Protein Sculptures for the People

By Julie Wallace

Figure 2: Birth of an Idea, 2007. Photo: © Dan Kvitka

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Many of us have marveled at a two-dimensional representation of a protein in a book or on the computer screen. We may have even been awed at a three-dimensional recreation of such a structure. Julian Voss-Andreae takes the beauty of these molecules a step further, producing protein sculptures that combine the natural beauty of the structures with his own personal, artistic touch. He is uniquely able to combine his talents as an artist, naturalist and physicist to create works of art for the public (such as "The Heart of Hemoglobin" found at the corners of 1st Street and A Avenue in the City of Lake Oswego, Oregon) to works for scientists (such as "Birth of an Idea," based on the potassium channel KcsA and commissioned by Dr. Roderick MacKinnon).

The Naturalist, Artist, and Physicist

German-born Voss-Andreae spent his time drawing and painting in his youth, uninterested in school and homework. However, he was always interested in the natural world, an appreciation with which he suspects he may have been born. "Thinking back now it seems that I was outside pretty much the whole weekend [in my childhood] with my friends, building stuff in the forest," he said. At the age of 12, Voss-Andreae was introduced to his first computer and learned computer programming which had a deep impact on his worldview. "I just couldn't imagine that the beauty of the world was generated in any way other than algorithmically," explained Voss-Andreae, "and I wanted to understand how nature does that."

Propelled by his desire to explore nature more formally and deciding to "make up for all the 'laziness' of his school years," Voss-Andreae studied physics and received a Master's degree in quantum physics from the University of Vienna. While Voss-Andreae enjoyed his research, in 2000 he returned to art and received a BFA in Sculpture from the Pacific Northwest College of Art in Portland, where Voss-Andreae's studio is currently located. The return to art suits him well; "I find it very difficult to be living mostly in a state of logical reasoning. Thinking is fine for me, but not during most of my work day. I need more dream time than that, and in art I can devote a fair share of my time to dreaming."

The Appeal of Protein Structures

Voss-Andreae's interest in proteins developed the first time he saw the structure of green fluorescent protein (GFP). At the time, he was interested in extending his research experiments to "probing the quantum mechanical wave nature of large particles into the world of biomolecules" and turned to a graduate student in neuroscience, Adriana. She was using GFP to mark receptors in the brains of mice and she suggested that he consider it for his studies. "When I saw its structure for the first time, I was blown away by the molecule's beauty," noted Voss-Andreae. (Voss-Andreae has since completed two sculptures based on the structure of GFP, "Green Fluorescent Protein" [2004] and "Steel Jellyfish" [2006]. The latter is currently located at the University of Washington's Friday Harbor Laboratories, where GFP was first isolated by Osamu Shimomura in 1962.)

Protein structures continue to have a tremendous appeal for Voss-Andreae. "The idea of a building block is of greatest interest to me since my childhood obsession with Lego," Voss-Andreae said. "The idea that proteins are nature's way of going from one-dimensional DNA to our three-dimensional bodies by linking amino acids into chains and having them wind up in space is intriguing to me." But how does he translate this concept into a visual, attractive piece of art? "That aspect," continued Voss-Andreae, "is captured visually if the protein is reduced to its backbone, as is often done in the scientific literature. Interesting in such a rendition is that the negative space, the space in between the backbone, feels artistically very alive because in the actual molecule it is filled pretty evenly with the atoms from the side chains."

An Objective Truth as a Subjective Art

As an artist, Voss-Andreae walks an interesting line when presenting scientific structures in art. It is important to be accurate, especially when the works are commissioned by Nobel laureates who elucidated these structures, but accuracy can limit artistic and creative vision. When I asked Voss-Andreae about the role of accuracy in his art as a "protein artist," he responded, "The only kind of accuracy important for an artist is the ability to accurately map one's vision into the art object. You [get] better at refining what it is that you want to express artistically and at the same time you [get] better at evaluating your success at it."

Often times, the reality of materials and the physical nature of creating large structures can also impact the accuracy. Voss-Andreae described, "For my protein structures, mechanical accuracy is very important as well. The inevitable small errors in each joint between two amino acids quickly add up since the protein is essentially one-dimensional. And a protein that is not exact looks very wrong. For example, adjacent beta sheets have a clear functional relationship with their neighbors resulting visually in their forming of a zigzag pattern together. That is why I use laser-cutting. It allows me to make the angles between the amino acids as precise as possible with steel. But still, in larger pieces, I have to compensate for accumulated local errors every now and then to make it globally more accurate."

