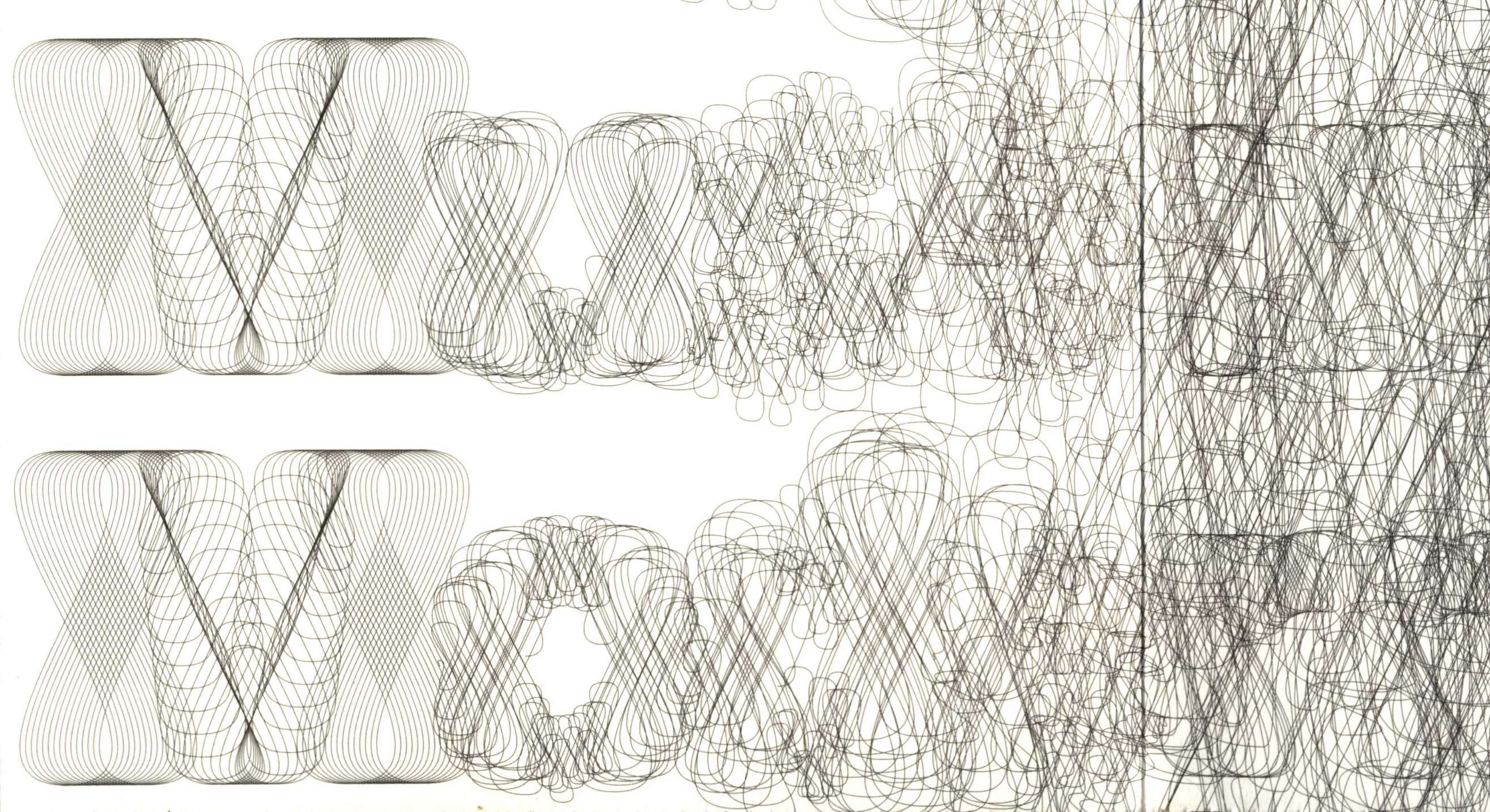
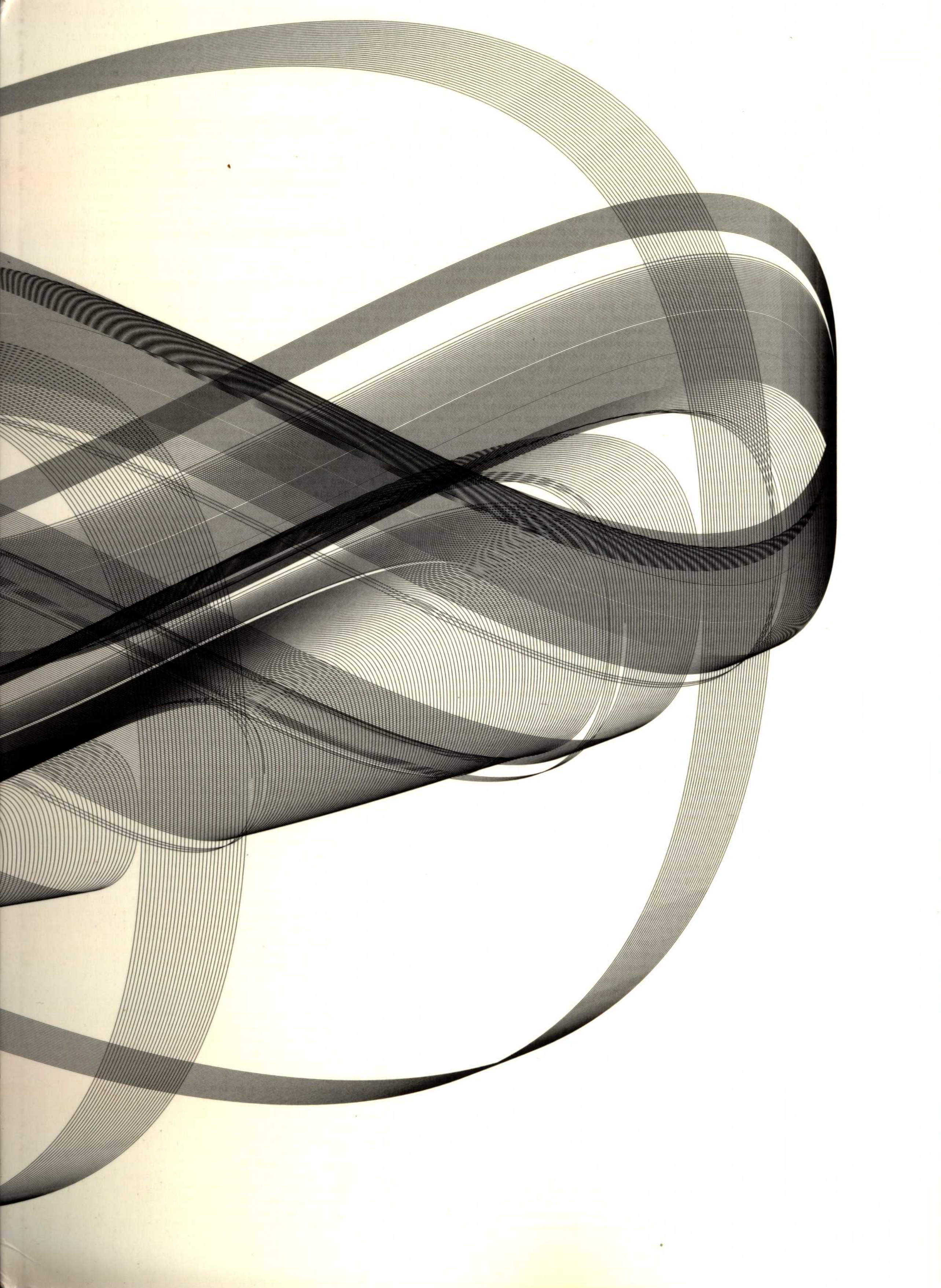
Design and the Elastic Mind





Design and the Elastic Mind

The Museum of Modern Art, New York

Published on the occasion of the exhibition Design and the Elastic Mind, February 24–May 12, 2008, at The Museum of Modern Art, New York, organized by Paola Antonelli, Senior Curator, and Patricia Juncosa Vecchierini, Curatorial Assistant, Department of Architecture and Design

The exhibition is made possible by the Mrs. Hedwig A. Van Ameringen Architecture and Design Exhibition Fund.

Generous funding is provided by NTT DoCoMo, Inc., and Patricia Phelps de Cisneros.

Additional support is provided by The Contemporary Arts Council of The Museum of Modern Art.

Produced by the Department of Publications, The Museum of Modern Art, New York
Edited by Libby Hruska and Rebecca Roberts
Designed by Irma Boom
Production by Elisa Frohlich
Typeset in Courier Sans
Printed and bound by Oceanic Graphic Printing, Inc., China
Printed on 120 gsm Arctic Amber Preprint

Library of Congress Control Number: 2007939768
ISBN: 978-0-87070-732-2

Published by
The Museum of Modern Art
11 West 53 Street, New York, NY 10019-5497
www.moma.org

Distributed in the United States and Canada by D.A.P./Distributed Art Publishers, Inc., New York

Distributed outside the United States and Canada by Thames & Hudson, Ltd., London

Cover design by Irma Boom
Cover type by Daniël Maarleveld

Printed in China

Contents

Applied Curiosity

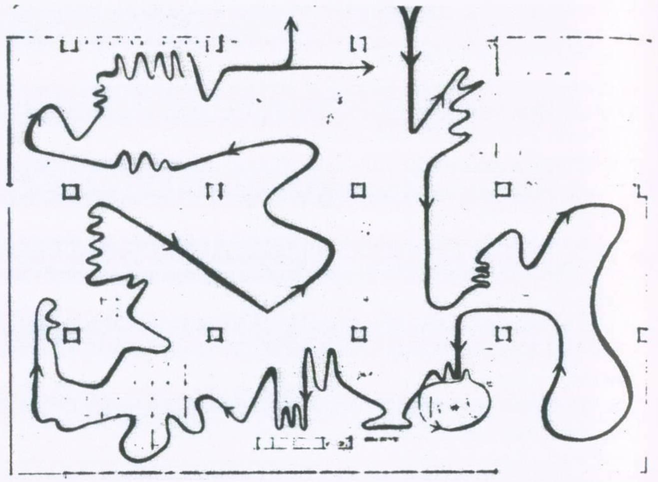
Hugh Aldersey-Williams

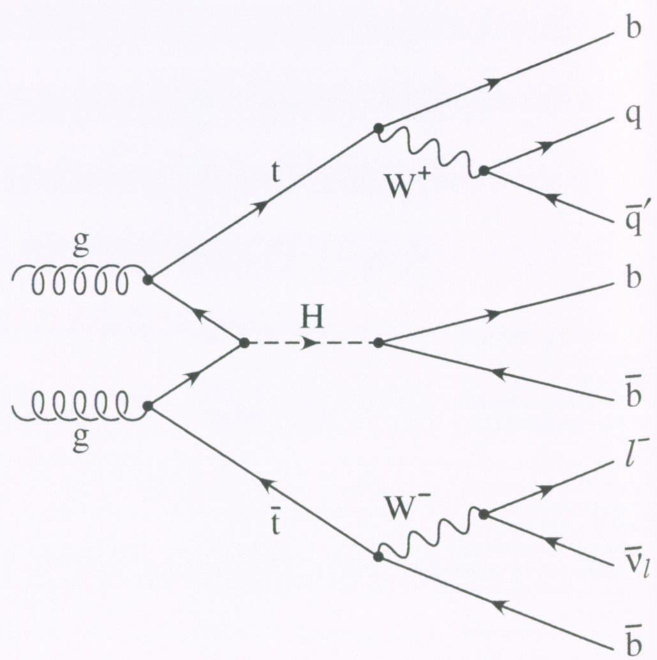
Though they both lived and worked for many years in the Los Angeles area, it seems that designer Charles Eames and physicist Richard Feynman never met. From their studio at 901 Washington Boulevard in Venice, Charles Eames and his wife, Ray, created some of the most innovative furniture and other designs of the twentieth century. Feynman worked less than twenty miles away, at Caltech, and in 1965 was awarded the Nobel Prize for his development of quantum electrodynamics, which explains the interaction of particles and electromagnetic radiation such as light in terms of quantum theory.

Not much in common, it might seem at first glance. But what set the Eameses apart from other designers was an ability—and an urge—to communicate complex ideas in visual terms. In addition to furniture, they produced films and exhibitions, many of them on scientific themes. Feynman, too, was acclaimed as a teacher and communicator for whom visualization was an essential tool. His most eloquent demonstrations of the power of visualization in science are the diagrams that now bear his name. These describe the interaction of radiation and particles of matter in a shorthand that is both mathematically accurate and graphically narrative. The timelines that the Eameses pioneered in order to present complex ideas in history and science have similar powers for a different audience. Both kinds of diagrams map time and space to portray relations between events that may be causal or coincidental.

There are more specific reasons to lament this missed connection. In 1959, Feynman gave a now-famous lecture titled "There's Plenty of Room at the Bottom."[1] In his characteristically iconoclastic way, he had looked broadly at science and found what others had largely missed, namely that it would be nice to be able to do chemistry with precision for a change, building desired molecules atom by atom rather than throwing together large quantities of reactants and leaving all the organization to chemical forces outside our control. Feynman imagined how novel and useful articles might be assembled atom by atom, giving as an example a robot that could enter the body to perform medical procedures. This was the seed of nanotechnology. The Eameses, in turn, invited contemplation of that nano-sized world in their 1968 film _Powers of Ten_, inspired by Kees Boeke's book _Cosmic View: The Universe in Forty Jumps_ (1957). The eight-minute film is in effect a single zoom shot, calibrated according to the level of magnification seen at any instant through the camera, expressed in exponential powers of ten. The need for designers is implicit in Feynman's challenge. And the potential for designers to respond is evident from the nature of the Eameses' intelligence. The combining of these two forces is a consummation to be devoutly wished for. Yet it did not happen in Los Angeles forty years ago, and it does not happen in general today.

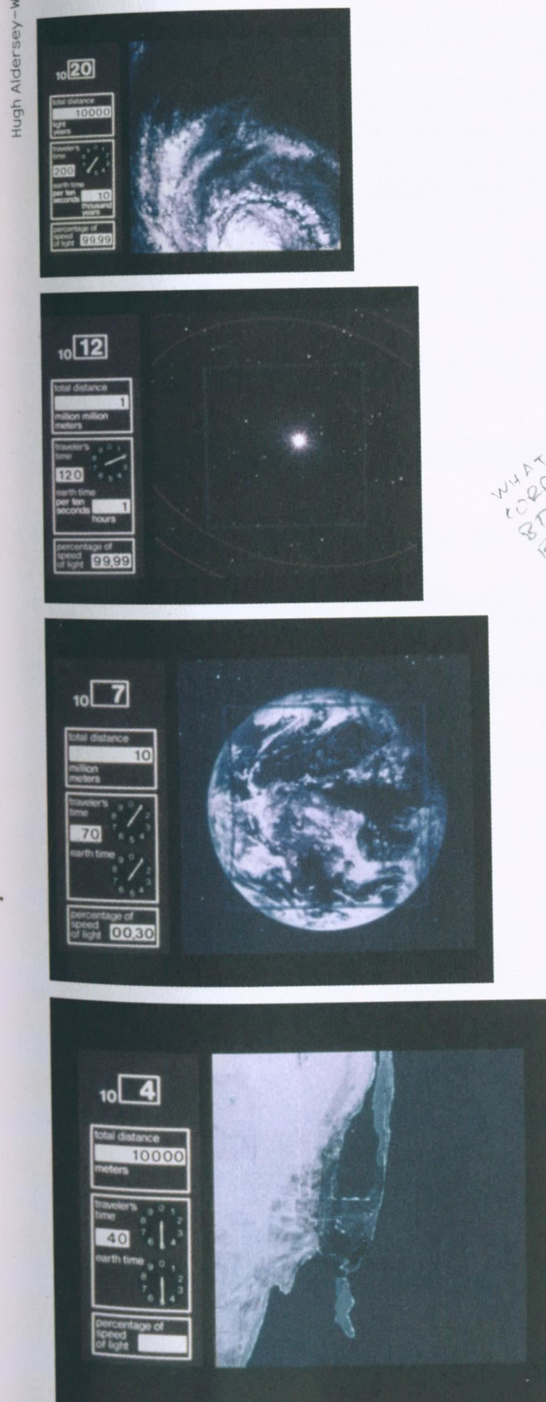
Charles Eames and Ray Eames. The Office of Charles and Ray Eames. **Traffic pattern for the exhibition** _**Good Design**_, Chicago. 1950





Richard Phillips Feynman. **Feynman Diagram.** 1949

below and pages 48–51: Charles Eames and Ray Eames. The Office of Charles and Ray Eames. Stills from _**Powers of Ten: A Rough Sketch for a Proposed Film Dealing with the Powers of Ten and the Relative Size of the Universe**_. 1968

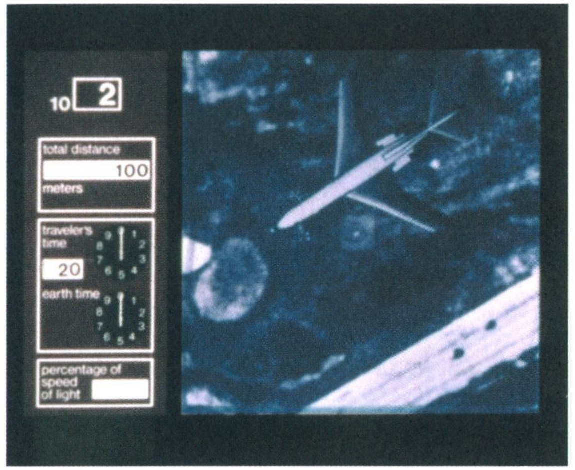


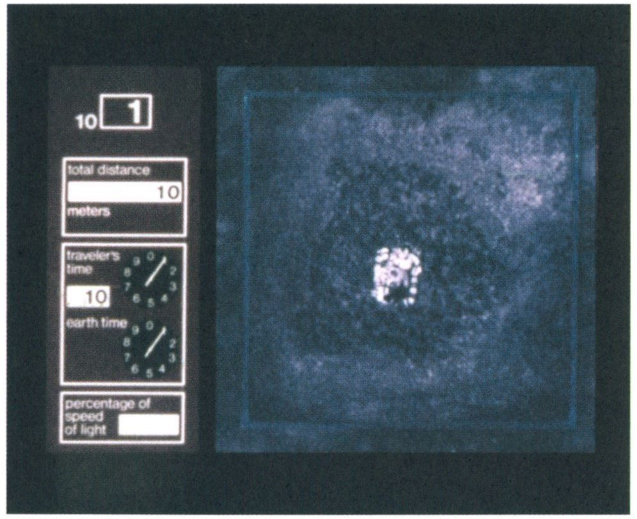
The sense that there is a connection between science and design at all stems from the vague notion that these two disciplines were once one and the same. Leonardo da Vinci was the archetypal designer-scientist, the Renaissance man whom we unreasonably hold responsible for our contemporary expectation of such a synergy. Less than two centuries later, Robert Hooke and Christopher Wren, two of the founders of the Royal Society in 1660, the world's first academy of sciences, were architects and scientists both. But just a century after that, the split was beginning to appear. The attempts of the illustrious club of scientists and entrepreneurs known as the Lunar Society (members included chemist Joseph Priestley, steam-engine pioneer James Watt, and industrialist and potter Josiah Wedgwood) to maintain a dialogue already seemed strained. After one moonlit session, Wedgwood was driven to complain: "I have got beyond my depth....These wonderful works of Nature are too vast for my narrow microscopic comprehension. I must bid adieu to them for the present, & attend to what better suits my Capacity. The forming of a Jug or Teapot."[2] For the sciences were growing in volume and complexity. Beginning with the microscope and telescope, new technologies enabled investigation of regions invisible to the naked eye, further removing the scientific from the daily realm. The Industrial Revolution and the commercialization of design—which became known as one of the "useful arts"—merely served to widen the chasm.

