Unraveling Life’s Building Blocks: Sculpture Inspired by Proteins

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There are a number of common themes woven through the fabric of my sculptural work. One such theme is the idea of the fundamental building block, the smallest unit that, upon assembly, displays an extraordinary transformation from geometric simplicity to organic complexity. Some of my recent work was inspired by quantum physics, the study of the building blocks of the physical world [1,2]. A larger body of work, begun in 2001 after I switched careers from quantum physics to art, is concerned with the structure and conceptual potential of proteins, the molecular building blocks of all life forms. This article presents a selection of these works, complementing others that I have described earlier [3]. The article’s final section places the work in the context of contemporary efforts that aim at expanding the current paradigm beyond the confines of scientific reductionism.

PROTEIN SCULPTURES

When we cut an organism into parts small enough to be handled intellectually, we both literally and emotionally lose its essential property of being alive. Perceiving the parts of a living being as inanimate often lets us presume that the “aliveness” of the whole being is just an illusion. But perhaps the opposite is true: Because the whole is alive, all its parts are in the same sense alive and should therefore be worthy of an equal emotional attachment. Among the smallest molecular parts specific to life are the proteins. It is through proteins that life accomplishes the transition from one-dimensional DNA, the carrier of genetic information, to three-dimensional organisms [4]. Proteins are chains of amino acids arranged in a specific sequence that is encoded in the DNA’s sequence of base-pairs, the “rungs” on the DNA “ladder.” The structure of a protein is largely determined by its sequence of amino acids. Inherently still one-dimensional, the linear molecular chain folds into an often well-defined, three-dimensional object. I use the application of compound mitered cuts, the rotation of every other part, and subsequent reconnection as an elegant way to recreate the structure of proteins from the ubiquitous one-dimensional building materials, such as lumber or steel tubing. My process is to search for proteins with determined structures that have aesthetic as well as conceptual appeal. After downloading the structural data, I run a custom-developed computer algorithm to generate the cutting instructions that provide the starting point for my sculptures (see Fig. 1). The basic ideas and processes are described in detail elsewhere [5,6].

Due to the inherent properties of the miter-cut representation, sculptures based on smaller proteins evoke the impersonal aesthetic language of modernist sculpture [7]. A good example is Alpha Helix for Linus Pauling [8] (Color Plate C[d] and Fig. 1[d]) based on a 15-amino-acid sequence. As the number of amino acids increases to several hundreds or even thousands, an exciting transition takes place: The cold and crystalline feel of a small number of polyhedral faces gives way to something that feels “warmer,” and the much more complex aesthetics of the organic world starts to emerge.

Light-Harvesting Complex

Plants and photobacteria (bacteria capable of photosynthesis) absorb sunlight, thereby providing us and virtually all other creatures with the energy and low entropy we need to maintain life. Photobacteria possess a beautiful and well-understood photosynthetic apparatus embedded in their cell membranes. Instrumental to the initial absorption of the light is a structure known as the light-harvesting complex, an array of two concentric rings of proteins. Coiled protein segments traverse the cell membrane and hold light-absorbing pigments in between the rings. Intrigued by both its structure and its function, I created a sculpture based on the light-harvesting complex. Each of the two protein rings is made up of nine identical subunits, which I portrayed using ½-in-diameter (13-mm) wooden dowels. The whole complex consists of 850 amino acids, corresponding to the same number of one-inch-long (25 mm) pieces of wood. Each protein subunit is anchored in position

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in a layer of transparent casting resin on a wooden disc. The sculpture is placed on the floor of a dimly lit room so that the structure casts moving shadows on the wall (see Fig. 2). The shadows evoke plants moving in the wind. It seems as if the macroscopic plants of our world have become ephemeral shadows, while the microscopic, and ordinarily not perceivable, basis for their existence has become the tangible object [9–11].

Unraveling Collagen

One of the many helical structures of vital importance to us is collagen, our body’s most abundant protein. In collagen, three amino acid spirals, reminiscent of a rope, wind around each other to create a meta-spiral. Collagen mainly provides our bodies with structural support [12]. In a sculpture inspired by collagen, I emphasized its structural function by reducing each of the sculpture’s faces to the backbone smoothed into a curve, each amino acid corresponds to a straight miter-cut piece. Compare this image to Color Plate C(d), instead of being presented with the backbone smoothed into a curve, each amino acid corresponds to a straight miter-cut piece. Compare this image to Color Plate C(d), a photo of an actual sculpture created after the same computer model. Panels (a–c) were generated using the molecular graphics visualization software RasMol [31] and panel (d) was generated using my own software.

