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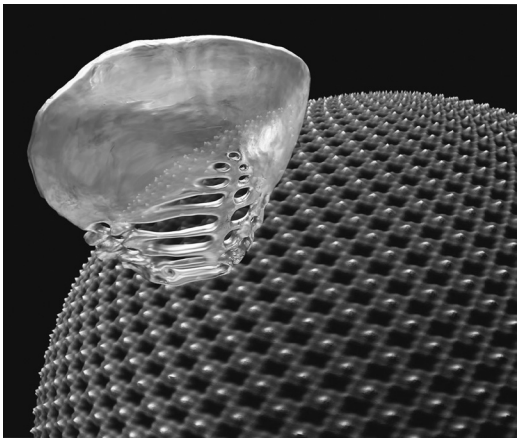
# Curiosity and Passion for Science and Art



Uwe B. Sleytr
University of Natural Resources and Life Sciences, Vienna, Austria

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# FOREWORD

Science and art are two sides of a single, fabulous coin. They both are rooted in humankind's natural curiosity, creativity, imagination, and honesty. These characteristics eventually lead not only to new insights and new knowledge but also to the expression of humans' deepest feelings toward nature and their fellow men. This trait is shared by all cultures, no matter how primitive or advanced.

Science and art each require, as a starting point, the careful observation and recording of natural phenomena. Whether it be landscapes or test tubes, the macro- or the microcosmos, scientists and artists study and record and reproduce nature in order to gain insights. With such insights, scientists make discoveries of biological and physical phenomena within the beauty of nature, while artists arouse human feelings through their most profound expressions.

Both scientific and artistic endeavors arise from a passion for understanding nature and for expressing human desire. The pursuit of science and art is not done with the aim of making money, but for the pleasure of finding things out and of expressing humans' innermost feelings. Science and art are not for the half-hearted, high-fliers, or career-minded seekers. They both need enduring practice and sustained patience — persistence even after numerous failures. It is often said that, in science, most experiments fail, and initial observations are difficult to repeat. Experimental work is routine and repetitious, but breakthroughs and new knowledge depend on reproducible results. Likewise, artistic breakthroughs often come after years of dedicated work.

It is my belief that art and science are the greatest legacy our ancestors left us, from stone carvings, cave paintings, and primitive tools to today's inventions that amplify human abilities and express the human mind. All else — kings, queens, religions, and empires — become irrelevant.

Uwe Sleytr has pursued science and art simultaneously with passion and achieved greatness. In this unique book, you will read about his relentless quest for an exceedingly important class of surface proteins — which he termed *S-layer proteins* — on numerous bacteria and nearly all archaea. Calculated by the mass

or weight of the living system on Earth, S-layer proteins are the single most abundant protein on the planet. Moreover, most important, S-layers represent a unique structural basis and patterning element for generating more complex supramolecular structures. Accordingly, they fulfill key requirements as building blocks and patterning elements for the production of new materials and nanoscale devices in molecular nanotechnology, nanobiotechnology, synthetic biology, and biomimetics.

At the same time, Sleytr has passionately pursued his interest in art, from early drawings and paintings like Gustav Klimt when he was in his early 20s, to his sculptures of amazing gold-coated clay masks, to his latest photography of optically distorted mask images and computer color mixing. Through these image distortions Sleytr expresses his vision of an unpredictable future of human beings and society possibly mediated by advances in synthetic biology and self-enhancement through genome editing.

As both an accomplished scientist and artist, Uwe Sleytr is able to present both kinds of visions. It is a great pleasure to read about his lifelong pursuit and interests in a single book. I hope that you will find it a fascinating book for your interest in both science and art.

*Shuguang Zhang*
*Massachusetts Institute of Technology*

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# CURIOSITY AND PASSION FOR ART

My scientific activities have never been my sole focus of interest. Looking back, my inspiration for artistic activities started quite early in my life. The walls in our home were full of oil paintings and watercolor pictures, mostly by my father, but some were from other artists, which my father had obtained in exchange for his own work. I do not know if it was the effect of such an environment or if I had inherited the proper genes (epigenetics), but already in elementary school my teachers noticed that I was very gifted in making fanciful drawings of animals and people. My father not only introduced me to different techniques for painting and drawing, but also explained to me how to plan compositions. I was quite motivated to try different techniques and to improve my performance. Moreover, while drawing or painting I could retreat into a subconscious world of fertile imagination, or "flow," using the prevailing term of psychology.

In Vienna there are several very famous art museums, and from quite an early age my father took me to various exhibitions. Most important, during our visits he did not attempt to show me as many of the artworks as possible, but rather he selected a few upon which to focus in more depth. These were thrilling occasions, where I learned to analyze artwork. While standing in front of a chosen picture, my father asked me many questions, such as "What do you see?", "Can you feel something?" and "Can you imagine the intention of the artist using these colors?". Or, while looking at sketches and drawings, "Can you recognize the effect the artist wanted to accomplish by changing the pressure of the pencil or carbon while drawing?". The last question was of particular relevance to analyzing the drawings of Gustav Klimt and Egon Schiele.