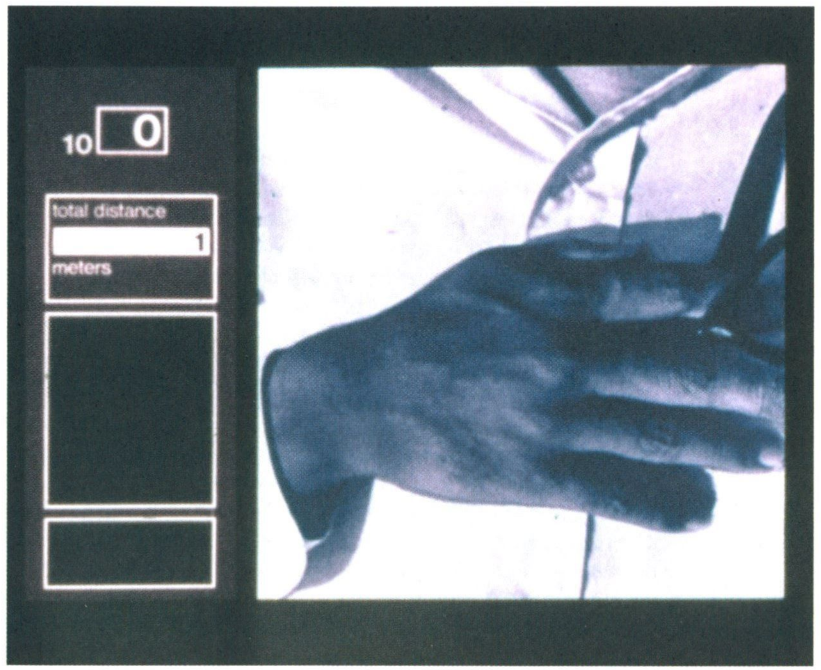
WHAT IS THE CORRELATION BTW DAILY ROUTINE & PERCEPTION?

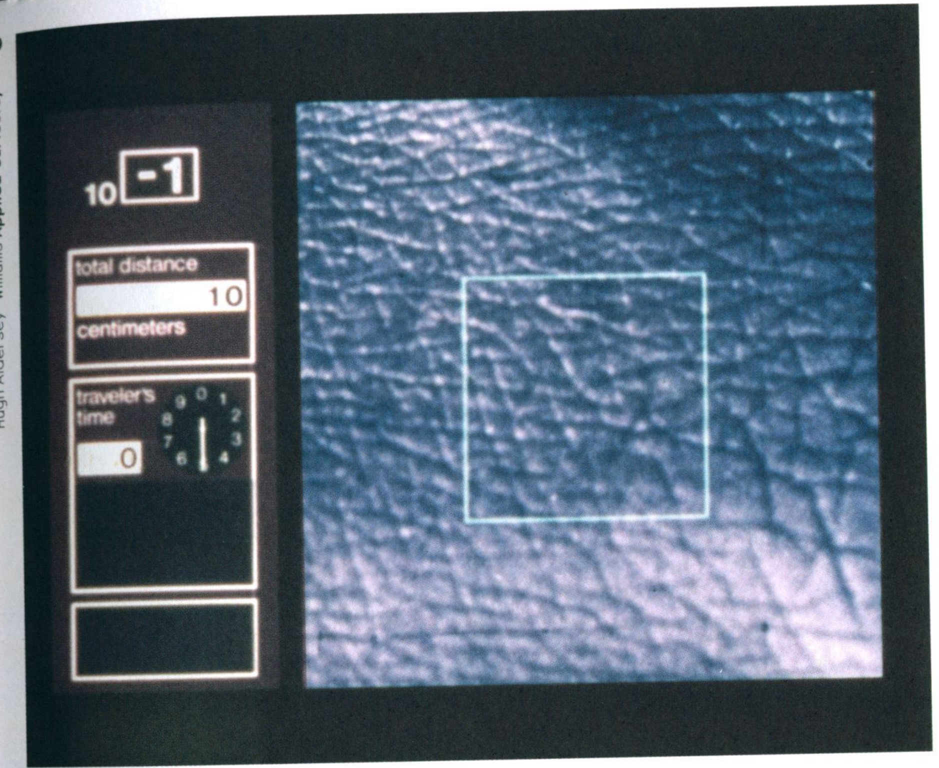
Today, at the beginning of the twenty-first century, the communities of both science and design see that they have removed themselves too far from society—and from one another. For many designers, it is no longer enough to fulfill the demands of commercial clients. They wish their art to be something more than just "useful." Through critical or polemical projects, they signal their readiness to play a more transformative role in society. For their part, scientists are confronted by growing mistrust of what they do, and many realize that they must work harder to win public support.

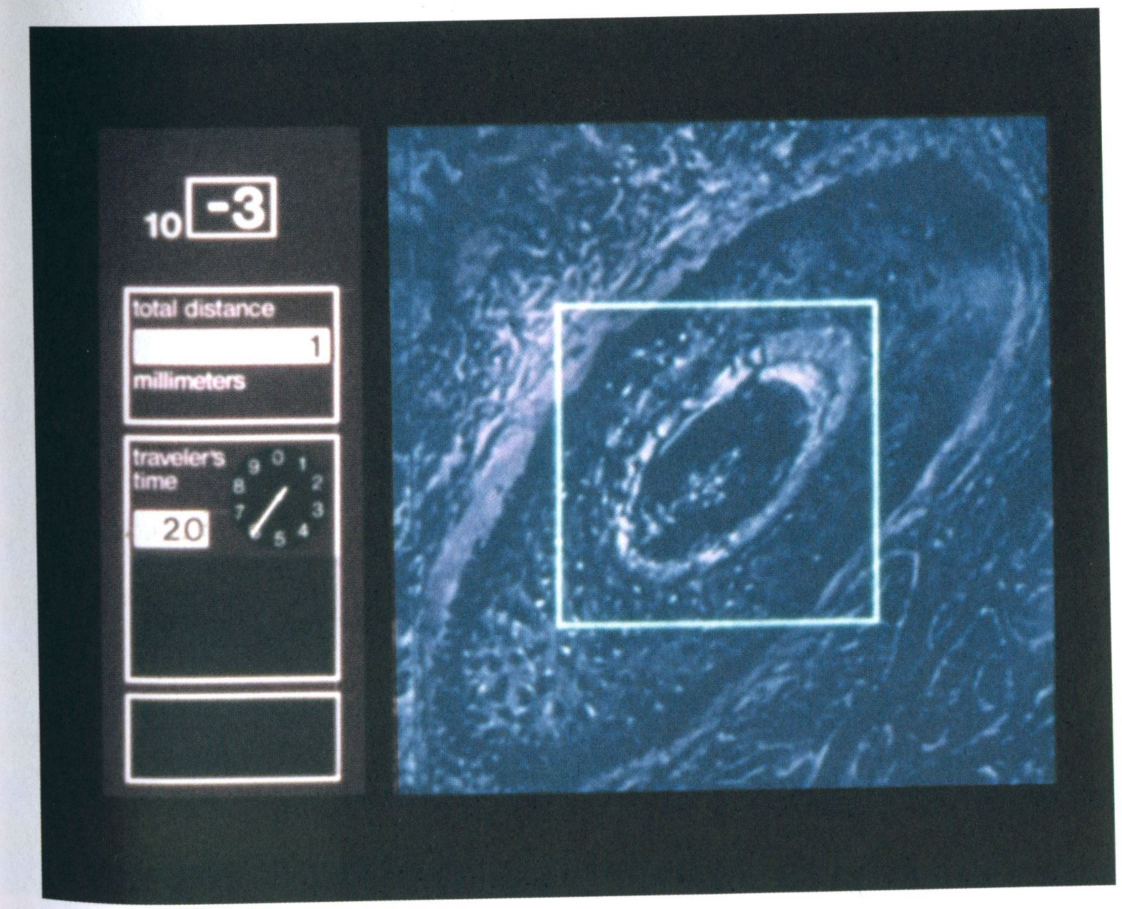
Some science is necessarily remote. Science seeks to encompass the dimensions of time and space from the 10^{-18} meters to the 10^{25} meters of _Powers of Ten_—and beyond. Yet for most of us, scale is a prison. We see our world in feet and inches, meters and centimeters. It is hard enough to resee the same world even as little as a factor of twelve smaller or larger, as Gulliver found on his travels to the islands of Lilliput and Brobdingnag. The difficulties only multiply when we try to perceive the world far smaller than this. They do so because, confusingly, while some of the normal rules of nature continue to apply in microcosm, other apparently fundamental qualities, such as color or gravity, seem to apply no longer, and bizarre new rules may even come to the fore in their place.

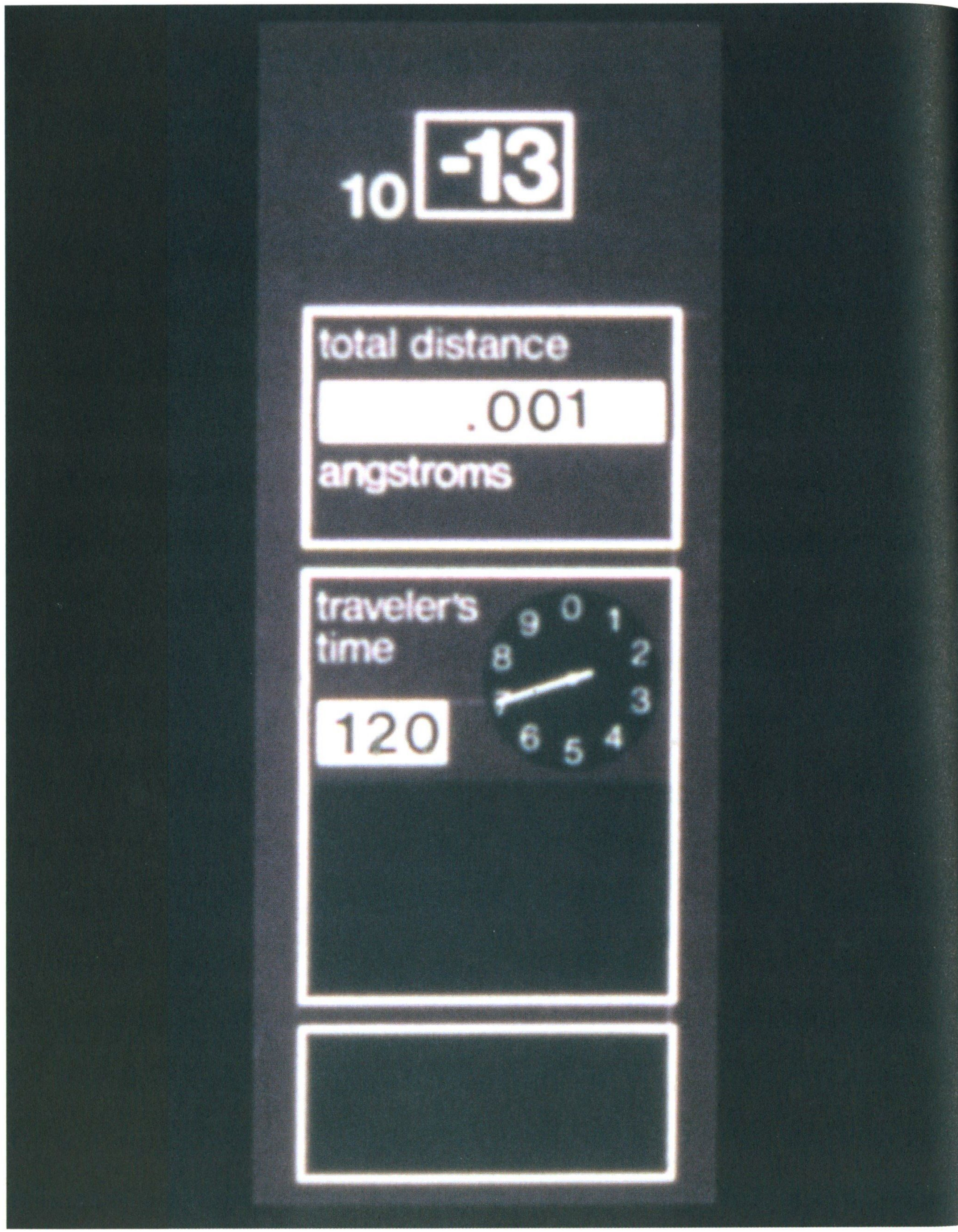

10 2
total distance
100
meters
traveler's time
20
earth time
percentage of speed of light

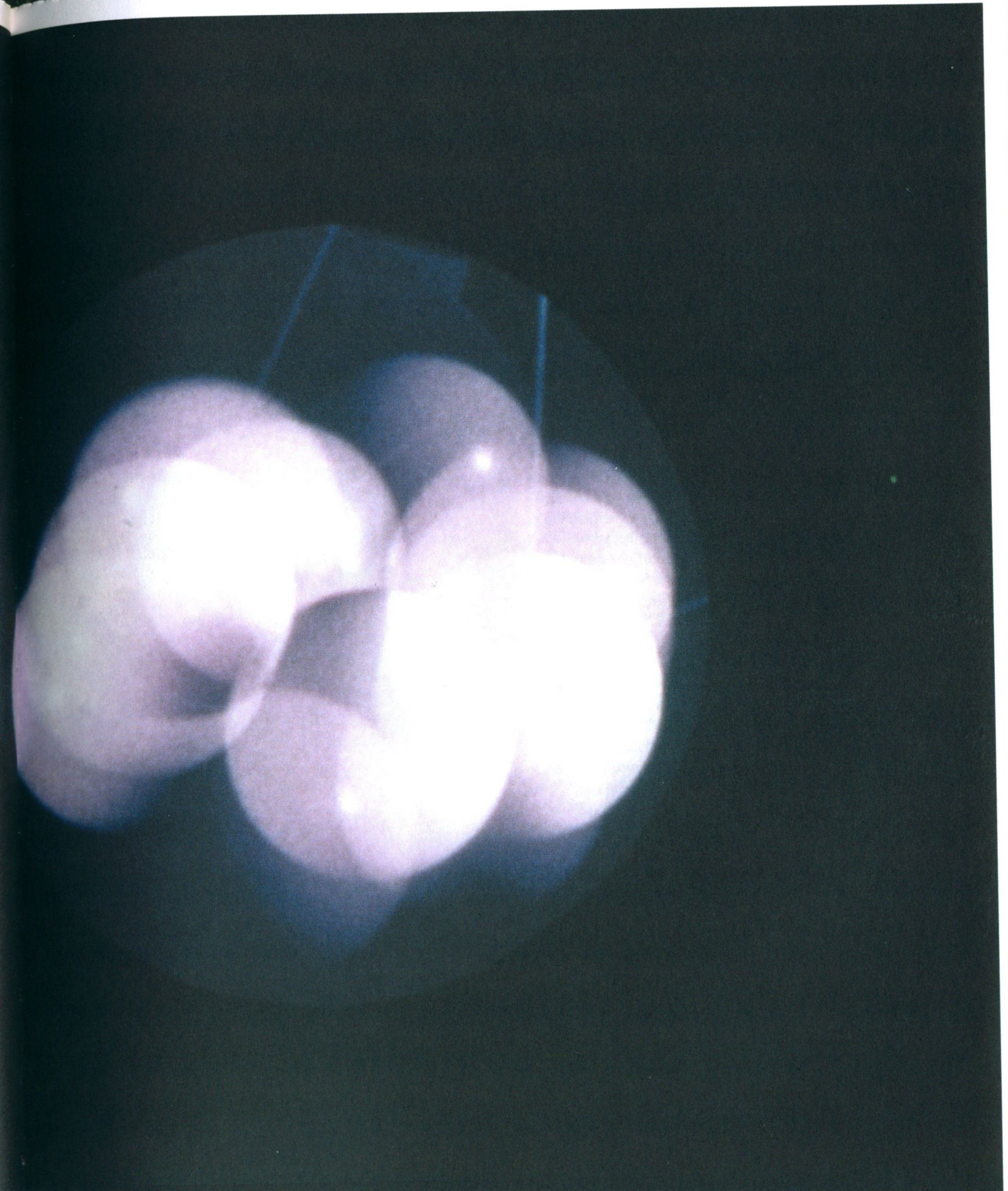

10 1
total distance
10
meters
traveler's time
10
earth time
percentage of speed of light


10 0
total distance
1
meters


10 -1
total distance
10
centimeters
traveler's time
0


10 -3
total distance
1
millimeters
traveler's time
20


10 -13
total distance
.001
angstroms
traveler's time
120
0 1 2 3 4 5 6 8 9



Visualization

Consider the symmetry of three-dimensional objects. The British and American chemists who in 1985 discovered a molecular new form of the element carbon—a surprise addition to the long-familiar forms of diamond and graphite—named it buckminsterfullerene. The molecule's sixty carbon atoms are arranged in a hollow, symmetrical cage, like the structure of one of architect Buckminster Fuller's geodesic domes. The shape of these molecules proves structurally advantageous at the scales of the chemical bond and human construction. The same symmetrical form is found elsewhere in nature, as well, for example in viruses and in the skeletons of the marine protozoa known as radiolarians—intermediate in scale between the molecular and the architectural. Recent studies in physics, meanwhile, have found that the same symmetry may be significant at the extreme ends of the scale: in the shapes of clouds of nuclear charge in the nuclei of atoms, and in some theories of the structure of the universe.

The recurrence of such visual motifs suggests persuasively that a design mentality may be helpful in comprehending the miniature three-dimensional worlds of microorganisms and molecules. By extension, perhaps designers can have something to say about the peculiar inside-out spatial realm that crystallographers find convenient to use, or about the x-dimensional extent of space-time (where x is four in the Einsteinian model but possibly ten or eleven in the more recent and still contentious "string" theory).

Visualization, however, can prove woefully misleading, and scientists have long debated whether it is a useful tool after all. Physicists Werner Heisenberg and Erwin Schrödinger argued bitterly about this in the 1920s. Schrödinger's image of a wave in a box describing the behavior of a small particle in a field of force, such as the negatively charged electron of a hydrogen atom held in orbit around the positively charged proton nucleus, was derided by Heisenberg, who felt that visualization was invalid for quantum phenomena occurring on a scale below the wavelengths of light.

