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Designing buildings, using biology

Today's architects turn to biology more than ever. Here's why

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When the celebrated 20th century architect Frei Otto set out to design what is arguably his magnum opus, the roof of the Munich Olympic arena, he looked for inspiration from a curious source: soap.

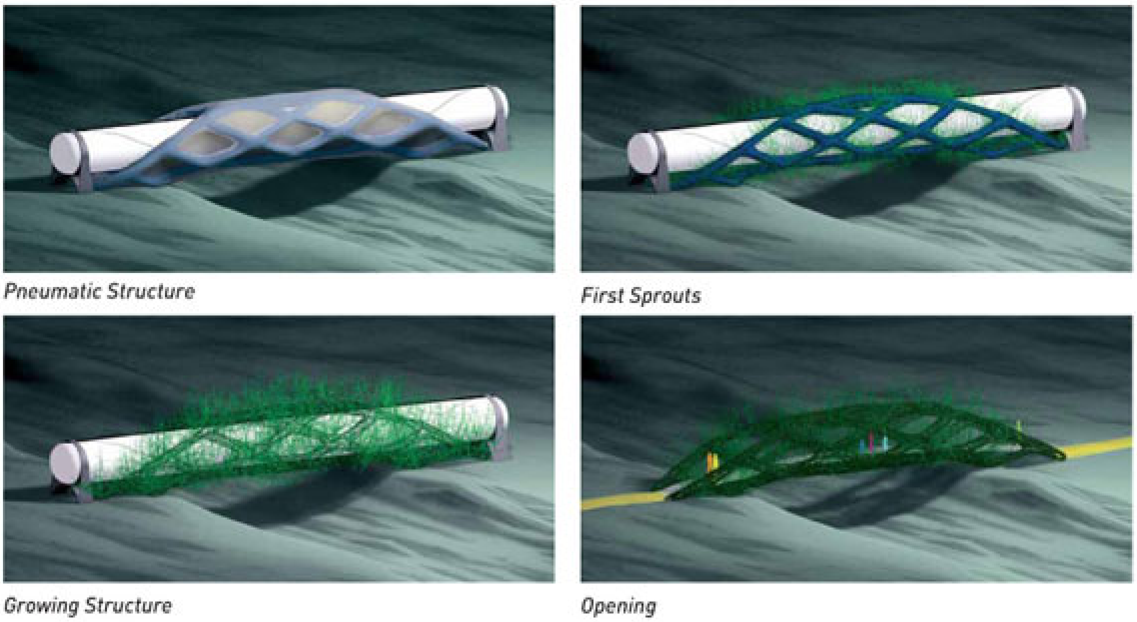
With the fastidious bias of a natural scientist, Otto studied the forms of natural systems like soap films, bamboo, diatoms, and radiolarian. But he didn't copy what he saw. Rather than sculpting elegant counterfeits of what nature looked like from the outside, like a Greek Corinthian column chiseled to reference acanthus leaves, Otto imitated the *internal processes* by which nature arrives at its forms. But what could architecture and biology possibly have in common? Otto recognized that natural systems are self-stabilizing, optimization machines. Any changes in the internal or external environment have a direct consequence on the form, so why not design the final form by imitating the processes that create the form of natural objects? Otto referred to his organic manipulations as "*self-formation* constructions," where "nature is not copied but made comprehensible."

For the Munich stadium roof, Otto scrutinized the properties of soap film. The surfaces of bubbles are efficient natural machines; balancing strength and lightness, they find the largest possible shape using the smallest amount of material. The film stretches to accommodate both internal and external differences in pressure, but rarely falls apart. This, he realized, was exactly what his roof structure -- made of a stretchy, tent-like membrane -- should do. He literally calculated the degrees of change along the surface of soap film, and used those figures to understand the same structural dynamic in the curvature of his roof. Before the 20th century, most architects detached their work from the place it was designed to go. Rather than understanding the city as a living, dynamic organization, these earlier architects established static forms and rules that did not take the environment into account. That's why the skylines of so many cities contain a series of boxes that often don't relate to each other, and could essentially be picked up and stapled down anywhere else.However, Otto didn't believe that, and he was not alone. Today, more designers are accepting the idea that physical structures are a part of a larger organic network, and that the structure, forms, and environment influence each other, just as in living systems.