Heart of Steel

Hemoglobin, the oxygen-carrying molecule that gives our blood its red color, is another well-known protein of vital importance to our existence. Its color stems from iron atoms, which are essential in capturing oxygen from the air and distributing it to the whole body. I created a sculpture based on the hemoglobin structure and alluded to the basis of our body’s ability to breathe by letting a similar reaction occur on the artwork’s surface: Initially sanded to a bright, silvery sheen, the steel sculpture started acquiring an increasingly deeper coloration [15,16] (Color Plate C[a–c]). The intricately shaped steel piece is complemented by a large, blood-red glass sphere in its center, evoking the image of a drop of blood [17]. The sculpture reacts sensitively to wind and touch, answering each push with an unexpected shiver, echoing the complex vibrational dynamics of large biomolecules [18].

Birth of an Idea

In 2007 I completed a sculpture (Article Frontispiece) based on the structure of an ion channel protein for Roderick MacKinnon, who received the 2003 Nobel Prize in Chemistry for his seminal work on such a molecule. Found in the nerve cells that make up our brain and its nervous connections to the rest of our body, ion channels control the passage of specific atoms through the nerve cells’
membranes. Intimately connected to our intellectual and emotional responses to the world, this mechanism is at the very foundation of the living nerve cells’ characteristic activity, the filtering and relaying of information through selective firing. When I was commissioned to create this sculpture, I was inspired by the ion channel’s potential to symbolize the “spark,” the small but all-important idea at the beginning of everything we do. Although we will probably never be able to point at one structure in our brain where that proverbial spark emerges, the ion channel provides a beautiful metaphor for it because it functions as the smallest logical unit in the vast network of our brain. Inspired by depictions of the potassium channel’s interior [20], I created an object welded from steel wire to represent the pore’s cavity. This pore object, surrounded by a protein scaffold made from blackened steel, is lacquered in a translucent blue. Like an isodensity plot of a molecule’s electron density [21], the pore object features bulges at the locations the ions populate during their single-file passage through the protein. The largest bulge corresponds to the channel’s main cavity, where the ion’s surrounding water molecules are stripped off to be replaced by specific protein atoms. The main cavity contains a yellow blown-glass bubble, evocative of a rising balloon. The sculptural pedestal is fabricated from hand-planed, one-inch-thick (2.5 cm) wooden boards connected by the ancient technique of finger joints, mirroring the fourfold rotational symmetry of the protein.

Angel of the West
When I was doing research for a sculpture based on the structure of our immune system’s key molecule, the antibody, I noticed an interesting similarity between this molecule and the human body, in both proportion and function: Shaped like a “Y,” the antibody features a pair of identical protrusions, resembling arms, that are able to move by means of a flexible region in the molecule’s center. These “arms” end in “hands,” highly spe-
specific regions that hold on to an intruder, for example a virus particle, thereby tagging it for destruction through the immune system. In order to allude to the similarity between man’s body and his antibody, I designed the sculpture to subtly evoke a Renaissance icon deeply anchored in popular culture: Leonardo da Vinci’s 1490 study of the human proportions, *Vitruvian Man*. When I superimposed the frontal view of the antibody’s 1,336-amino-acid structure, as provided by Eduardo Padlan [22], onto the *Vitruvian Man*, I was struck by the fact that the two images coincide perfectly (Fig. 5). For my design, I decided to utilize this powerful similarity and let the antibody molecule stand in place of Leonardo’s man while turning the surrounding circle into a tapered ring. I then added thin rods under the arms radiating out from the position where the center of the head was located in the drawing. This set of rays emanating from a central source makes the design reminiscent of spiritual imagery [23]. With the wing-shaped “arms” added, the image is evocative of an angel (Color Plate C[e]) [24]. Our antibodies can, in fact, be viewed as legions of tiny guardian angels, constantly protecting us from disease. Their ability to bind very specifically to certain molecules is also the reason the antibody molecule has become an indispensable tool in biomedical research, crucial for understanding the machinery of life [25]. I chose the name *Angel of the West* as a play on Antony Gormley’s monumental sculpture *Angel of the North* (1998), in Gateshead, U.K. The “West” in my sculpture is a reference to the Western approach to healing through the tools of Western science. The fabrication of the sculpture resembled a gigantic three-dimensional puzzle with about 1,400 pieces, laser-cut from steel sheet of varying thicknesses to fit the structural requirements [26].

**ART AND SCIENTIFIC REDUCTIONISM**

Despite our increasingly heavy reliance on science-derived technology, only a minority of people today recognize science as a vital part of human culture or have experienced feelings of wonder from scientific observations in the same way as they would from, say, a beautiful sunset. After an era of relative faith in science, culminating in the immediate post–World War II era, the public’s attitude toward the natural sciences began to shift, starting around 1970 [27]. My generation, born during that time, grew up with a new sense of mistrust that was triggered by the growing suspicion that the reductionist approach inherent in science and technology, and its profound effects on our lifestyle, could not be separated from the global environmental and spiritual crisis that was then becoming increasingly apparent.

