Structural Intuitions

SEEING SHAPES IN ART AND SCIENCE

Martin Kemp

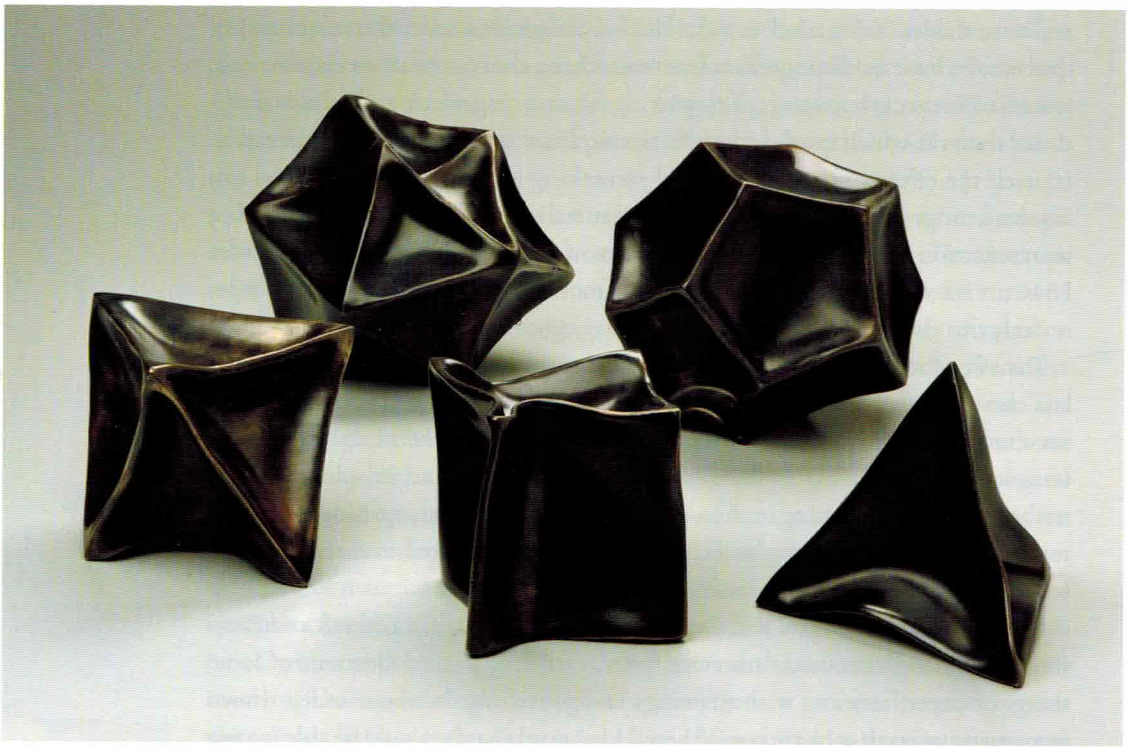

Figure 5. *Collapsed Platonic Solids*, Julian Voss-Andreae, bronze, 2009. (*From the left:* the octahedron, the icosahedron, the cube, the dodecahedron, and the tetrahedron; largest object 9 in/23 cm)

There are just five regular solids, that is to say, convex bodies composed from regular polygons of the same size with the same number of faces at each vertex or corner (fig. 5). It is perhaps surprising that there are only five such polyhedrons and that no more have been discovered since Euclid expounded their basic geometry. In the thirteenth and last book of his *Elements of Geometry,* written around 300 BC in Alexandria and one of the most perfect books ever conceived, Euclid discussed why there are only five. He describes the way that "that no other figure, besides the said five figures, can be constructed which is contained by equilateral and equiangular figures equal to one another." He shows that other possible solid arrays of flat figures result in geometrical "absurdity." They can all be inscribed in a sphere in such a way that their vertices lie on the surface of the sphere. In the eighteenth century the great Swiss mathematician Leonhard Euler noted that if we count the number of faces in each of the bodies, subtract the number of edges, and then add the number of vertices, we always obtain the answer 2. The strictly limited number and succinct visual conviction of the solids have entranced philosophers, scientists, and artists over the ages, and they have regularly been accorded deep significance in the nature of things. The version I am illustrating them with here is the intriguing set of *Collapsed Platonic Solids* by the German sculptor Julian Voss-Andreae, whom we will meet again.

What is the nature of our attraction to the five regular solids? It seems both visual and tactile. I suspect it lies in the combination of a deep symmetry around an intuited center and the controlled asymmetry they manifest as their facets are seen from progressively different angles under changing degrees of foreshortening. There is also the anticipatory tease of what the concealed faces will look like. Will our intuitions be met or uncomfortably confounded?