Even at the scale of the visible, the way we visualize things happening may not be the way they actually happen. Scottish polymath D'Arcy Thompson's On Growth and Form (1917) is a brilliant exploration of visual and structural similarity among natural organisms, but even this author is occasionally led into error by the attraction of a visual image. Thompson reasoned, for instance, that birds' eggs must have assumed their characteristic shape for ease of passage along the oviduct, where peristaltic contractions squeeze the tapered end, forcing the egg onward so that it is laid, as is observed, blunt end first. In fact, scientists later found that eggs pass along the oviduct tapered end first and flip round just before they are laid.

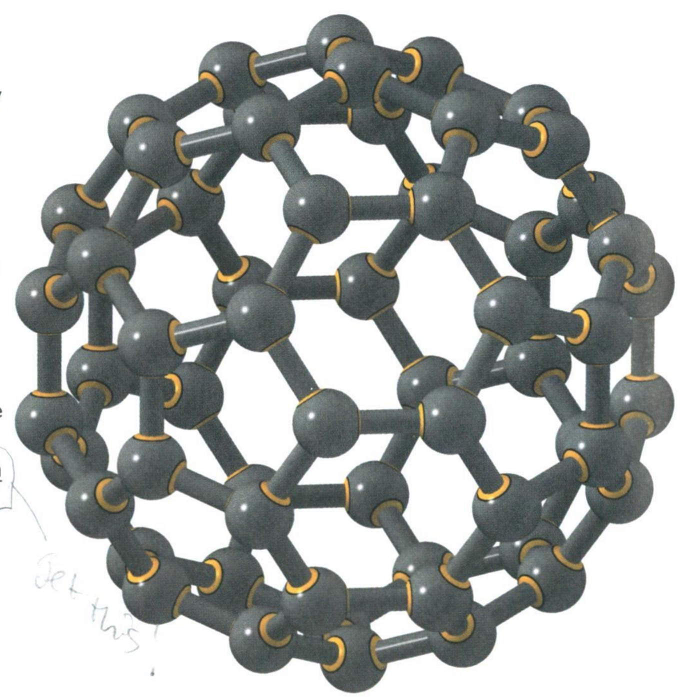
Writing a couple of generations after Robert Hooke's Micrographia (1665) first revealed life under the microscope, Jonathan Swift translated physical quantities related to the size of things with great care, knowing that a degree of rigor was vital in order to support his improbable tale. Thus, we learn that because Gulliver is twelve times taller than a Lilliputian, it takes a force 1,728 (12 cubed) times more powerful to move him about (because force relates to mass, and mass relates to volume, which is given by multiplying together all three linear dimensions). These more or less intuitive estimations quietly demonstrate the universality of physical laws: they apply indiscriminately at all scales; they do not themselves scale.

Swift's consistency breaks down, however, when it comes to less obvious laws of physics. If, when Gulliver wades into the sea to confound the navy of Blefuscu, Lilliput's enemy, he finds the water has its usual fluid qualities for him, then for the enemy ships it would be more like treacle, a glitch familiar from the execrable special effects in old films involving set-piece battles at sea. As you descend further in scale, still more physical laws become important that didn't assert themselves at the human scale. Try to envisage the forces present as a drug bonds to a receptor site, for example. The insertion of a key into a lock is the conventional metaphor. But it is misleading in physical terms because the forces relating to chemical bonds are unlike Newtonian forces in important ways. As Feynman wrote, "Atomic behavior is very difficult to get used to...both to the novice and to the experienced physicist."[3] Visualization becomes more treacherous the further you travel away from the human scale. Interestingly, some proponents of string theory think it may be more helpful to auralize rather than visualize what's going on: songs may be of more use than pictures!

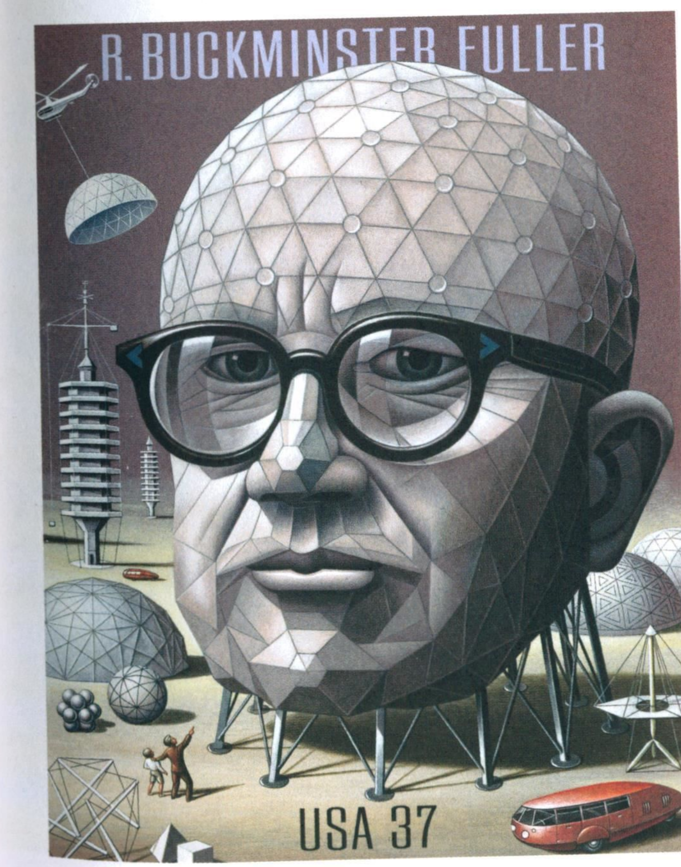
Extension and Inspiration

With the caveat that it may be unwise to be too literal about these things, let us travel, like Gulliver, to "remote nations of the world," both vast and tiny. Sensory interpretations of aspects of the world that may not be sensed directly are just that: interpretations. They are not reality; they cannot be. But they can be appreciated for their suggestive power, even when this goes beyond what is scientifically authentic. It is simply a matter of being clear where the dividing line lies. For NASA, it is on occasion useful to be able to visualize the forces surrounding black holes. But for cosmologists, theoretical physicists, and mathematicians seeking to understand such phenomena, such visualizations may equally be a distraction. Similarly, it is not necessary to have a visual image of the connectedness of the Internet in order to use it effectively. Nor may having such an image help a software designer. But then again, it just might do something for someone else, in ways unforeseeable until the task is attempted. Thus Barrett Lyon's Opte Project; on the one hand it is art, but it is also a map of the Internet that brings to light new information about the system itself and its representations of the world.

Beyond the visual, images of science have merely



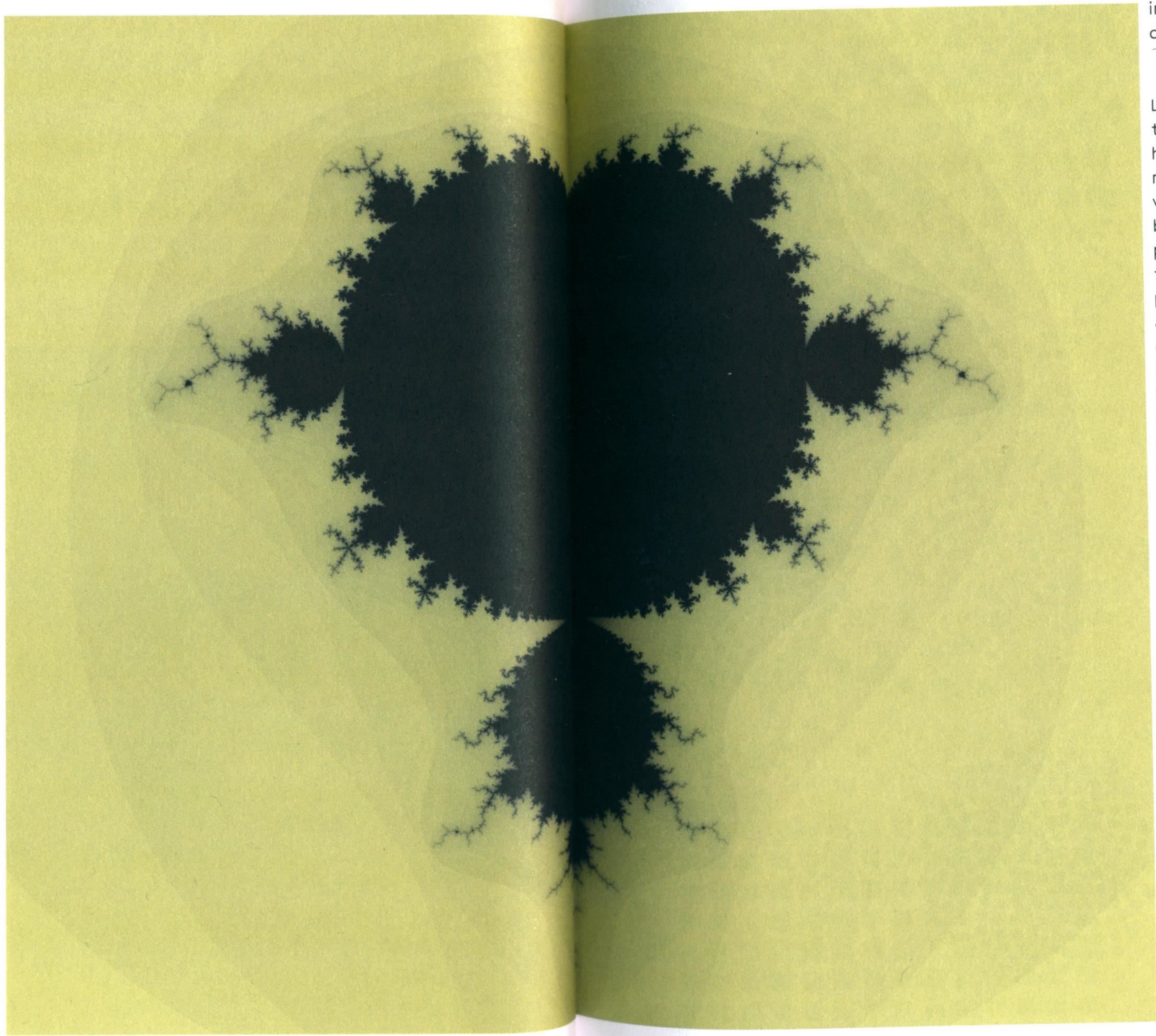
Joseph W. Lauher. State University of New York at Stony Brook. **Molecular Structure of Buckminsterfullerene.** 2007. Chem-Ray Molecular Graphics software



Buckminster Fuller stamp. (designed by Carl T. Herrman based on a painting by Boris Artzybasheff that appeared on the cover of Time magazine, January 10, 1964). 2003 (issued 2004). Prephosphored paper, 1 5/8 x 1 1/4" (4 x 3.2 cm) metaphoric power, typically communicating a sense of progressiveness and optimism through the objects that adopt them. In the heady early days of nuclear power, excitedly whizzing atoms adorned the packaging of consumer products as banal as soap powder. George Nelson's Ball Clock is another product that contains an echo of this short-lived infatuation. The analytical technique of X-ray diffraction, which was used with such success to decode the structure of DNA and other biologically important molecules, produced sufficiently novel patterns, pleasingly combining randomness and repetition, that these were taken up in fabric designs of the period. The double helix of DNA itself has become an enduring motif expressive of the machinery of life in art, design, illustration, and figurative speech. Benoit Mandelbrot's fractal geometry undoubtedly lies behind the emergence of a new baroque in contemporary decorative art, seen in objects such as Tord Boontje's lampshades or Mathieu Lehanneur's Q Quinton Spray, a nebulizer for aromatherapeutic use. Such work sometimes seems so at odds with other trends in design aesthetics that one wonders whether it would ever have taken this form but for the gloss of scientific validity.

Using science for inspiration is all well and good, but caution is necessary if larger claims are made for it. Not only must it be understood when a concept cannot apply for physical reasons, for example due to a change of scale, but it is also important to be clear that inspiration stemming from science has no special status over and above inspiration from the usual sources in history or in other arts. Critic Charles Jencks is thus misled when he answers his own question, "Why should one look to the new sciences for a lead?" with these words: "Partly because they are leading in a better direction—towards a more creative world view than that of Modernism—and partly because they are true."[4] Both of these justifications seek to endow design that is inspired by science with a superior moral authority. But garden ironwork such as Jencks himself has created inspired by "quantum waves" has no higher morality or deeper meaning than a cornstalk fence. Designs with randomized elements chosen on the basis of DNA sequences—a recent fashion in architecture schools—have no closer connection to life as a result. These phenomena are as good a basis for a stylistic idea as any, but no better.

The essential shallowness of this sort of fetish for science is apparent from the selection of ideas involved. For a start, they are not in fact "new sciences." It is a full century since the structure of the atom, quantum theory, and relativity were properly described. Even the theories of chaos and complexity originated more than forty years ago. If not novelty, then perhaps "weirdness" is what counts, especially weirdness involving richness and uncertainty. And yet long-standing weirdness is neglected. Quantum theory fires the imagination because it reintroduced something



William Ngan of Metaphorical.net. **Mandelbrot Set.** 2006. Java and Processing software

intrinsically mysterious and indeterminate to science just at the time when it seemed that all might soon be known for certain. Meanwhile, gravity remains fundamentally very odd, but because we live with it every day it is judged less worthy of artistic exploration. The second law of thermodynamics, the law of entropy, has likewise escaped much attention, perhaps because it lacks a convenient visual lexicon, or perhaps because its implication—that the universe must run down in ultimate disorder—is too depressing for the creative arts.

Mesoscale Mystery

Like Gulliver, we return from Lilliput and Brobdingnag only to find that some of the strangest goings-on are happening at the human scale. There is a case to be made that, for all their unanswered questions, it is the very large and the very small that are best understood by science. The middle of the range, the mesoscale, offers plenty of mysteries yet. There is much that we know, from Newton's laws to chemistry, but there are also the puzzles of the organization of life, the conscious mind, and the uncontrollable weather. You don't need to go down to the scale of the atom and Schrödinger's wave-in-a-box to be awed by the mysteries of waves. Mitsui Zosen's arrangement of wave generators in a circular tank in order to create standing waves of unwavelike shapes, such as letters of the alphabet, reminds us that they are strange enough in the everyday world. The mesoscale is where matter and energy behave in the ways intuitively familiar to us, where visualization is most relevant, and therefore where it is most likely that designers have a real contribution to make.

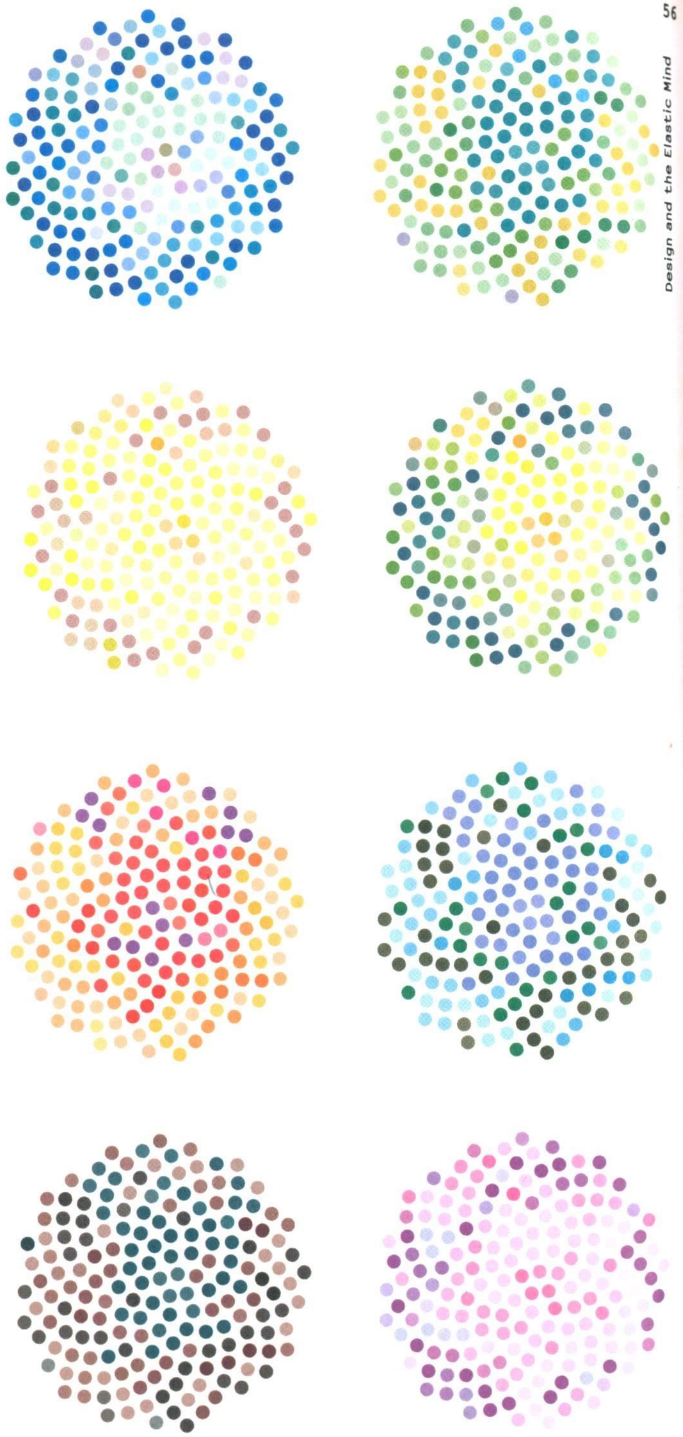
All of biology happens at this scale. When he wrote about technology as the extension of man, Marshall McLuhan did not explicitly invoke technologies based on biological systems, although that possibility is inherent in our conception of such powers—we speak of having eyes like a hawk or the hearing ability of a dog, we envy bats' radar and migrating birds' navigational skill. The huge progress in biological sciences during the twentieth century now dictates that designers should no longer consider only the mineral world as their raw material. Early work at this new boundary between science and design is both exciting and disturbing. Susana Soares uses the fact that bees can be "trained" to react to specific odors to harness them in a kind of olfactory appurtenance that could enable us to sense toxins or pheromones. The idea may seem bizarre now, but is it really any stranger in principle than an explosives-sniffing dog? It is beyond question that closer appreciation of biological systems of all kinds now raises the prospect of extending human capabilities in many ways.

If tissue cells can be cultured to emulate human parts for use in reconstructive surgery, some designers have reasoned, then they can also be made to follow entirely novel forms. It is a relatively straightforward matter to produce something faintly creepy using these techniques, as Oron Catts and Ionat Zurr do in their long-running project, Tissue Culture & Art. Their Pig Wings Project, wing shapes grown from pig tissue, is an example of a semi-living object, one which, by title and appearance, mocks the aspirations of the very biotechnology it utilizes to achieve its result. It is altogether harder, in these early days, to produce a thing of beauty. However, Tobie Kerridge, Nikki Stott, and Ian Thompson may have succeeded with Biojewellery, a project that allows wedding rings to be exchanged that are made of bone grown from each marriage partner's bone cells.