Nowadays, this approach to art appreciation and art understanding can be considered to be the standard procedure in art education, but during my youth it was rather exceptional to experience such an introduction, by my father. Standing in front of a picture and letting it sink in became exciting because I was also taught that there is commonly not just one interpretation or meaning for artwork; there are generally a variety of possible interpretations. Equally important, I was assured that it is part of me as an individual which generates a meaning, and that my interpretation is permitted to diverge significantly from the intention of the artist. I also absorbed the message "Relevant artwork should generate an emotional resonance in the observer and should not leave one in an unconcerned state." Moreover, there may be a broad spectrum of reactions, ranging from rejection to empathy and admiration. Much later, I realized that the theory of communication and in particular the radical constructivism of the psychologist

and philosopher Paul Watzlawick might be appropriate for explaining the broad spectrum for individual interpretations of artwork. Interdependency with art is a phenomenon best described as a kind of "communication" between the observer and the producer of the artwork. I am convinced that through this nonverbal approach, people sensitized for "diving" into artwork may quite often learn a lot about themselves. Gustav Klimt and Egon Schiele fascinated me with their later work to such an extent that around the age of 20 I even copied selections from their oeuvres with the intention of immersing myself in the emotional world of both artists and gaining a feeling for the unique techniques they used.

As noted before, during my high school years, irrespective of my interest in the natural sciences, I was still very interested in art and primarily engaged in painting and drawing. At the age of 16, I also started woodcarving, having my grandfather's carving tools on hand. This activity was primarily focused on copying African art and, as far as I remember, was initially triggered by visiting an exhibition of Pablo Picasso's work, including his African (Proto-Cubist and Cubist) period. At that time I was already well aware that many artists of the emergent European modernism, followed by Expressionists, Cubists, and Surrealists, were strongly influenced by the expressive power of African sacred sculptures and particularly of the traditional masks. My fascination for masks was also intensified when I saw African, Asian, Oceanic, and Native American mask collections in the museum of ethnology in Vienna. Moreover, in my mother's bookstore I had access to a variety of related art books including high quality color illustrations.

Masks representing humans or animals, which have been used as a very ancient human practice across the world for ceremonial and practical purposes as well as protective armor, possess for me enormous expressive power. This is the primary reason I still use masklike sculptures to visualize the intersection between science and art, and in particular the unpredictability and mystery of scientific visions.

I find it most fascinating to be able to switch between the seemingly unconnected worlds of science and art. For me, the common denominator of the two worlds is creativity. The capacity to produce creative thoughts is still one of the most mysterious tricks of our brain and cannot yet be explicitly localized in the neuronal network. Moreover, I am convinced that creativity in science and art cannot be forced. Rather, it happens during a state of recovery or daydreaming, and often after a period of very intensive mental occupation with a particular subject. In other words, creativity occurs during a period of escape and deviation from standard patterns of thought. In this context, it is essentially a quasimental return to a playful attitude, characteristic of childlike behavior, and thus an invaluable mental state frequently lost with increasing age.

Upon switching between the worlds of science and art, I became aware of the serious intrinsic divide between them.

Science evolves in a stringent framework of providing reproducible methods anywhere in the world, which also determine the limits for results and findings. Thus, most relevant in science, we do not unconditionally get "what we want," but rather "what we can." And this "what we can" depends on the methods available for performing examinations and studies. Symbolically, scientific progress generates an expanding network of reproducible knowledge.

With art, such limits do not exist, and with a creative mind one can enter and experience virtually an unlimited freedom of thought, and arbitrarily fill the "open space" left between the networks of knowledge. Moreover, art — and this also concerns other art forms, like music — opens up a world of sensations and emotions barely known at such an intensity from scientific activities.

To give this chapter a personal touch, I wish to emphasize that, looking back, I feel very fortunate that from time to time I could remove the straitjacket of pure science and was able to transfer scientific questions into the world of art.

In Section 5, a compilation of images is presented, giving examples of how I express fundamental and unanswered scientific questions related to synthetic biology and evolution as art.

For my artworks concerning synthetic biology and evolution, I would like to begin with a few basic remarks. It is now evident that achievements and predictable progress in synthetic biology and genome editing imply the potential for a most significant interference with the course of evolution. In this context, it is good to remember that fossil findings and molecular biology data allow a fairly precise reconstruction of the evolution of life forms, including that of humankind in its present manifestation. Nevertheless, the accumulated data and knowledge do not allow any prediction of the future of evolutionary events. On the other hand, future methods emerging in synthetic biology might enable the engineers of biology to design new species of living organisms or even a new "creature" that could be seen as the next stage of human evolution. Thus, the result of synthetic biology might be considered to be an intentional extrapolation of evolutionary events, bypassing billions of years of biological developments, which up to the present have been driven by mutation, epigenetics, natural selection, and survival of the fittest.