Scientific reductionism, the assumption that complex systems can be completely understood through an under-
standing of their components, is deeply ingrained in the very structure of the natural sciences and has been an extraordinarily successful guiding principle in the West since the Age of Enlightenment [28]. Art, by contrast, is non-reductionist in its very nature: The profound effect of a great work of art cannot be comprehended by adding up the effects the work’s separated parts would have. Nor can that artwork’s impact be reduced to the intellectual knowledge of specific interpretations of it. True appreciation of art seems impossible in a frame of mind that clings to the object-subject dichotomy that has become so deeply entrenched in Western thinking for the past few centuries. According to Einstein, in art, “We show [what we behold and experience] in forms whose interrelations are not accessible to our conscious thought but are intuitively recognized as meaningful” [29]. The presented works take the notion of artistic counter-reductionism to another level: Departing from a mere structural representation of proteins, the exemplary specimens of reductionist biology, these works take living beings’ components, typically considered inanimate, and bring them metaphorically back to life. In this way, these sculptures, born from scientific data, are capable of imparting an artistic experience of life that complements the understanding provided by reductionist scientific theory and thereby inspire a more holistic view of nature.

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References and Notes

Unedited references as provided by the author.


4. I use the term “n-dimensional” (where n = 1, 2, 3) in this article as it is commonly used to describe objects of the real world (as opposed to mathematical entities): An object is n-dimensional if it extends significantly only into n of the 3 dimensions of physical space. Its extent into the remaining 3−n dimensions is negligible compared to its extent into the other n dimensions, i.e. smaller by some orders of magnitude.

5. J. Voss-Andreae [5].


7. Voss-Andreae [6], chapter 5.1.

8. J. Voss-Andreae [5].


12. The symptoms of scurvy drastically illustrate what happens to our bodies if, due to a lack of Vitamin C, we fail to keep up the regular synthesis of new collagen.


17. I should note that this sculpture is not (nor is any of my work) intended to be a scientifically accurate model. For example, my placement of the red glass sphere in the center of the sculpture was a purely artistic decision and does not correspond to the location of the iron in the actual molecule.


20. See Fig. 5 (B) in D. Doyle et al., “The Structure of the Potassium Channel: Molecular Basis of K+ Conduction and Selectivity,” Science 280 (1998), p. 74; and Fig. 2 in Y. Zhou et al., “Chemistry of ion coordination and hydration revealed by a K+ channel-Fab complex at 2.0 Å resolution,” Nature 414 (2001), p. 45.

21. Such structures’ “shape,” governed by quantum mechanics, is a spatial probability distribution of the likelihood of measuring an electron. In order to transform this kind of information into something we are accustomed to dealing with, scientists often visualize molecules through a pseudo-surface that is defined by a specific, constant likelihood of finding an electron, the “isodensity plot.”


23. One of the images that guided my design was Gianlorenzo Bernini’s famous 1666 alabaster window at St. Peter’s Basilica, depicting the Holy Spirit as a dove.

24. Images of angels, winged humans, date far back into pre-Christian times. A well-known example is the Nike of Samothrace, from about 200 BC.

25. This makes the antibody an appropriate symbol for The Scripps Research Institute, which commissioned the sculpture as the signature piece for their new Florida campus.


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Initially trained as an experimental physicist, Julian Voss-Andreae is a German-born sculptor based in Portland, Oregon. His sculpture is critically acclaimed and has been commissioned by multiple institutions and private collectors in the U.S.A. and abroad.
Julian Voss-Andreae, (a–c) *Heart of Steel*, weathering steel and glass, height 5 ft (1.60 m), 2005. (© Julian Voss-Andreae) The images show a time-sequence of the hemoglobin-based sculpture’s metamorphosis: Photo (a) was taken right after unveiling, (b) after 10 days and (c) after several months of exposure to the elements. (d) *Alpha Helix for Linus Pauling*, powder-coated steel, 10 ft (3 m) high, 2004. (© Julian Voss-Andreae, Collection of The Linus Pauling Center for Science, Peace, and Health.) This memorial for Linus Pauling is located in front of Pauling’s childhood home in Portland, OR. (e) *Angel of the West*, stainless steel, 12 × 12 × 4 ft (3.70 × 3.70 × 1.20 m), 2008. (© Julian Voss-Andreae. Photo by James McEntee, courtesy of The Scripps Research Institute.) Commissioned as the signature sculpture of The Scripps Research Institute’s new campus in Jupiter, FL, this sculpture plays upon the striking similarity between the human body and our immune system’s key molecule, the antibody.