Other designers are taking their ideas from nature but executing them in artificial materials. Here is where nanotechnology and biosciences—apparently so different both in scale and in what one might call their romance—actually overlap. James King's project Fossils from a Nanotech Future continues a tradition that runs from Gothic gargoyles to the Tiffany lamps and Blaschka glassware inspired by contemporaneous drawings of marine organisms by German biologist Ernst Haeckel. Such objects are evidence of a shift away from the machine and toward organism as cultural metaphor. This shift is seen most unequivocally in Barry Trimmer's quest to develop "soft-bodied" robots—automata as different as can be from the clanking metallic monsters of classic science fiction. The aim of such projects should be to learn from nature's economy in both material and energy. Joris Laarman's Bone Chair also exemplifies this biomimetic approach, showing how a minimal structure may be achieved by examining, in this case, the way that bones sacrifice weight where it is not needed. Though complex in shape, Laarman's resulting structure is highly efficient—and very likely to be judged elegant because of its "natural" appearance.

Taken a little further, the biomimetic argument raises some challenging new questions. One of design's greatest problems, often ignored completely, is that of matching a product to its use not in the physical three dimensions of space but over time. Some products break before we have finished with them; others far outlast any conceivable utility and are wastefully dumped or destroyed. In nature, this problem is deviously solved by death: An organism dies once it ceases to have a use and ceases to have a use after it dies. A prime goal for designers now has to be to bring their objects' material existence and practical utility into similar harmony. One might counter that nature is wasteful in its own way, cruelly redundant in its overproduction of species that merely become another species' prey. But this is only wasteful from the species' point of view: Nature's concern is for the most economical management of the overall system. A comprehensive biomimetic design philosophy will require systems thinking a mile away from the designer's traditional focus on the object.

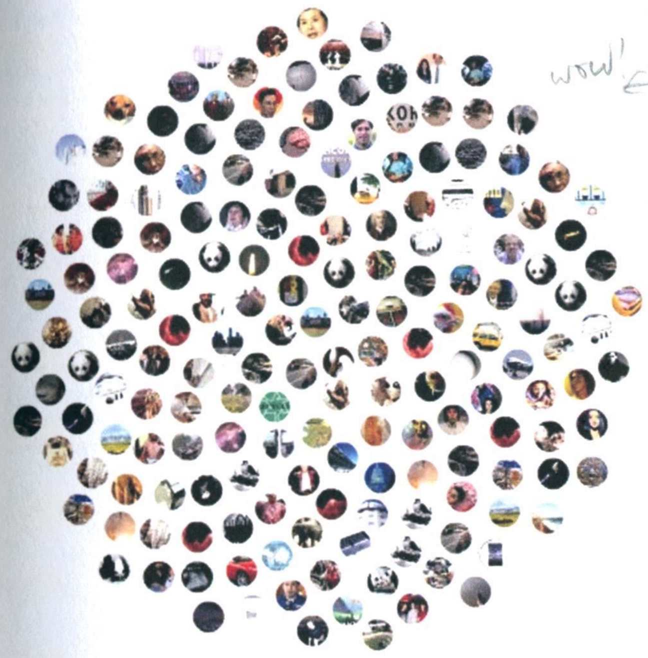
This approach to design seeks to adapt specific advantages observed in natural organisms into human technology, but the polemical subtext of any design



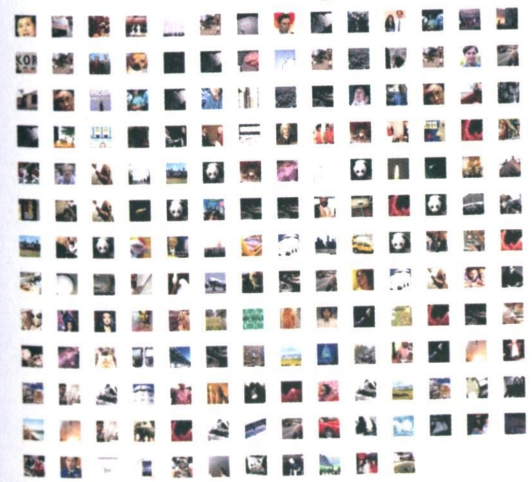
above:
Stefan Sagmeister and Matthias Ernstberger of Sagmeister Inc.
Seed Media Group Identity. 2005

right:
Jonathan Harris of Number 27.
Phylotaxis. 2005–ongoing. Perl, MySQL, PHP, and Flash software

Seed's mission is to establish science's position in culture, and Stefan Sagmeister and Matthias Ernstberger's adaptable logo is based on the phyllotaxis structure, a quintessentially organic algorithm. Jonathan Harris took the logo as a basis for a Web-based project that symbolizes the space where science meets culture.



November 18, 2005



inspired by nature is that we are in danger of losing touch with the natural world. It pleads for the biological, the technological, and the ethical to come together. This is the objective of "consilience," the term coined by biologist Edward O. Wilson for the reunification of the strands of intellectual inquiry artificially separated as a consequence of the growth of specialized disciplines in science and the humanities. In his book Consilience: The Unity of Knowledge, Wilson writes: "If the world really works in a way so as to encourage the consilience of knowledge, I believe the enterprise of culture will eventually fall out into science, by which I mean the natural sciences, and the humanities, particularly the creative arts."[5]

Charles Eames and Richard Feynman were consilient personalities, but their meeting never happened because the world didn't work in the right way. The question is: Does it now?

wow!

ethics = human
natural sciences = biological
is technology somewhere 'between'?
AS AN "ETHICAL" IMPLEMENTATION OF NATURAL SCIENCES?

Notes

1. Richard Feynman, "There's Plenty of Room at the Bottom" (lecture, December 1959). For a transcript of the lecture, see www.its.caltech.edu/~feynman/plenty.html.

2. Josiah Wedgwood, letter to Thomas Bentley, quoted in Humphrey Jennings, Pandaemonium: The Coming of the Machine As Seen by Contemporary Observers (London: Macmillan, 1995), p. 63.

3. Richard Feynman, Six Easy Pieces (London: Penguin, 1998), p. 117.

4. Charles Jencks, The Architecture of the Jumping Universe (London: Academy Editions, 1995), p. 9.

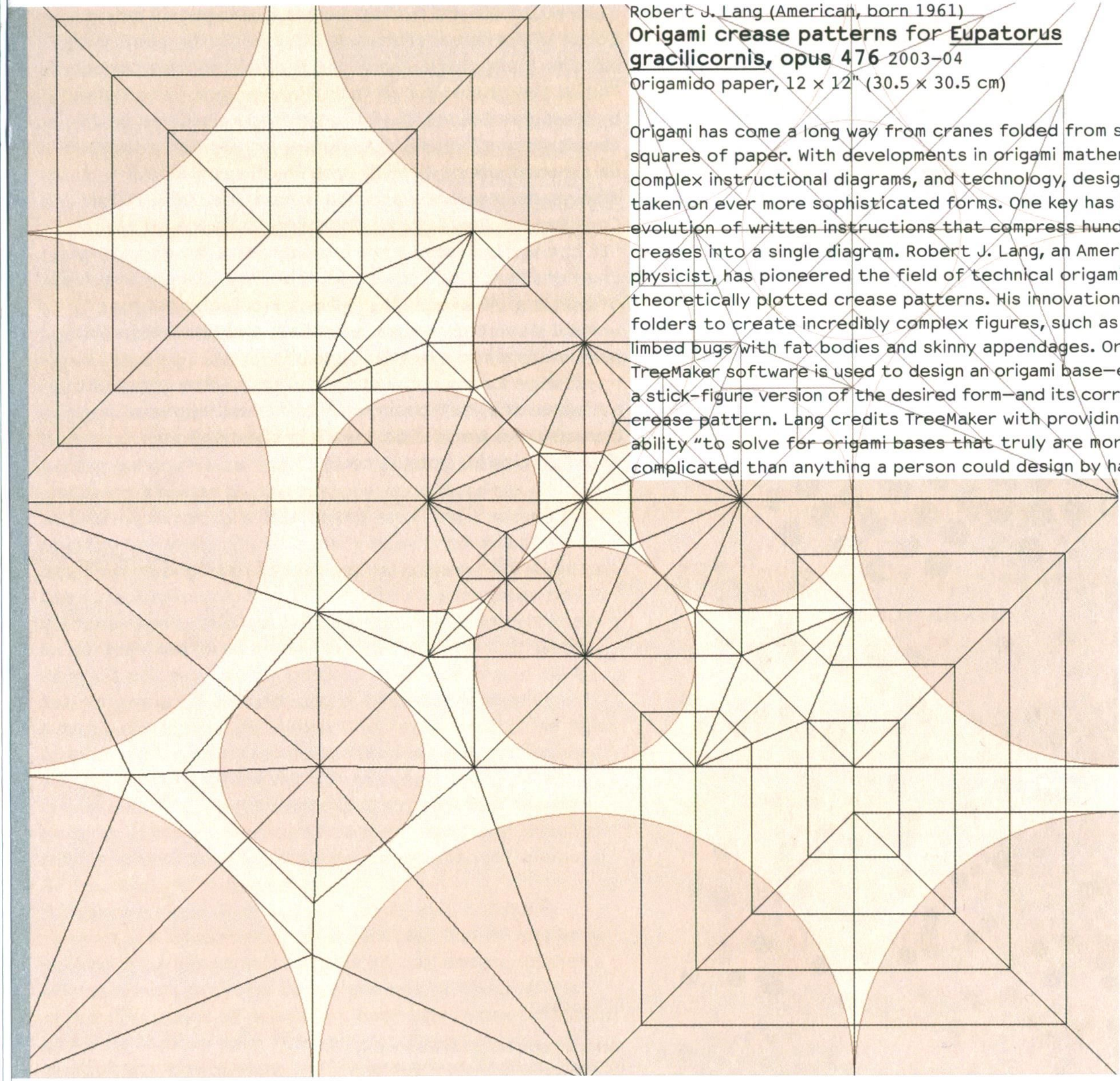
5. Edward O. Wilson, Consilience: The Unity of Knowledge (London: Little, Brown, 1998), p. 10.

Robert J. Lang (American, born 1961)

Origami crease patterns for _Eupatorus gracilicornis_, opus 476 2003–04

Origamido paper, 12 × 12" (30.5 × 30.5 cm)

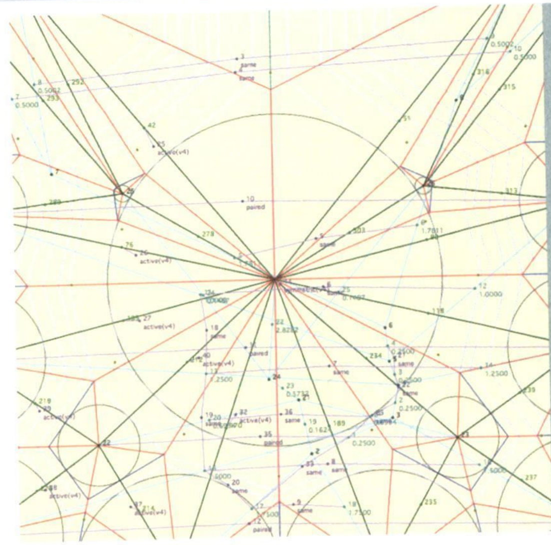
Origami has come a long way from cranes folded from single squares of paper. With developments in origami mathematics, complex instructional diagrams, and technology, designs have taken on ever more sophisticated forms. One key has been the evolution of written instructions that compress hundreds of creases into a single diagram. Robert J. Lang, an American physicist, has pioneered the field of technical origami with his theoretically plotted crease patterns. His innovations allow folders to create incredibly complex figures, such as multi-limbed bugs with fat bodies and skinny appendages. Origami TreeMaker software is used to design an origami base—essentially a stick-figure version of the desired form—and its corresponding crease pattern. Lang credits TreeMaker with providing the ability "to solve for origami bases that truly are more complicated than anything a person could design by hand."

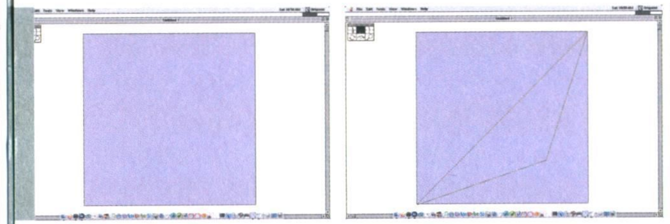


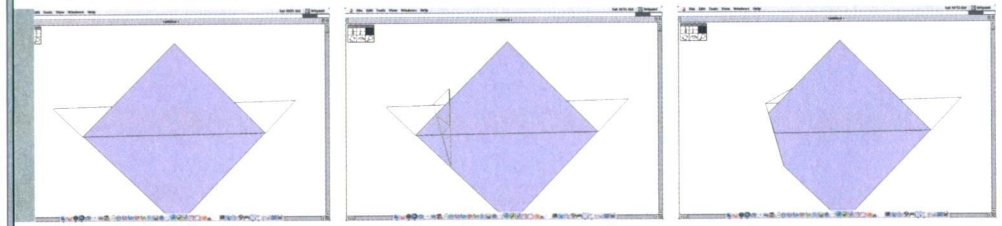
Robert J. Lang (American, born 1961)

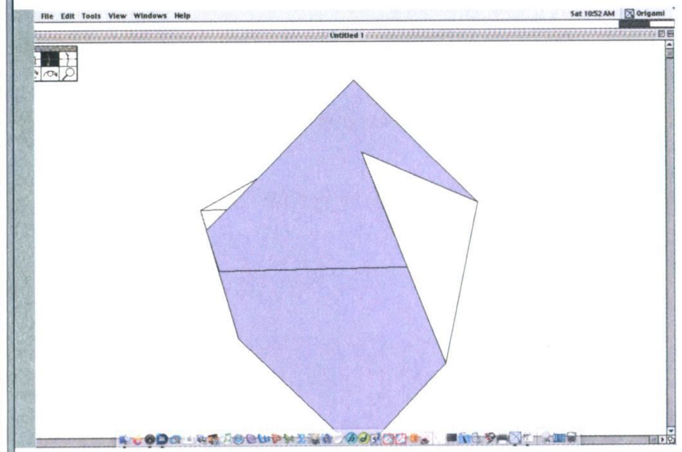
Scorpion varileg, opus 379 and its Origami TreeMaker file 1990–2006

Origamido paper, 3 × 3 × 5" (7.6 × 7.6 × 12.7 cm)









Robert J. Lang (American, born 1961)
Origami Simulation software 1990–92
THINK Pascal and THINK Class Library software

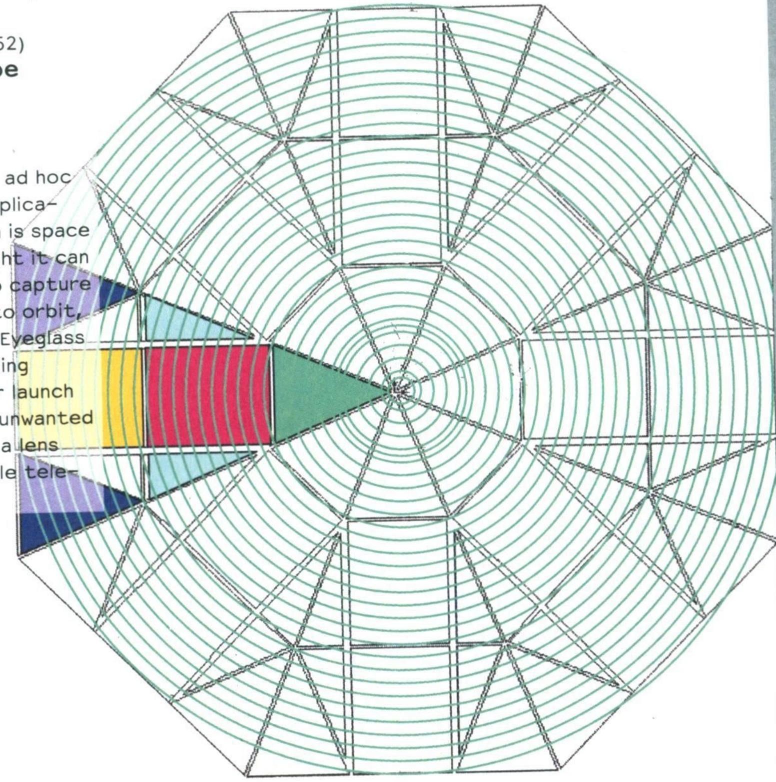
Origami Simulation, a program that Lang designed to simulate the folding of paper on a computer screen, allows users to experiment with various folds and easily undo or redo a folding sequence with the click of a mouse.

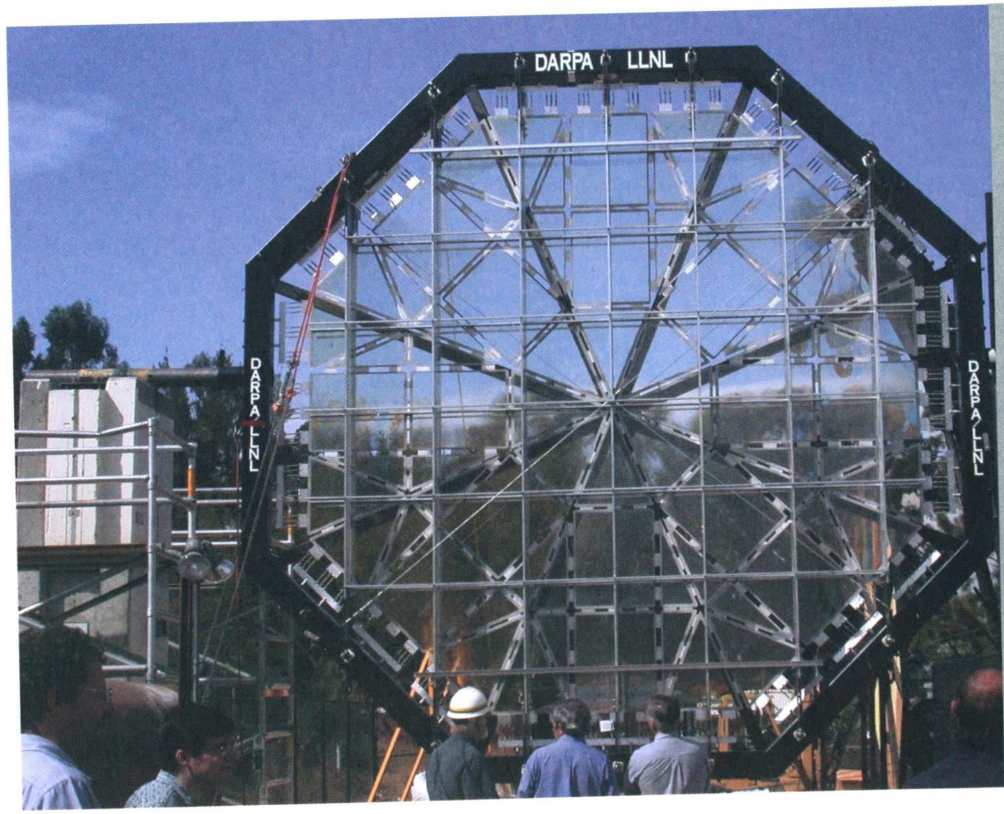
Erik Demaine (American, born Canada 1981) and
Martin Demaine (American, born 1942)
Massachusetts Institute of Technology (USA, est. 1861)
Computational Origami 2003–07
Elephant hide paper, 16 × 12" (40.6 × 30.5 cm) diam.