Accuracy, while always on Voss-Andreae's mind, does not dictate the final sculpture. "Sometimes I do depart from the 'correct' structure," explained Voss-Andreae, "but only when it makes sense to me. I made, for example, a large collagen piece which

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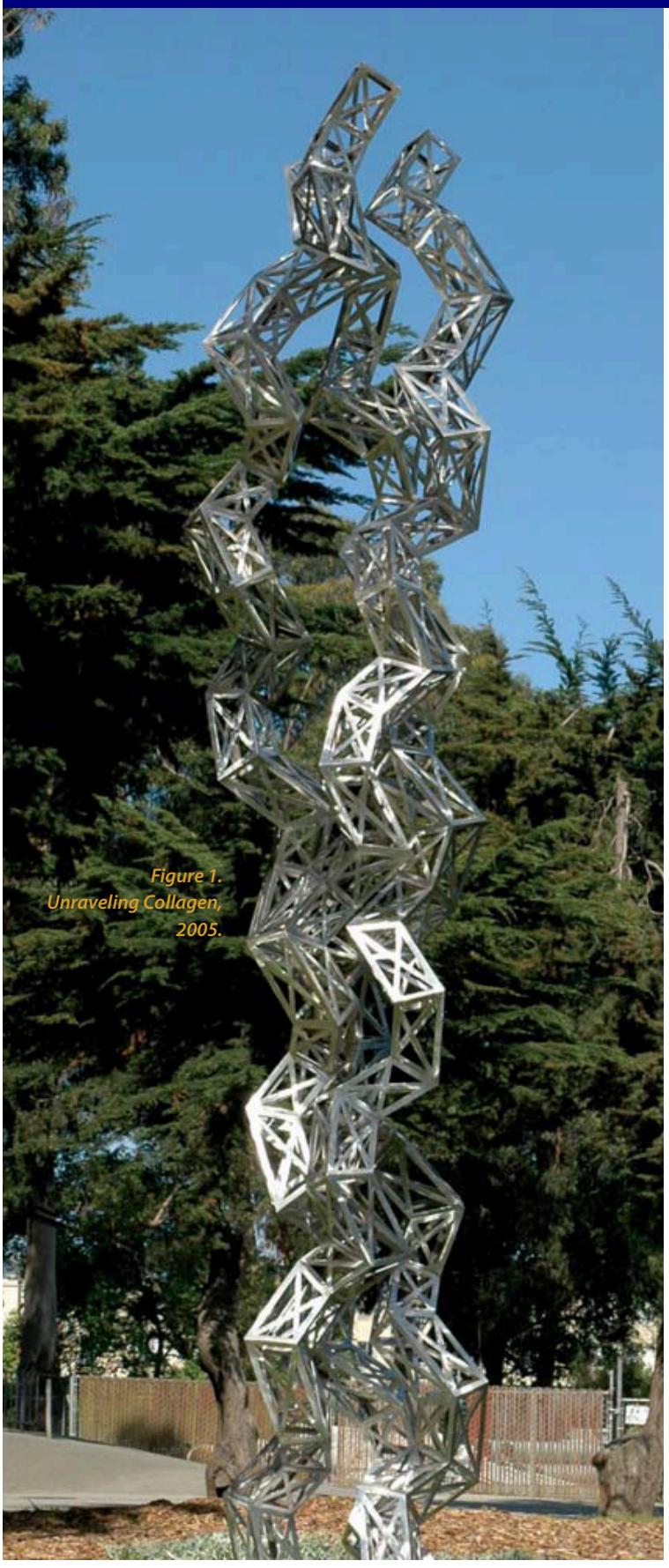

Figure 1. Unraveling Collagen, 2005.

looked much better after opening up the triple helix towards the top. Instead of a rigid column, it looked more like a tree that way. I ended up calling the piece 'Unraveling Collagen' (Figure 1). I find it a natural association to think of aging and how it relates to the decay of collagen resulting in wrinkles."

During the course of learning about the protein and its role in the cell, and during his own creative process, these associations emerge for the artist. "I am trying to make objects that have meaning as opposed to being only fun to look at," remarked Voss-Andreae, "But I don't mean the kind of simple meaning you can write down, have your audience read it and then they will 'get it.' I am not after some kind of intellectual understanding. I want to make work that appeals foremost to the senses and is ideally intuitively recognized as meaningful. The conscious thoughts come after that." Voss-Andreae has noted that scientists and scientifically educated laypeople tend to like his protein-based work more than those who have no interest in science. He has observed that his sculptures can trigger a sense of wonder even in scientifically uneducated people. "Having an intriguing sculpture in combination with the most basic knowledge like 'this is shaped after something in your body that makes you live' can get people thinking about deep questions, such as 'what does it mean to be alive?' or 'what is left of me if I subtract my biochemistry?'"