To stretch over the 1,443 ft. distance of the Munich stadium, Otto treated the ceiling like skin -- the fabric, which is stretched between guide wires, is organized in such a way that the tension of the fabric helps stabilize the structure. So the masts hold up the wires, which hold up the skin. The skin,

reciprocally, stabilizes the masts, covering and anchoring the stadium. Where the structural system meets the ground, the skin weaves into the unique topography, water and circulation of the place.Twentieth century architects are preoccupied more than ever before with the concept of self-organization. In natural systems, life stays in constant flux to adapt to its environment, but still operates under a set of constraints, such as genotype. Architects reason: Start with the constraints that limit a structure, then permit some variation but not so much the entire system falls apart, and, with control, let the final architectural forms grow from there. Two prime examples of this are Toyo Ito's and Cecil Balmond's 2002 Serpentine Gallery Pavillion, in the UK, and the Watercube under construction in Beijing.

In Suburban Prototypes', by Nastasi Architects, the houses are not placed just anywhere. Instead, walls curve, roof lines shift, and foundations aren't arrayed in a perfect line. This unconventional arrangement ensures that each house gets the most exposure to light and works around the natural movement of groundwater. Like in a living organism, each part of this project is influenced by its relationship to the other parts. In Living Plant Constructions, at the University of Stuttgart, Gerd de Bruyn and students Ferdinand Ludwig and Oliver Storz use temporary air filled tubes to support and direct the growth of strangler fig trees into a self-stabilizing pedestrian bridge between the German and Polish border. (The design is still in development, and will likely take seven years to grow before it is strong enough to use.)



Frie Otto spent years researching "pneus," air-filled structures. Katja Linnig, one of my graduate students at the Illinois Institute of Technology, explored self-organization using paper 'cells' and a balloon-type object that offers the structural support of air. These materials have a measurable tolerance and simply analyzed range of structural properties, which changes depending on how the parts are manipulated in relation to one another as the form self-organizes and grows. Architects certainly turn to biologists for inspiration: Otto worked side-by-side with biologist JG

Helmke, and today architecture professors and practitioners, including myself, meticulously mine texts by biologists like Eric Bonabeau and Stewart Kauffman. Indeed one biologist, Donald Ingber at Harvard, turns the tables, and studies architecture for principles that explain how the cytoskeleton comes and stays together. As Otto once said: "Biology has become indispensable for architecture -- but architecture has also become indispensable for biology." *Eric Ellingsen is a senior lecturer at the Illinois Institute of Technology, where he teaches architecture and landscape studios, history, and theory courses. He is co-editor of the forthcoming book 306090: Models*.Eric Ellingsen mail@the-scientist.comImages: Munich Olympic stadium, courtesy of Kristina Katich, Flickr.com. Serpentine Pavilion. copyright by Arup. Watercube in Beijing, Luca Gagno, Flickr.com. Nastasi Architects' Suburban Prototype, courtesy of Nastasi Architects. Living plant, IGMA, (Institut Grundlagen Moderner Arckitektur und Entwerfen) [Institute for the Basics in Modern Architecture Design], University of Stuttgart; Gerd de Bruyn. Katja Linnig sculpture, photo by Eric Ellingsen.Links within this article:Frei Otto http://www.greatbuildings.com/architects/Frei_Otto.htmlNastasi Architects http://www.nastasiarchitects.comSlought Foundation http://www.slought.org/content/11339Cross-Catalytic Architecture http://www.icosystem.com/about_management.htmDonald Ingber http://www.hms.harvard.edu/dms/bbs/fac/ingber.html306090: Models http://www.306090.org