"Computational origami aims to understand the underlying geometry of paper folding and studies how computers can help automate the design of sophisticated paper sculptures," explains Erik Demaine. This design, by Demaine and his father, Martin Demaine, explores curved creases and demonstrates that computational origami can be used to create elegant, organic forms.

Roderick Hyde (American, born 1952), Sham Dixit (American, born 1955), and Robert J. Lang (American, born 1961)
Lawrence Livermore National Laboratory (USA, est. 1952)
Fresnel lens for the **Eyeglass Space Telescope**
Reduced-scale prototype. 1998–2005
Glass, aluminum, and steel, 16' 4 7/8" (500 cm) diam.

As origami has become more complex and adaptable to ad hoc interventions, it has also become more useful, with applications for a wide range of devices. One such application is space telescopes. The bigger a telescope's lens, the more light it can gather, and with bigger apertures comes the ability to capture objects deeper in space. Sending large glass lenses into orbit, however, is difficult. The Fresnel lens for the planned Eyeglass Space Telescope makes use of an origami-derived folding concept that allows the lens to be tightly packed for launch into space and then unfolded without suffering from unwanted marks or creases—creating the possibility of building a lens that will unfold to 100 meters; by contrast, the Hubble telescope sports a lens with a diameter of 2.5 meters.

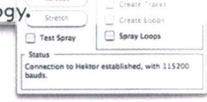


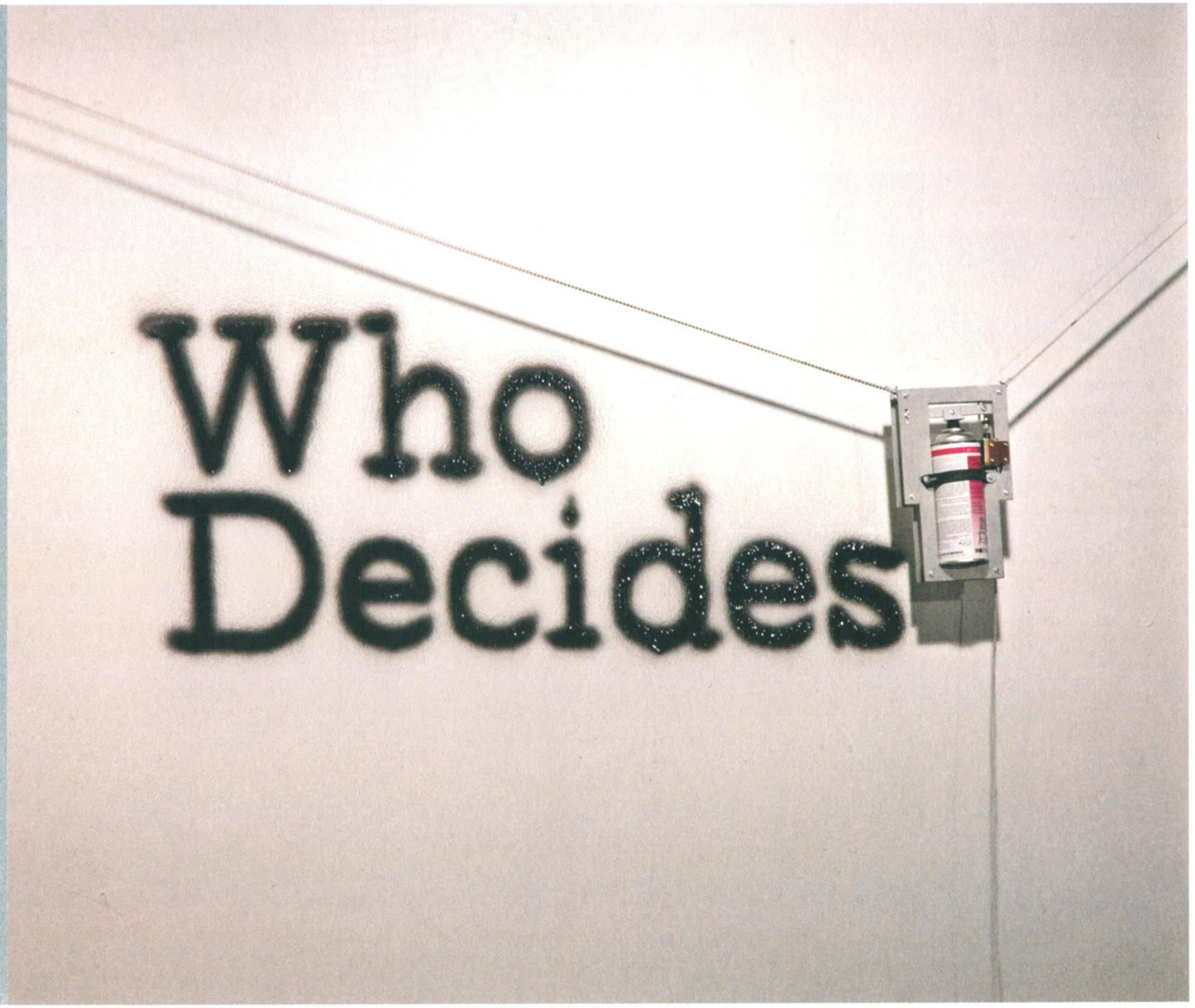


Jürg Lehni (Swiss, born 1978)
and Uli Franke (German, born 1978)
École cantonale d'art de Lausanne (écal) (Switzerland, est. 1821)

Hektor spray-paint output device Prototype. 2002–ongoing
Stepper motor, toothed belts, aluminum casing, spray-paint can, suitcase, custom-made electronics, and Scriptographer software, motor: 3 × 4 × 6 1/2" (7.5 × 10 × 16.5 cm); spray-paint can holder: 9 7/8 × 6 × 1 1/8" (25 × 15 × 3 cm)

In a publishing world dominated by paper and ink, Hektor—a computer-driven output device in which the human hand only clicks a button—allows for printing on a vertical surface with spray paint. The contraption commands a suspended spray-paint can that "prints" text written using Scriptographer, an Adobe Illustrator scripting plug-in designed by Jürg Lehni. The designers explain that "during operation, the mechanism sometimes trembles and wobbles and the paint often drips," creating a tension between low- and high-tech aspects of construction, application, and technology.

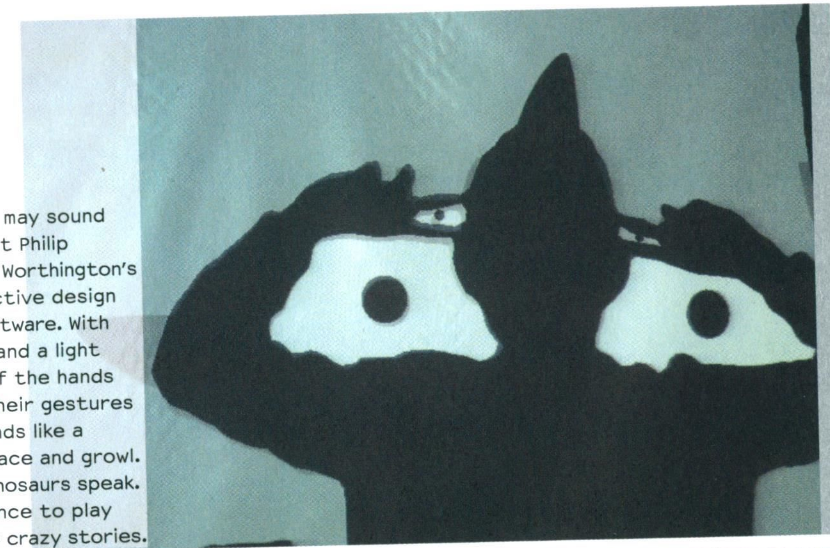


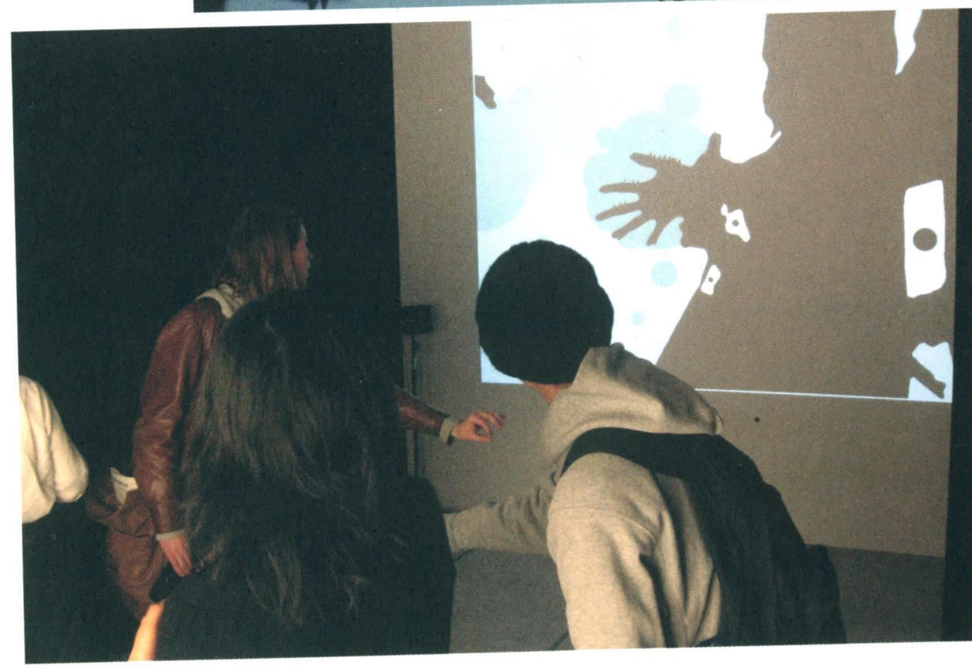


Philip Worthington (British, born 1977)
Design Interactions Department (est. 1989),
Royal College of Art (UK, est. 1837)

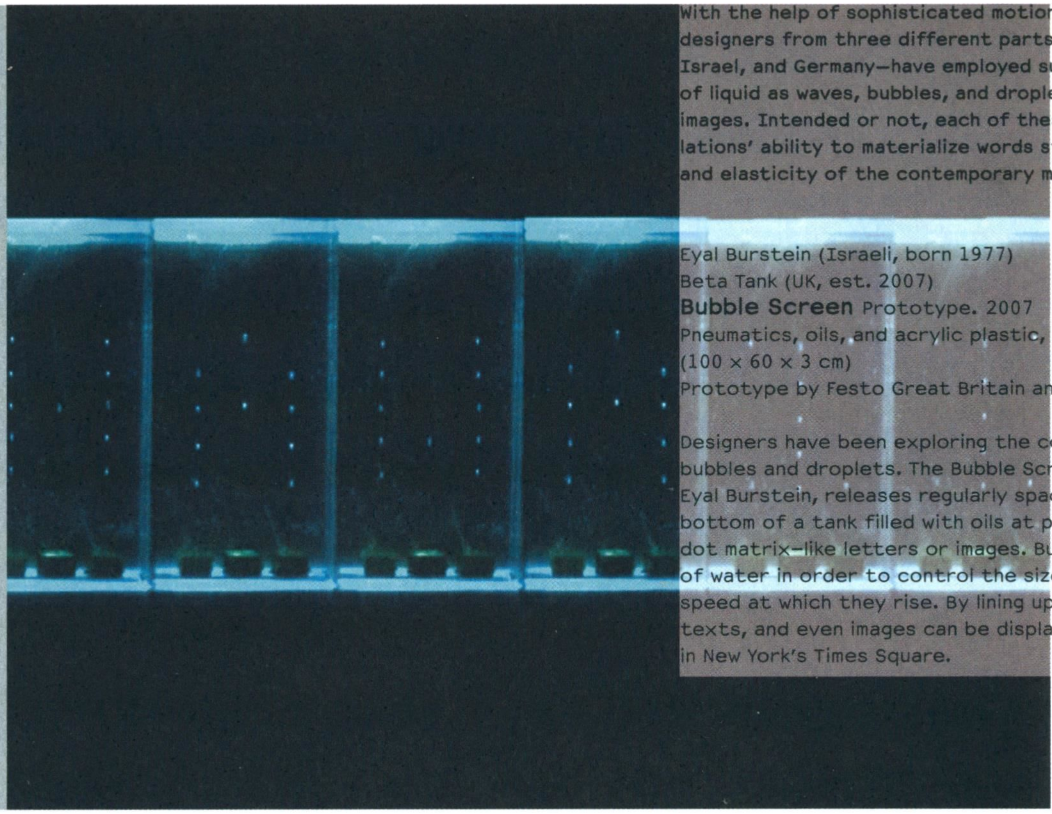
Shadow Monsters 2004–ongoing
Java, Processing, BlobDetection, SoNIA, and Physics software

Monsters materializing from shadows cast on walls may sound like something from a child's active imagination, but Philip Worthington has made the playful concept a reality. Worthington's Shadow Monsters project is an example of interactive design based on custom-designed vision-recognition software. With the support of a computer, a camera, a projector, and a light box, fantastic creatures emerge from shadows of the hands of participants as the software elaborates on their gestures with sound and animation. Open and close your hands like a mouth, and a wolf with razor-sharp teeth will surface and growl. Tongues, eyes, and fins appear. Birds squawk and dinosaurs speak. It's a magical experience that inspires the audience to play with body posturing in order to create delightfully crazy stories.



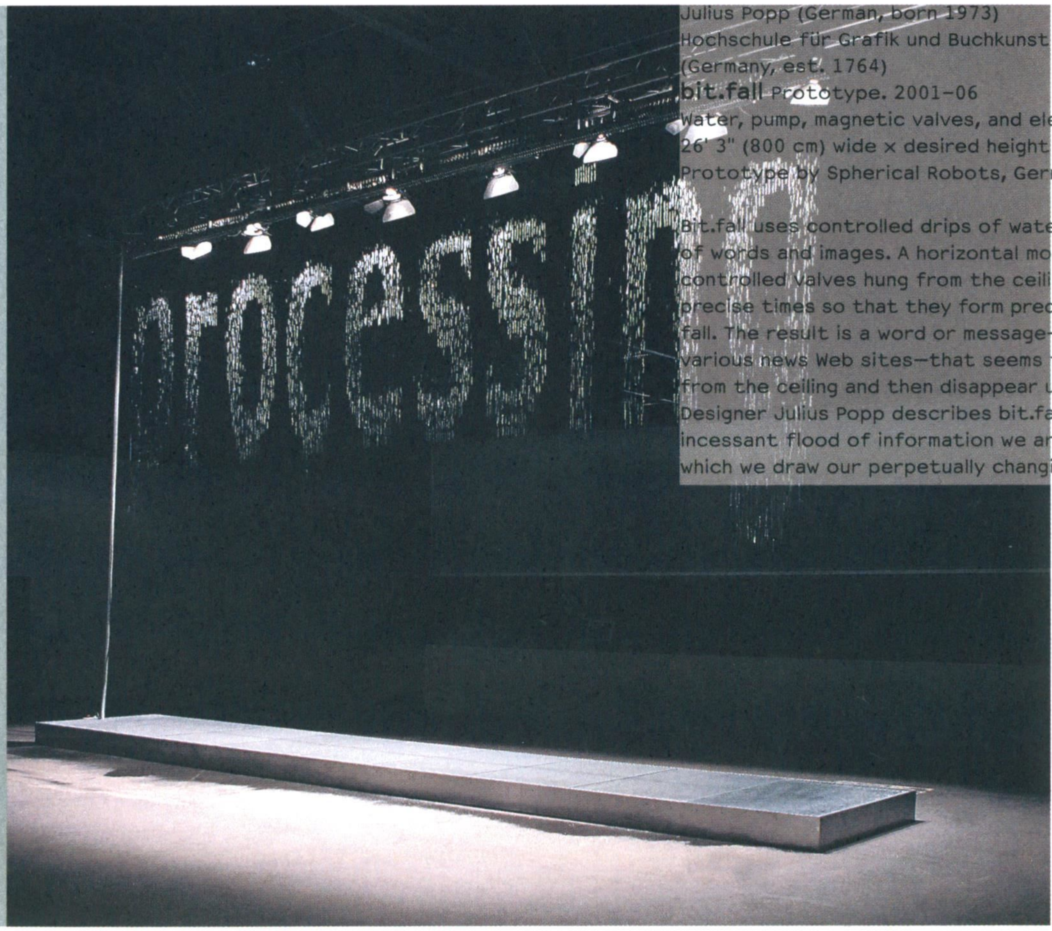


With the help of sophisticated motion-control technologies, designers from three different parts of the world—Japan, Israel, and Germany—have employed such familiar features of liquid as waves, bubbles, and droplets to create ephemeral images. Intended or not, each of these three watery installations' ability to materialize words symbolizes the fluidity and elasticity of the contemporary mind.



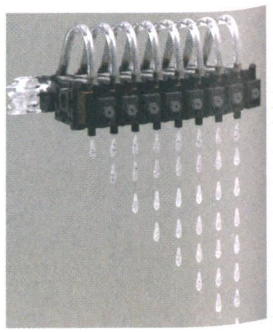
Eyal Burstein (Israeli, born 1977)
Beta Tank (UK, est. 2007)
Bubble Screen Prototype. 2007
Pneumatics, oils, and acrylic plastic, 39 3/8 × 23 5/8 × 1 1/8" (100 × 60 × 3 cm)
Prototype by Festo Great Britain and Beta Tank, UK (2007)

Designers have been exploring the communication potential of bubbles and droplets. The Bubble Screen, by Israeli designer Eyal Burstein, releases regularly spaced bubbles from the bottom of a tank filled with oils at precise intervals to create dot matrix–like letters or images. Burstein chose oil instead of water in order to control the size of the bubbles and the speed at which they rise. By lining up multiple tanks, words, texts, and even images can be displayed, as on a news ticker in New York's Times Square.