The Birth of an Idea: the KcsA Potassium Channel

Voss-Andreae's recent sculpture based on the KcsA potassium channel has generated much excitement (Figure 2). The sculpture, titled "Birth of an Idea," stands 5 feet (1.5m) tall and was commissioned by Nobel laureate Dr. Roderick MacKinnon of Rockefeller University. Voss-Andreae had already been thinking about proposing a large sculpture based on an ion channel to Cold Spring Harbor Laboratories and had begun to read on ion channels. The beauty of the KcsA potassium channel had struck him and the message Voss-Andreae wanted to convey had also begun to develop. "I knew I wanted to use the channel protein structure to create a metaphor for 'the spark,' the small but all-important idea in the beginning of everything we do. Although it is probably not the case that we can point at one structure in our brain where that kind of spark emerges, the ion channel can nevertheless symbolize that because it is something like the smallest logical unit in the vast network of our brain. I liked that it has the shape of a vessel which is an ancient symbol for receiving inspiration from the Gods."

During the time of Voss-Andreae's brainstorming, he received a grant from Portland's Regional Arts and Culture Council to travel to New York City, and there Dr. MacKinnon agreed to speak with Voss-Andreae about his ideas. This conversation helped Voss-Andreae narrow down his approach; "One of the most fun aspects of making a protein sculpture is actually getting to look into the science behind it and talking with people who know the molecules really well." In the final version of "Birth of an Idea," the pore is represented as a blue wire mesh. "This was inspired," explained Voss-Andreae, "by those isodensity plots often used in scientific literature to turn a quantum mechanical probability distribution

Self-portrait, 1990.

into something resembling a classical hard-edge object we can easily get a three-dimensional feel for. The piece stands on a pedestal crafted from massive, hand-planed wood planks connected with old-fashioned finger-joints." Voss-Andreae originally planned to make the pedestal from bronze but changed his mind. "I had the idea to visibly connect the construction principle of the pedestal to the way nature constructs the molecule out of four identical subunits arranged in C4 symmetry." The ion is represented by a yellow glass globe that focuses the viewer's eye to the center of the sculpture and reflects the transport process.

Unique Techniques and Novel Inspiration

While most of Voss-Andreae sculptures to date have balanced the protein structure with the negative space, he is now exploring ways "to fill 3D space elegantly with a network consisting of connected 1D pieces of similar length." Like any of us, inspiration for Voss-Andreae comes at the most unexpected of times. "This realization came to me when I tried to cut down my two older kids' sugar intake by forcing them to share a single vanilla milk at Starbucks. They requested those large transparent cups and poured their drink in there, which barely covered the base. But after blowing air in with a straw, the stuff bubbled up, filling the whole volume." Voss-Andreae's next goal is to make a bronze cast network like the geometry of this foam to reflect the shape of the human body. He is currently experimenting with this technique physically by creating an artificial foam out of balloons and theoretically by collaborating with a mathematician on simulations. Voss-Andreae wants the piece to be about "the emergence of something new through a high degree of interconnectedness, as it happens in our brain." If this description has stimulated your brain to make a connection, Voss-Andreae wants to hear from you. He is looking for a name for this sculpture and would welcome your good idea.

Voss-Andreae is also finishing a piece for the new Scripps Research Institute in Jupiter, Florida based on the structure of the antibody, a protein produced by the immune system to recognize foreign substances in the body. With over 1,300 amino acids in these proteins, this is his "most complex protein piece so far." The work will be installed in November 2008 and "highlights the similar proportions I noticed between the antibody and the human body by placing [an antibody protein] into a circle like Leonardo's famous 'Vitruvian Man' in the circle."

Just as Voss-Andreae was blown away by the beauty of GFP, the scientist that introduced him to GFP caught his attention as well. Dr. Adriana Voss-Andreae, the neuroscience graduate student who originally introduced Julian to protein structures, continues to influence his art. "I frequently ask Adriana for advice with specific pieces and she has contributed really good ideas many times. She generally influences my thinking very much." Both Julian and Adriana are fascinated and concerned with how science is reflected and utilized outside the scientific world. With his art, Julian gives his viewers a means to visualize the building blocks of life and an opportunity to appreciate the wonders of nature. Through these beautiful and awe-inspiring protein structures and sculptures, Julian hopes to engage us in the natural world that we often take for granted.

Finally, what does Adriana think of Julian's work?
"She loves it, of course!"

Julie Wallace received her Ph.D. in Biology from MIT and recently finished her postdoctoral work at the National Institute of Diabetes and Digestive and Kidney Diseases at the NIH. She currently is a Health Research Policy Analyst with the NIDDK."