The five polyhedrons are commonly known as the "Platonic solids" after the great philosopher of the fifth century BC. Plato was not their discoverer but was the first to characterize them as the fundamental building blocks of the created cosmos. In his *Timaeus,* written more than half a century before Euclid's treatise, he identifies four of the solids with the elements of earth, water, air, and fire, while the fifth, the dodecahedron, "god used in the delineation of the universe." Plato's leading speaker in the dialogue, Timaeus, expounds how god created the universe in its whole and in its parts according to a system of harmony and proportions.

Kroto brought to the Buckyball team his natural instincts as a visualizer and designer. He had considered at one point founding a studio to develop scientific graphics. He is one of those major visualizers, like Leonardo and Kepler, who have a special sense of how complex symmetries in works of nature and art operate in three dimensions.

The Buckyball became the new star of chemistry. As Kroto said in his 1996 Nobel Prize address: "This elegant molecule . . . has fascinated scientists, delighted lay people, and has infected children with a new enthusiasm for science and in particular it has given chemistry a new lease of life."

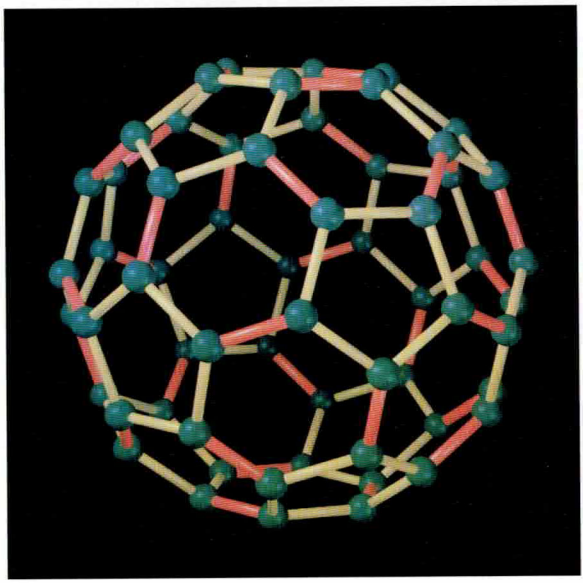

Figure 19. Buckminsterfullerene, C_{60}

The form of C_{60} has become familiar beyond its scientific context as a symbol of science—not as famous as the double helix, but it does look as if it is assuming iconic status. It has, as we might expect, been picked up in art. The German sculptor Julian Voss-Andreae, based in the United States, where he qualified as a physicist, has consistently explored molecular issues on large scales as a form of scientific sublime. He has worked a number of variations on Buckyballs, one of which weaves its geometrical way around and through vertical trunks in a Portland forest—a dialogue between geometry and nature of the kind that runs through this and later chapters (fig. 20). At the start of chapter 1 (fig. 5) we saw a set of his collapsed platonic solids in bronze for his *Quantum Objects* series. It is as if a portion of their internal breath has been sucked out, leaving them with creased contours and concave faces. The effect of the hollow versions of the semicrumpled bodies is notably somatic, amusing, and uneasy. Alongside such artistic manifestations, collapsed solids have recently been investigated in the context of the science of elastic shells by Ee Hou Yong and his colleagues at Harvard, who have mathematically modeled what happens when a crystalline shell with defects or faults is deflated, creating analogues of the Platonic solids.

A neat story, then. A semiregular, Archimedean solid memorably cements engi-

Figure 20. *Quantum Reality (Large Buckyball around Trees)*, Julian Voss-Andreae, Douglas firs and steel, diameter of the steel structure 30 ft/9 m, 2007

neering solutions at the largest and smallest scales, and insinuates itself into artistic imaginations and into new scientific research. However, everything turns out to be not quite as it looks.

Kroto decided as a jeu d'esprit to use a molecular modeling kit to build a small-scale Bucky dome, along the lines of the one he had seen in Montreal, but without the inner skin of triangular struts. The assumption was that an array of hexagons punctuated by pentagrams would naturally form a dome that approached a portion of a regular sphere. This proved not to be the case. The resulting models (fig. 21), on which he worked with Ken McKay, did not turn out as expected. The model that corresponds to a giant fullerene of 240 molecules is discernibly not constant in curvature but seems to exhibit "ghost" vertices coinciding with each of the pentagons. There seems to be something like a dodecahedron or icosahedron lurking immanently in the structure. Adding more faces (or atoms) on