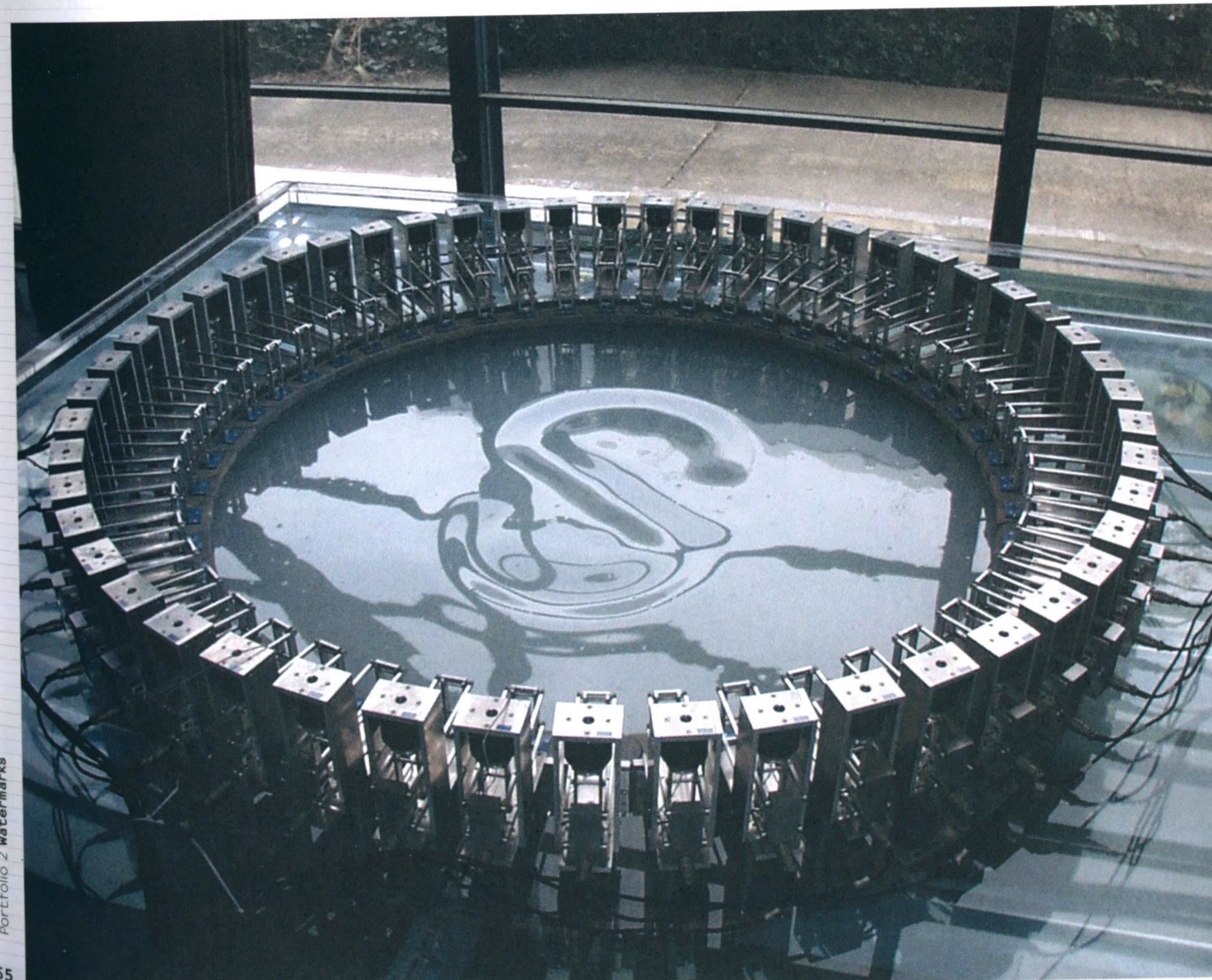
Julius Popp (German, born 1973)
Hochschule für Grafik und Buchkunst Leipzig (Germany, est. 1764)
bit.fall Prototype. 2001–06
Water, pump, magnetic valves, and electronic circuits, 26' 3" (800 cm) wide × desired height
Prototype by Spherical Robots, Germany (2006)

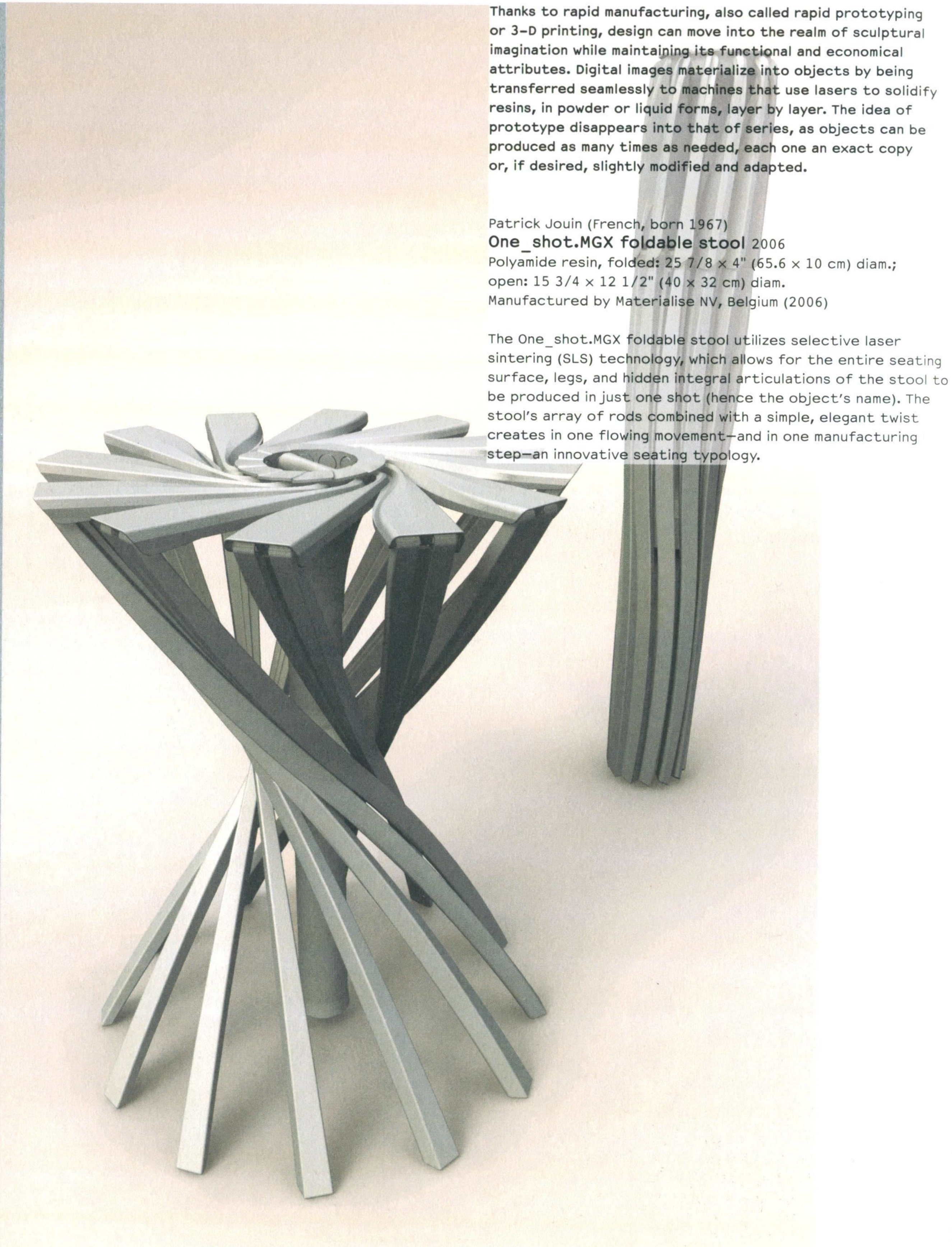
bit.fall uses controlled drips of water to create a waterfall of words and images. A horizontal module with computer-controlled valves hung from the ceiling releases droplets at precise times so that they form predetermined shapes as they fall. The result is a word or message—randomly chosen from various news Web sites—that seems to magically rain down from the ceiling and then disappear upon impact with the floor. Designer Julius Popp describes bit.fall as a "metaphor for the incessant flood of information we are exposed to and from which we draw our perpetually changing realities."



Shigeru Naito (Japanese, born 1944) of the Department of Naval Architecture and Ocean Engineering, Osaka University (Japan, est. 1931)
Etsuro Okuyama (Japanese, born 1977) of Akishima Laboratories (Mitsui Zosen), Inc. (Japan, est. 1917)
AMOEBA (Advanced Multiple Organized Experimental Basin) Prototype. 1997
Aluminum, acrylic plastic, and water, 11 3/4" × 9' 10" × 9' 10" (30 × 300 × 300 cm)
Prototype by Akishima Laboratories (Mitsui Zosen), Inc., Japan (1997)

The AMOEBA, or Advanced Multiple Organized Experimental Basin, was originally built to evaluate the effects of waves on ship designs. It is a circular basin about the size of an inflatable children's pool. Using fifty plungerlike mechanical units installed along its rim, AMOEBA can produce a variety of wave conditions and then calm the water's surface on command. One of Shigeru Naito's students found an unintended use for this equipment: creating the alphabet on the water's surface. When waves in various frequencies converge, the water's surface rises at specific points; by connecting these points, lines and shapes can be drawn. In 2002, Etsuro Okuyama of Mitsui Zosen's Akishima Laboratories was asked to further develop this theory.

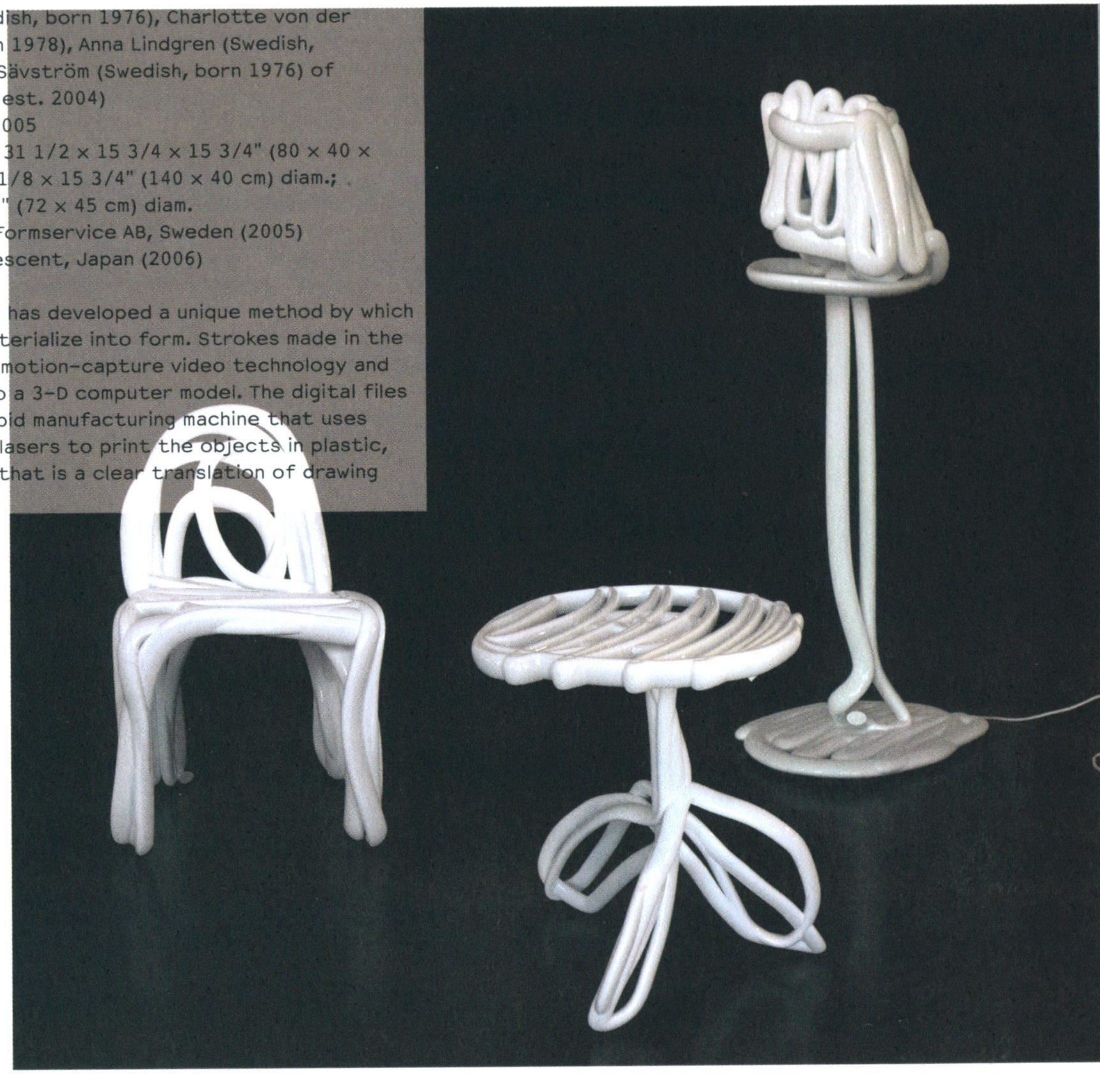




Thanks to rapid manufacturing, also called rapid prototyping or 3-D printing, design can move into the realm of sculptural imagination while maintaining its functional and economical attributes. Digital images materialize into objects by being transferred seamlessly to machines that use lasers to solidify resins, in powder or liquid forms, layer by layer. The idea of prototype disappears into that of series, as objects can be produced as many times as needed, each one an exact copy or, if desired, slightly modified and adapted.

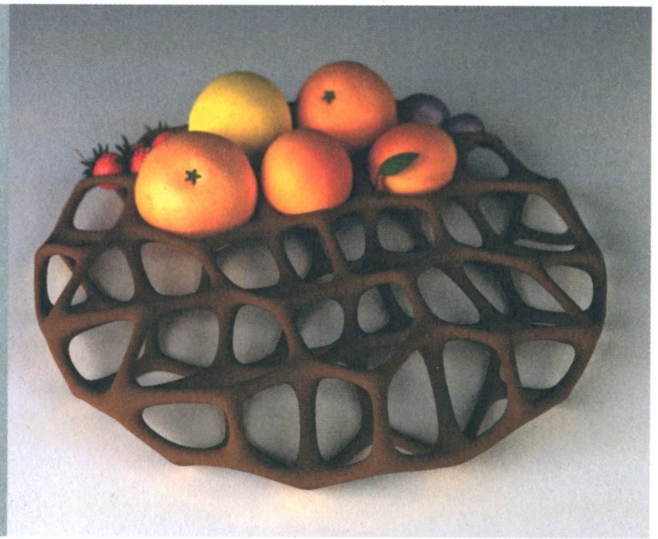
Patrick Jouin (French, born 1967)
One_shot.MGX foldable stool 2006
Polyamide resin, folded: 25 7/8 x 4" (65.6 x 10 cm) diam.; open: 15 3/4 x 12 1/2" (40 x 32 cm) diam.
Manufactured by Materialise NV, Belgium (2006)

The One_shot.MGX foldable stool utilizes selective laser sintering (SLS) technology, which allows for the entire seating surface, legs, and hidden integral articulations of the stool to be produced in just one shot (hence the object's name). The stool's array of rods combined with a simple, elegant twist creates in one flowing movement—and in one manufacturing step—an innovative seating typology.



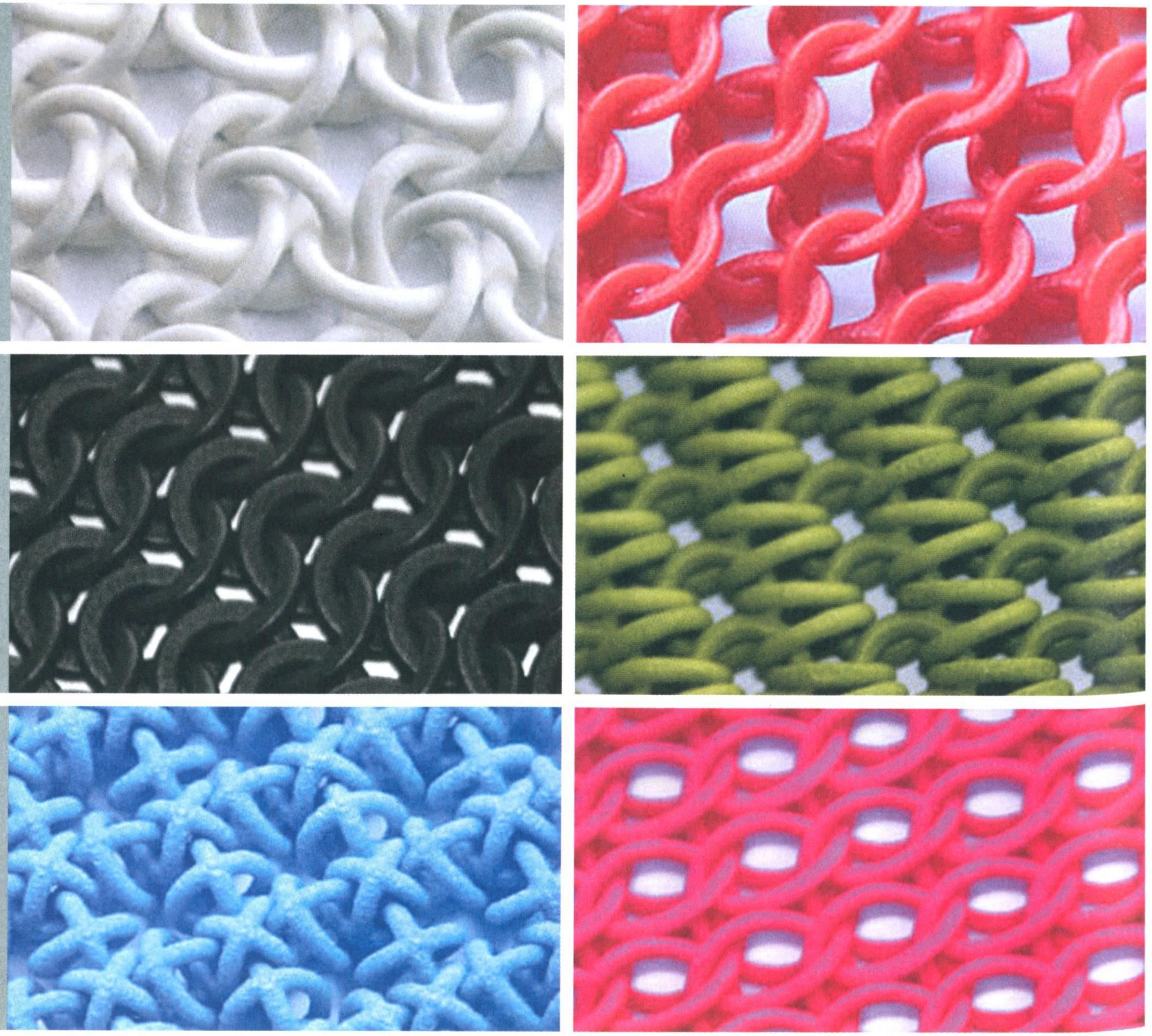
Sofia Lagerkvist (Swedish, born 1976), Charlotte von der Lancken (Swedish, born 1978), Anna Lindgren (Swedish, born 1977), and Katja Sävström (Swedish, born 1976) of Front Design (Sweden, est. 2004)
Sketch Furniture 2005
Polyamide resin, chair: 31 1/2 x 15 3/4 x 15 3/4" (80 x 40 x 40 cm); floor lamp: 55 1/8 x 15 3/4" (140 x 40 cm) diam.; table: 28 3/8 x 17 3/4" (72 x 45 cm) diam.
Prototypes by Acron Formservice AB, Sweden (2005)
Motion capture by Crescent, Japan (2006)

The Front Design team has developed a unique method by which freehand sketches materialize into form. Strokes made in the air are recorded with motion-capture video technology and are then digitized into a 3-D computer model. The digital files are then sent to a rapid manufacturing machine that uses computer-controlled lasers to print the objects in plastic, resulting in furniture that is a clear translation of drawing into object.



