beyond Measure* at Kettle's Yard in Cambridge, UK, brings together patterns with a geometrical flavour in different media.
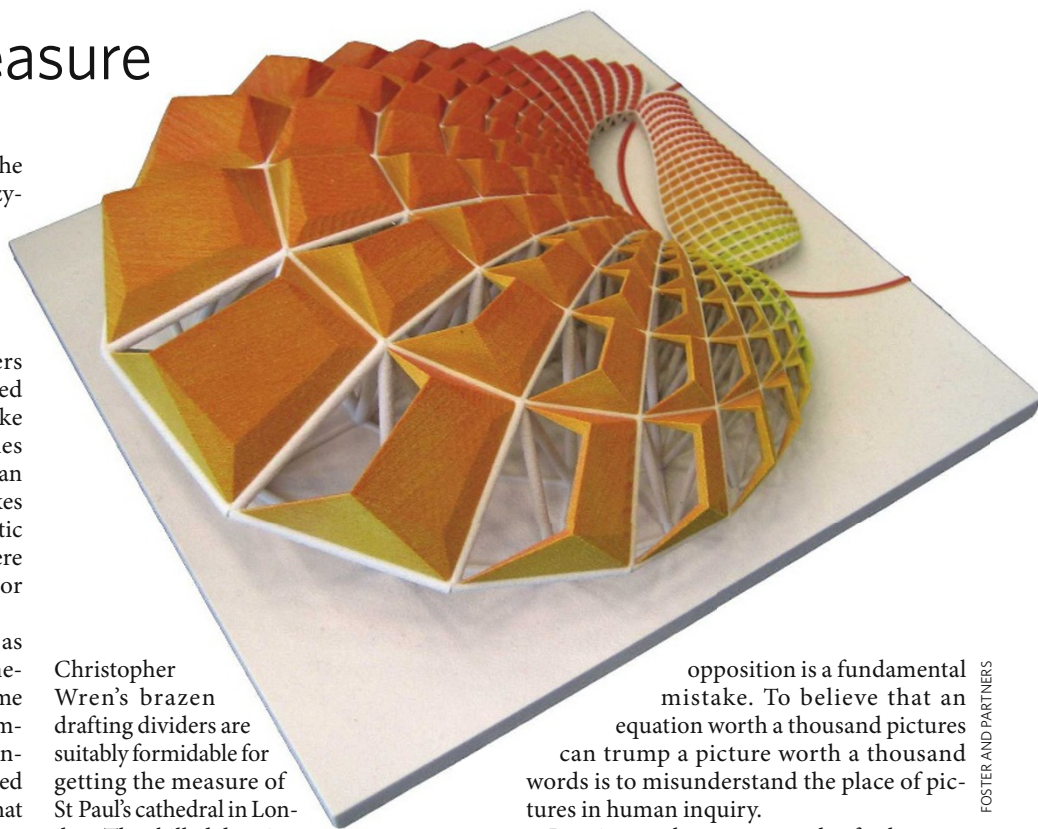
Many patterns we find attractive, others not. Indeed, the Artist Paul Klee remarked that emphasizing only the beautiful is like using a mathematical system that handles only positive numbers. *Beyond Measure* is an illuminating collection of exhibits that mixes both; the displayed objects combine aesthetic quality with functionality because they were created to illustrate, to teach, to decorate or to demonstrate.

Some exhibits hail from the past, such as wooden models of platonic solids, archimedean polyhedra and geological crystals. Some are wonderfully contemporary, like the complex building models (pictured) by London-based architects Foster and Partners, sculpted using a three-dimensional colour 'printer' that gradually builds up the solid structures by laying down hundreds of strata of thin, coloured laser-cut paper.

The diverse collection captures the nineteenth-century extension of geometry into geometries. The discovery of non-euclidean geometries dismissed the old belief that euclidean space was the only logical possibility, forcing mathematicians to accept a point that had been appreciated and demonstrated by artists for more than 400 years. This relativism unleashed a rush of innovative designs and new explorations of the geometry of space, from cubism to its mind-bending counterparts based on the geometries of the sphere, the cylinder and the cone.

Kettle's Yard curator Barry Phipps searches out geometry in unexpected places. Beautiful drawings by medical consultants show the steps in a surgical operation, annotated with reassuringly illegible medical script and scalpel guidelines drawn on the patient's arm. Collections of subtly coloured, crocheted representations of the complex surfaces of Calabi-Yau spaces are presented for string theorists to knit their brows over, alongside ball-and-stick models from the laboratories of eminent biochemists who imagined the structures of proteins and viruses. As a topological surprise, a line of elegant blown-glass Klein bottles and their many-handled cousins grace a wall, not knowing their inside from their out.

Human touches are evident. Architect

Christopher Wren's brazen drafting dividers are suitably formidable for getting the measure of St Paul's cathedral in London. The skilled drawing of mathematical physicist Roger Penrose is clear in his book illustrations, which are shaded with a characteristic stippling technique to bring out the nuances of space and space-time. Crystallographer John D. Bernal's notebook sketches of crystal symmetries bring to life his search for the structure of the very graphite atoms his pencil left on the page, and the comfort of Tom Dixon's Pylon chair exploits the unique rigidity of triangles over other polygons.

Not all of the geometrical structures on display are of human construction. The University of Cambridge's Botanic Gardens have supplied fractal succulent plants that exhibit a range of self-similarity. Using dry ice, you can freeze your own snowflake and admire its six-fold symmetry, a large-scale reflection of the geometrical symmetry of its molecular lattice. Look closely and you will see tiny deviations from that symmetry along the arms, each one unique because of slight differences in each snowflake's thermal history as it froze.

This vivid exhibition lays bare the many places where symmetry has a role in the world, and the importance of visualization in science and mathematics. Traditionally, pictures and models have been regarded as an unnecessary dilution of the true task of formal mathematics — to provide generalized proofs that make no appeal to particular examples. But to see these two activities in opposition is a fundamental mistake. To believe that an equation worth a thousand pictures can trump a picture worth a thousand words is to misunderstand the place of pictures in human inquiry.

In science, there are no rules for how we come by our theories. We can dream them up, see them in our tea leaves or take them out of the library. It doesn't matter. What does matter is that there is a rigorous process for testing those ideas to destruction through experiment and observation. Analogously, in mathematics there are no rules about how we gain intuitions about what might be true. Pictures can play an important part in that quest, but there is a formal process for establishing the truth or falsity of picturesque intuitions.

As in any small exhibition, other items could have been included. For example, no Vedic Sri Yantra or Islamic tessellated designs are displayed. The gallery's own geometry might have been contemplated, and more explanatory material would have been valuable, perhaps revealing why the Pylon chair needs to be made of triangles. Molecules such as the soccer-ball-shaped carbon-60 could have been shown, and at least one of the works of Maurits Escher, Oscar Reutersvärd or Lucio Saffaro deserve a place in any gallery of geometry. But these omissions suggest only that it would be good to have another exhibition like this. There is more to measure. ∎

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Beyond Measure: Conversations Across Art and Science is at Kettle's Yard, Castle Street, Cambridge CB3 0AQ, UK, until 1 June (www.kettlesyard.co.uk).

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