## 2.1. Synthetic Biology and Evolution: An Artistic Approach

In the sculptures (Chapter 5; pictures of sculptures of baked clay gilded with gold leaf), the multiple sense organs (such as the eyes and the noses), the components of the skeleton, or changes in the skull dimensions emblematize the nonpredictable, self-induced (or self-enhanced) evolution of humans as a consequence of the input and application of synthetic biology, particularly genome editing. Generally, the masklike sculptures were produced from baked clay, which was subsequently

gilded with gold leaf. I should add that I formed the clay exclusively with my bare hands, without any modeling tool for achieving a direct transfer from part of my morphology into the ductile material, like a derivative in the course of an arbitrary evolution event. Most important, I did not start with any drawing but simply let the formation happen in a state of "flow." In essence, it was the intention to create a *sui generis* result nourished by subliminal creativity. With sculptures composed of two or multiple parts linked together, the lower part, which may resemble morphological details recognized in the main body, symbolizes the release of information as required for communication. I choose gilded surfaces for obtaining a surface image that is as neutral as possible, thus preventing any optical distraction from the proper morphology. On the other hand, gold has a particular decorativeness, and I well remembered the use of gold in Gustav Klimt's pictures. When I was copying his pictures of "water serpents" (Fig. 6) and "Danae," I immediately became aware of the intuitive strength and suggestive power which the pictures obtained after the addition of the gold foil.

**Fig. 6.** A copy of Gustav Klimt's picture of "water serpents" next to a series of mirror images of sculptures obtained by reflection in a piece of distorted mirror foil.

To illustrate the intrinsically unpredictable evolution, even when determined by synthetic biology and genome editing, the sculptures were subsequently modified in two ways. One procedure involved splashing them with colored water (Fig. 7, and selected artwork in Chapter 5). It was performed and photographed under the guidance of the recognized conceptual photographer Fritz Simak (who spent some time working with the famous photographer Ernst Haas).

**Fig. 7.** A scene from the procedure involving splashing sculptures with colored water.

In a modified approach, we poured colored water over the mask sculptures from a watering can and by coincidence witnessed the striking phenomenon that water as a thin layer can form waves in the course of free fall.

In a second approach to illustrating arbitrary evolutionary events, I generated dynamically distorted images of the sculptures in deformed mirror foil (Fig. 8, and artwork in Chapter 5).

**Fig. 8.** Assembly used for obtaining images of sculptures in distorted mirror foil.

The intention was to symbolize with these snapshots trial-and-error events during a biological evolution driven by humans. Again, although being part of such a process, the results are unimaginable and incomprehensible due to human intellectual limitations on selecting in the long term features that surpass straightforward enhancement and optimization criteria. Thus, synthetic biology alerts us to the time-limited existence of humankind based on existing qualities, and consequently the misleading meaning encoded in the term "the pride of creation."

My contemplations of the relevance and potential of synthetic biology for the future changes to our species, particularly self-enhancement and acceleration of evolutionary processes, led me to the production of images from different surroundings in arbitrarily distorted mirror foil without any mirrored sculptures (artwork in Chapter 5). These images were subsequently modified in their colors by computer. I associate these pictures with the idea that developments in synthetic biology may eventually lead to (human) beings endowed with cognitive abilities far beyond our present capability for abstract thought and intellectual efficiency. Just as hominid primates are limited and would not grasp complex human ideas and intellectual concepts (such as quantum mechanics, indeterminism and chance, or free will), perhaps our current species is also limited in comparison with future humans, with no present capacity for understanding what humans (if we can still call these beings "human") will be capable of in such a future world. Our view of the future will necessarily be distorted by our cognitive limitations. The abstract images taken from the mirror foil and subsequently superimposed onto the (distorted) sculptures (artwork in Chapter 5) symbolize this vision.

Selected images from both the splashed sculptures and images obtained in deformed mirror foil have found a permanent place as the exclusive decoration in the recently erected building of the Vienna Institute of Biotechnology, which belongs to the University of Natural Resources and Life Sciences, Vienna (Fig. 9).

Short videos on "Synthetic Biology and Evolution" based on the described artwork produced with Camillo Meinhart and the valuable input of Sonja Bäumel can be downloaded under the following links:

https://vimeo.com/29911150

https://vimeo.com/102540883

**Fig. 9.** Pictures in the hall of the Vienna Institute of Biotechnology, University of Natural Resources and Life Sciences, Vienna (2015).

## 2.2. Epilogue

Writing this short recapitulation spanning half a century of activities in the worlds of science and art has made me once more aware that despite the fact that science dominated my life it was very important that the two areas could coexist in my neuronal network. It occurred to me that a form of synesthetic thinking may have influenced my performance. Hence, living in a world of science and art, I could benefit from the mutually stimulating effect of the two domains. Most relevant, the time I was engaged in art allowed me to linger and dream in a state of unlimited freedom of thought and mood, which presumably subconsciously fueled the creativity required for solving problems within the rather curtailed canon of science.

Retrospectively, I was also very fortunate to have found such fascination in the beauty and diversity of a macromolecular structure, which itself represents a work of art created and optimized by nature in the course of billions of years of biological evolution.

## Acknowledgments

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