Janne Kyttänen (Finnish, born 1974)
Freedom Of Creation (FOC) (The Netherlands, est. 2000)
Macedonia fruit bowl 2007
Quartz sand with epoxy infiltration, 1 3/4 x 12 1/2" (4.6 x 32 cm) diam.
Manufactured by Freedom Of Creation, The Netherlands (2007)

In Italian and Spanish, the word macedonia means fruit salad; the original etymology of the term harks back to the heterogeneous composition of the people of the Balkan region of Macedonia. Janne Kyttänen designed this fruit bowl inspired by the formation and structures of soap bubbles. Kyttänen printed it using sand mixed with resin, proving that even when employing the most advanced technique and an innovative form, a conventional material can restore a balance between novelty and tradition.

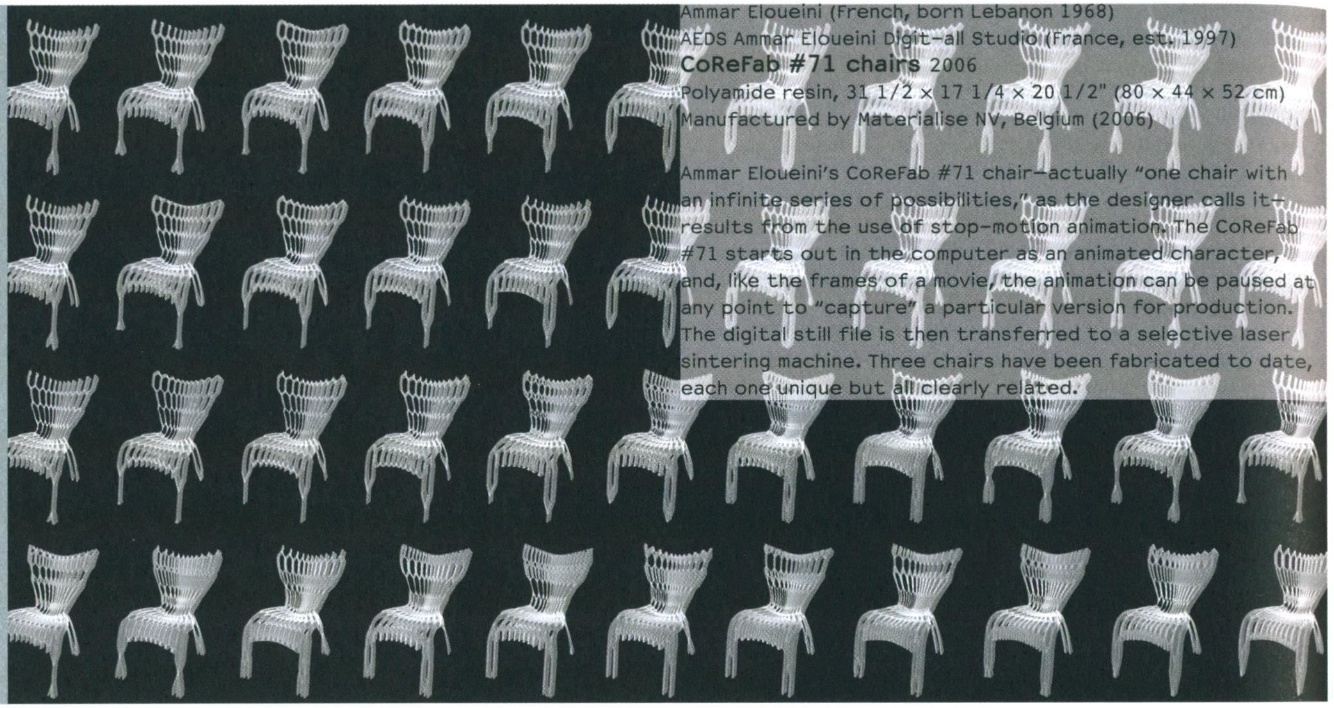


Janne Kyttänen (Finnish, born 1974) and
Jiri Evenhuis (Dutch, born 1973)
Freedom Of Creation (FOC) (The Netherlands, est. 2000)

page 68, bottom:
Laser-sintered textiles 2000–06
Polyamide resin, dimensions variable
Manufactured by Freedom Of Creation, The Netherlands (2000–06)

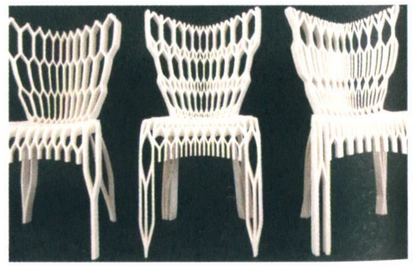
below:
Punchbag handbag 2005
Polyamide resin, 11 3/4 x 11 x 5/8" (30 x 28 x 1.7 cm)
Manufactured by Freedom Of Creation, The Netherlands (2005)

Freedom Of Creation designers Janne Kyttänen and Jiri Evenhuis have taken the concept of rapid manufacturing to the realm of textiles. Rather than the traditional method of weaving materials and then cutting and sewing them together, laser-sintered textiles are built tridimensionally, layer by layer. Because the textile is first created on a computer, its threads digitally interwoven, the fabric is easily customizable in various patterns, sizes, and colors.



Ammar Eloueini (French, born Lebanon 1968)
AEDS Ammar Eloueini Digit-all Studio (France, est. 1997)
CoReFab #71 chairs 2006
Polyamide resin, 31 1/2 × 17 1/4 × 20 1/2" (80 × 44 × 52 cm)
Manufactured by Materialise NV, Belgium (2006)

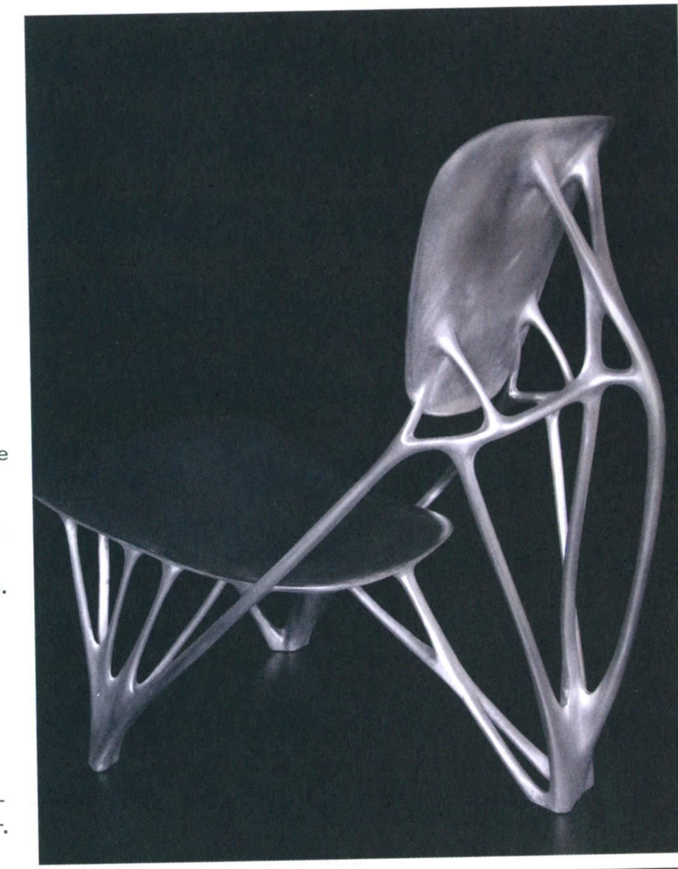
Ammar Eloueini's CoReFab #71 chair—actually "one chair with an infinite series of possibilities," as the designer calls it—results from the use of stop-motion animation. The CoReFab #71 starts out in the computer as an animated character, and, like the frames of a movie, the animation can be paused at any point to "capture" a particular version for production. The digital still file is then transferred to a selective laser sintering machine. Three chairs have been fabricated to date, each one unique but all clearly related.

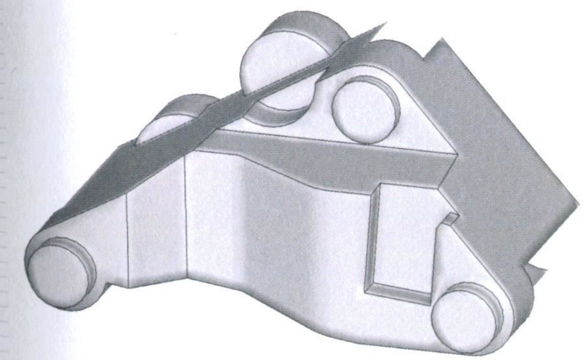


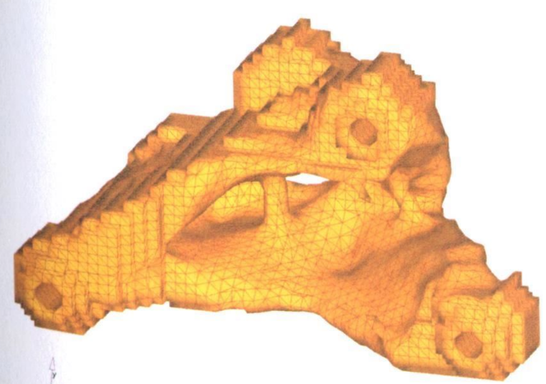
right:
Joris Laarman (Dutch, born 1979)
Bone Chair 2006
Aluminum, 29 3/4 × 29 7/8 × 17 1/2" (75.6 × 75.8 × 44.5 cm)
Manufactured by Joris Laarman Studio, The Netherlands (2007)

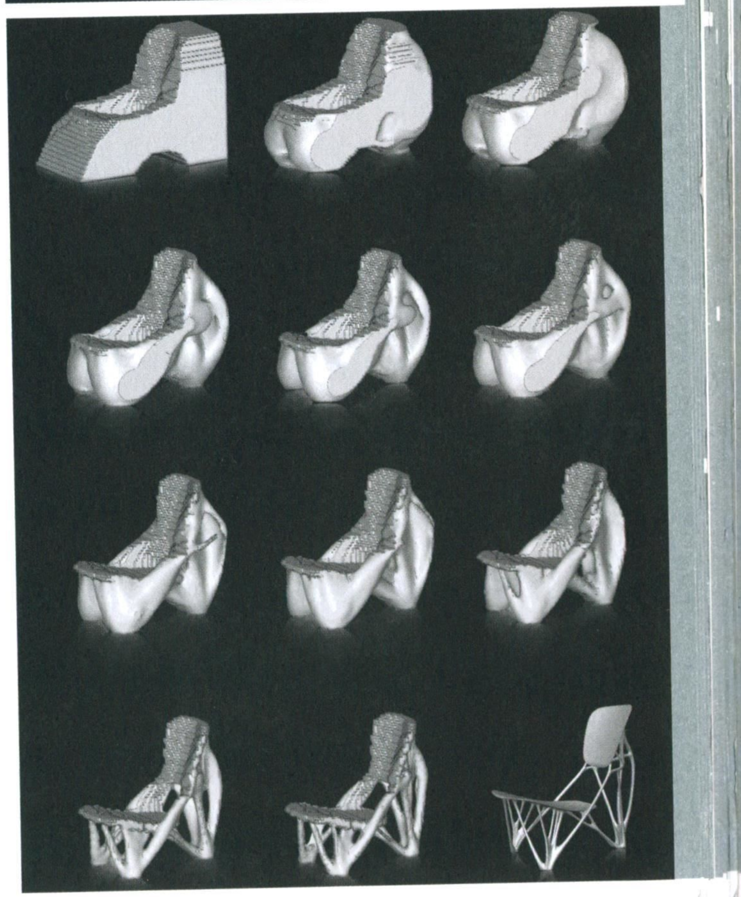
below:
Lothar Harzheim (German, born 1956)
Adam Opel GmbH (Germany, est. 1862)
Engine mount production component 1998
Aluminum, 1 × 3/4 × 5/8" (2.5 × 2 × 1.5 cm)
Manufactured by Adam Opel GmbH, Germany (1998)

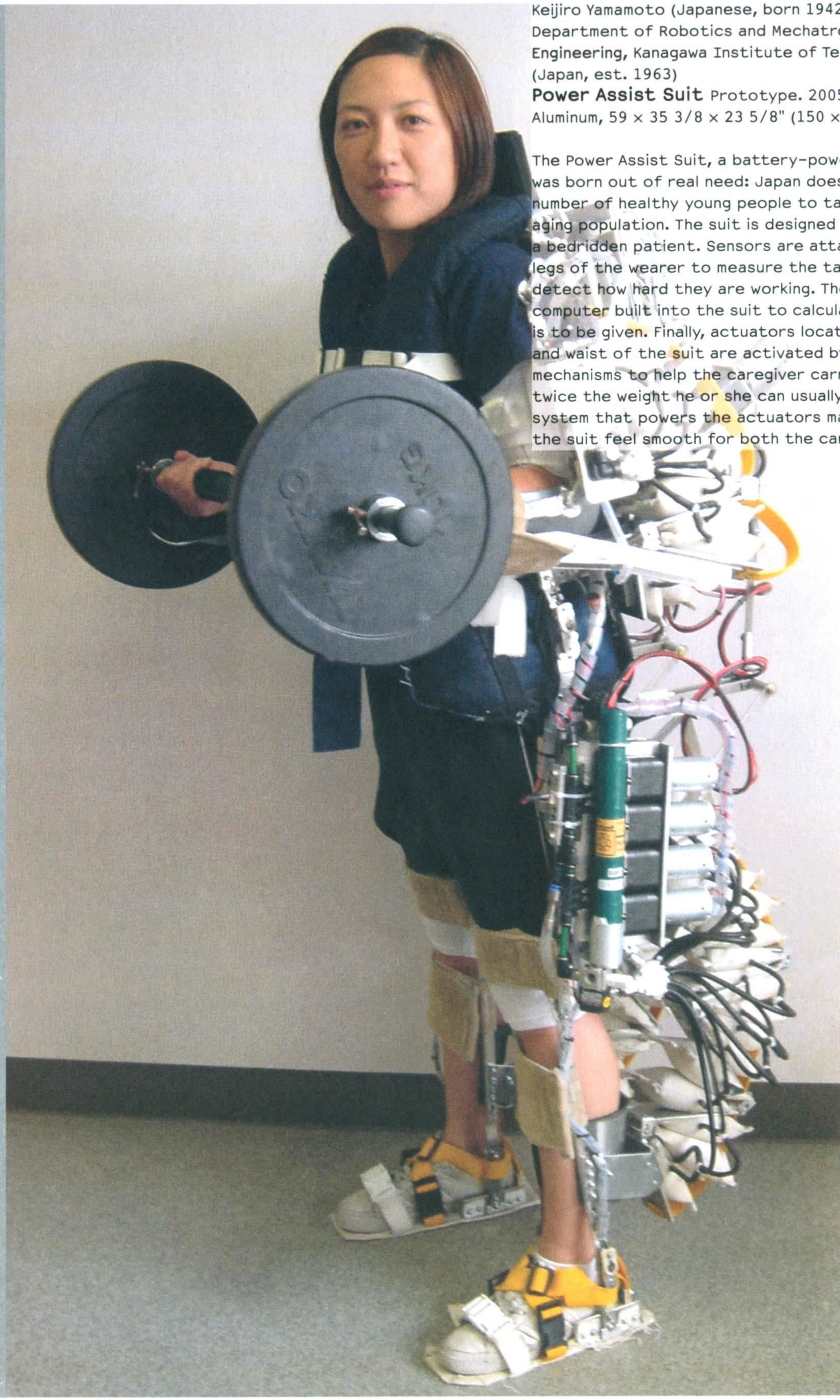
The International Development Center at Adam Opel GmbH, General Motors' German subsidiary, has developed 3-D optimization software that mimics biological growth and applies its rules to objects of all kinds. Originally designed for automotive chassis components and called SKO (Soft Kill Option), the software has been applied by designer Joris Laarman to the design of furniture. The transfer of technology between the natural world and synthetic constructs is at the heart of Laarman's Bone Chair, which is based on the generative process of bones. As bones grow, areas not exposed to high stress develop less mass while areas that bear more stress develop added mass for strength. Doing away with the superfluous results in an optimized structure that performs with the least amount of material. Using 3-D optimization software to generate form rather than applying the software to a preexisting structure, Laarman's Bone Chair moves beyond imitation of a biological structure to emphasize the implementation of a natural building process, suggesting that nature is the ultimate form giver.











Keijiro Yamamoto (Japanese, born 1942)
Department of Robotics and Mechatronics, Faculty of Engineering, Kanagawa Institute of Technology (Japan, est. 1963)

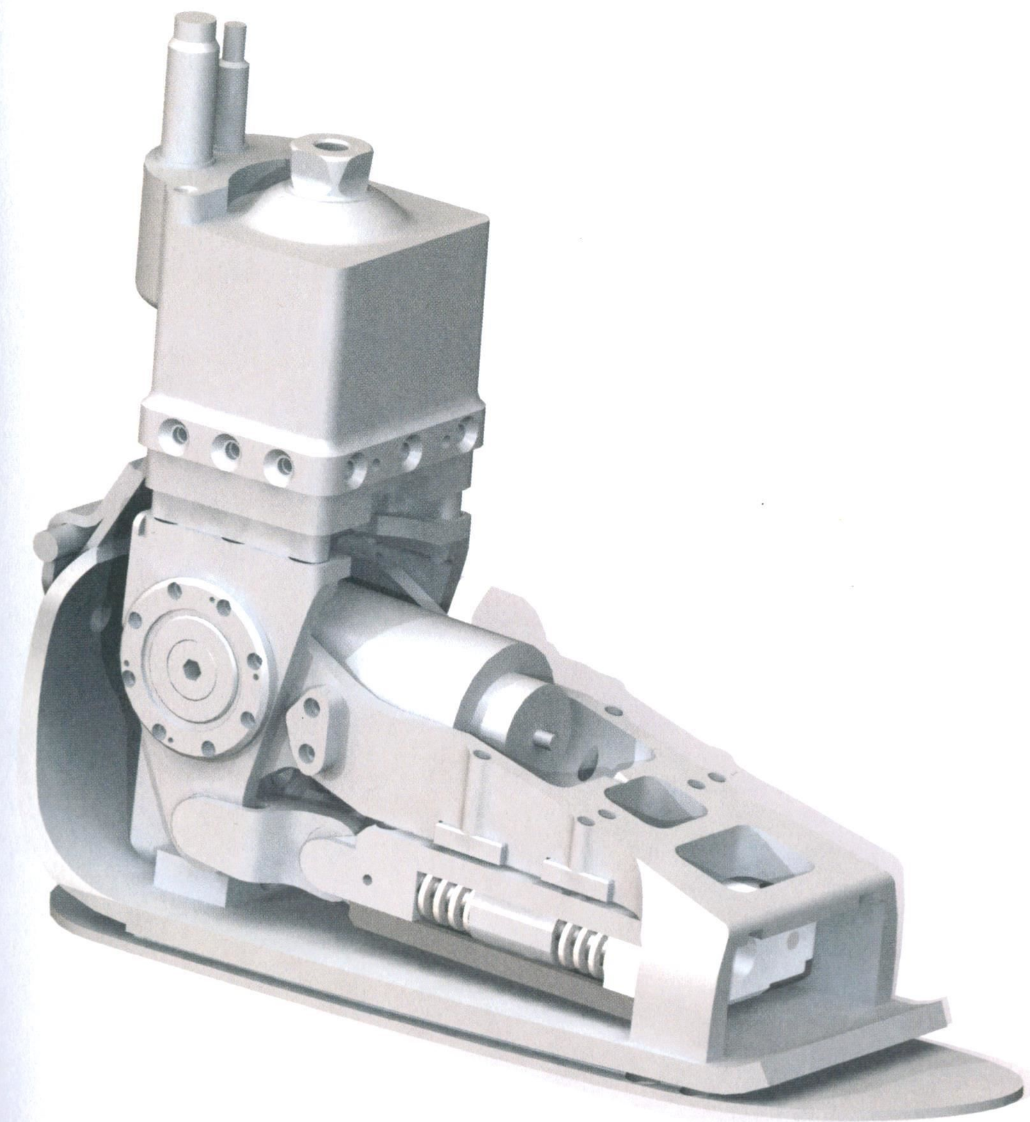
Power Assist Suit Prototype. 2005
Aluminum, 59 × 35 3/8 × 23 5/8" (150 × 90 × 60 cm)

The Power Assist Suit, a battery-powered exoskeleton suit, was born out of real need: Japan does not have an adequate number of healthy young people to take care of its rapidly aging population. The suit is designed to help a caregiver carry a bedridden patient. Sensors are attached to the arms and legs of the wearer to measure the tautness of muscles and detect how hard they are working. The data is sent to the computer built into the suit to calculate how much "assistance" is to be given. Finally, actuators located at the elbows, knees, and waist of the suit are activated by inflating airbag-like mechanisms to help the caregiver carry up to approximately twice the weight he or she can usually bear. The pneumatic system that powers the actuators makes the operation of the suit feel smooth for both the caregiver and the patient.

Hugh Herr (American, born 1964), Jeff Weber (American, born 1969), and Bruce Deffenbaugh (American, born 1946)
Biomechatronics Group (est. 2004), Massachusetts Institute of Technology (USA, est. 1861)
iWalk, Inc. (USA, est. 2006)

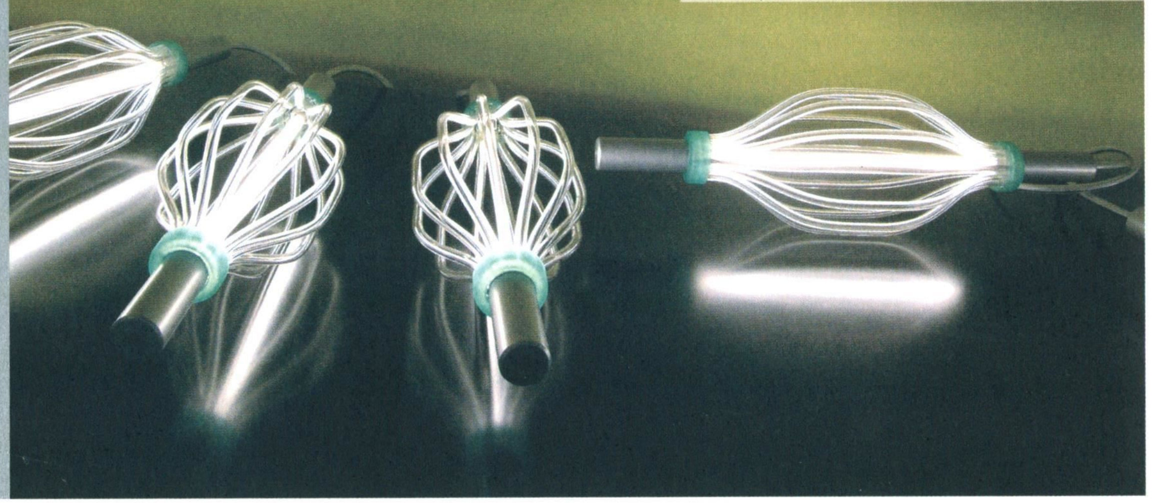
Powered Ankle-Foot Prosthesis Prototype. 2005–07
Titanium, aluminum, carbon composite, and polyurethane, 7 × 3 × 10 1/2" (17.8 × 7.6 × 26.7 cm)
Prototype by iWalk, Inc., USA (2007)

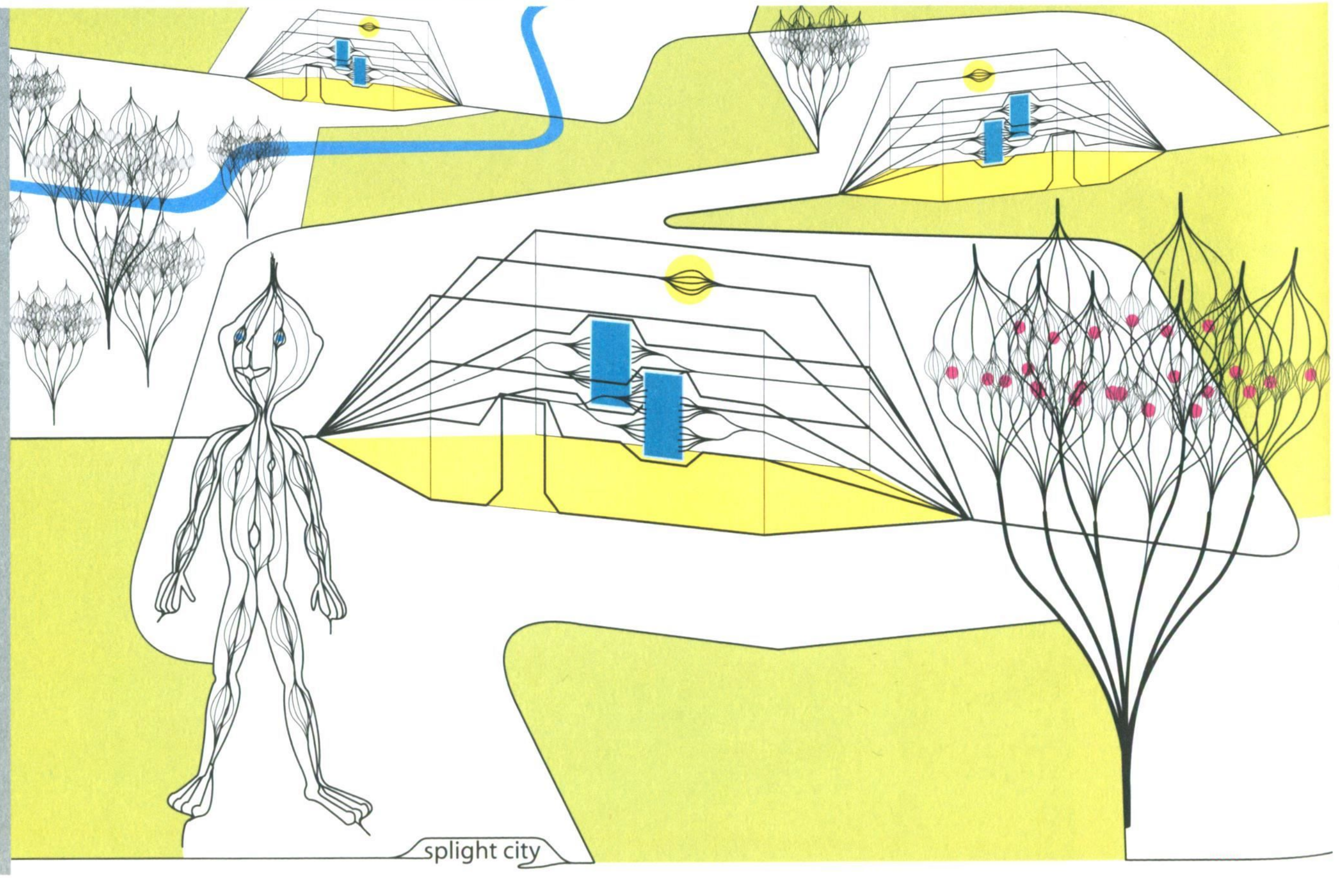
Most of today's prostheses cannot equal actual limbs. A conventional ankle-foot prosthesis, for example, requires the amputee to exert thirty percent more energy when walking than a biological ankle does. This is because the biological ankle and foot provide energy for walking beyond that which can be stored from the spring of the foot alone. Hugh Herr and his Biomechatronics Group at MIT have developed an artificial ankle-foot that can mimic the real thing. Instead of muscle and tendon, a battery-powered motor and multiple springs are used to make walking easier and a person's gait more natural.



matali crasset (French, born 1965)
Splight table lamps Prototypes. 2005
Steel and glass, 15 3/4 × 8" (40 × 20 cm) diam.

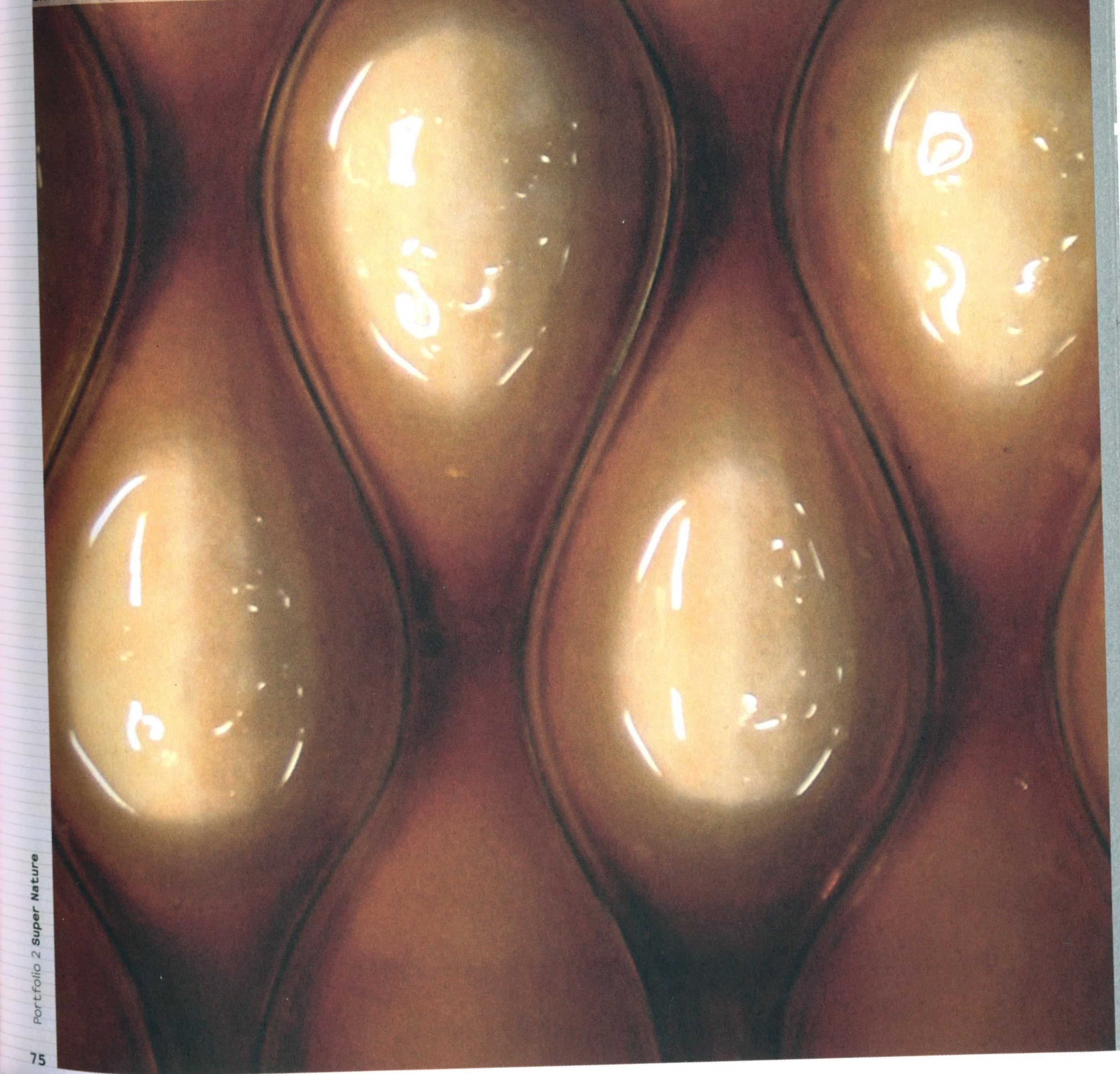
The Splight table lamp is inspired by the interconnected nature of our world. The name is a fusion of spline, a mathematical function used for interpolation, and light. Splight's light source is surrounded by glass "fibers," a cage that establishes a link between two electrical poles. Just as energy flows through a muscle's fibers, powering appendages in the greater system of the body, energy flows through the lamp, powering the light and by extension the greater environment. The lamps can stand alone or be grouped into organic formations, creating an entity that may be both an autonomous object and part of a whole.

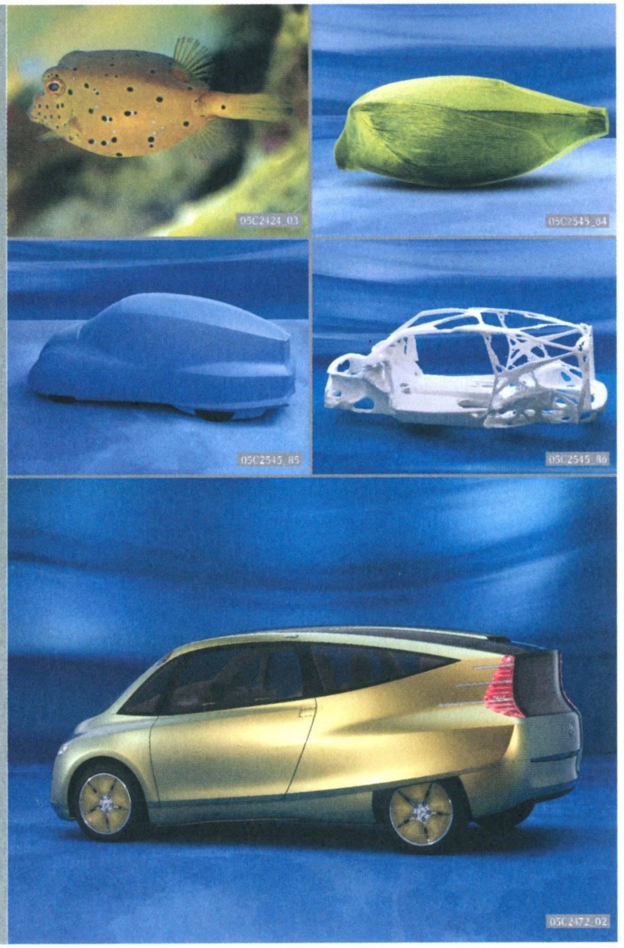




Neri Oxman (Israeli, born USA 1976)
Materialecology (USA, est. 2006)
Massachusetts Institute of Technology (USA, est. 1861)
The Eyes of the Skin Prototype. 2006
Resin, liquid rubber, and metal wire, 12 × 12' (365.8 × 365.8 cm)

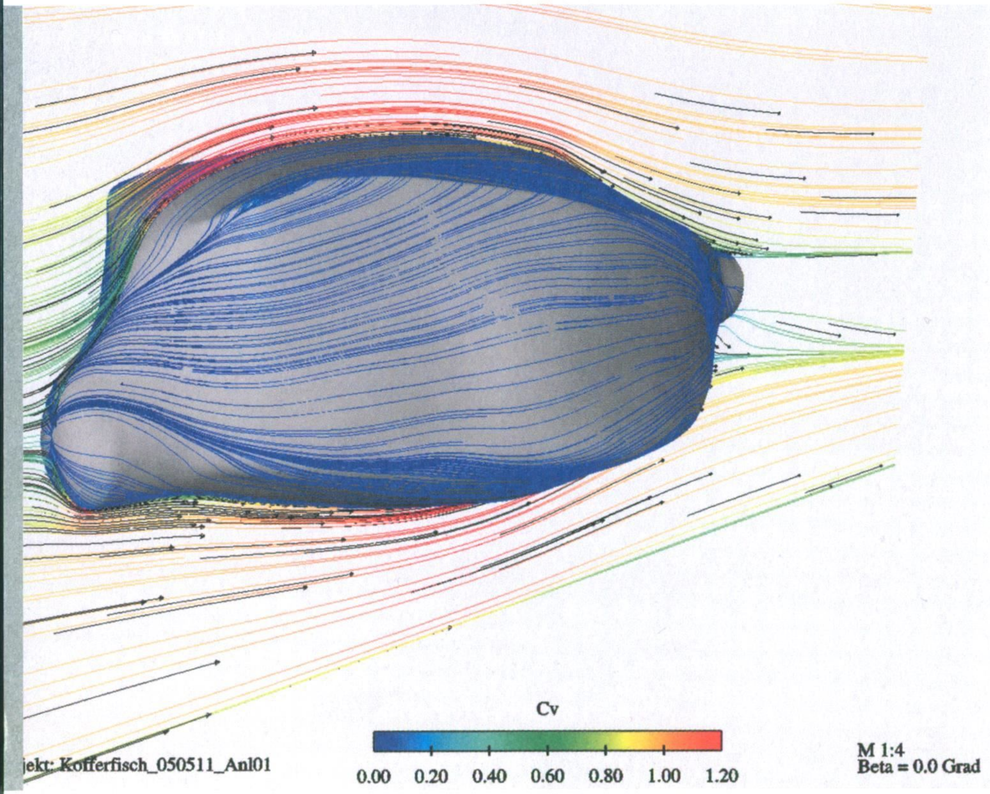
A number of architects today are working toward creating dynamic buildings that adapt to changing environmental conditions and levels of occupancy, almost as if they were living organisms. Facades and their permeability have been privileged areas of experimentation. Neri Oxman's concept of a "breathing" skin for buildings is realized with a latex membrane applied on an adjustable mold. The Eyes of the Skin is a first step toward designing efficient, self-regulating buildings that will adapt to shifts in light, pollution, and movement, among other variables.





Peter Pfeiffer (German, born 1943)
Daimler AG/Mercedes-Benz Design (Germany, est. 1998/1926)
Mercedes-Benz bionic car Concept. 2005

With billions of years of research and development under its belt, it's no wonder that nature has achieved the optimal solutions for the toughest design problems—and sometimes the best solution is surprisingly counterintuitive. When Daimler engineers were searching for an aerodynamic form for a new lightweight, fuel-efficient car, they turned away from the prevailing teardrop shape and looked instead to the boxfish. Angular yet elegant, the boxfish is unexpectedly streamlined for easy maneuverability, while its skin, consisting of hexagonal bony plates, provides protection with minimal weight. Using bionic modeling, the engineers developed a concept for a vehicle that benefits from a low drag coefficient, high engine performance, and a safe, rigid construction.



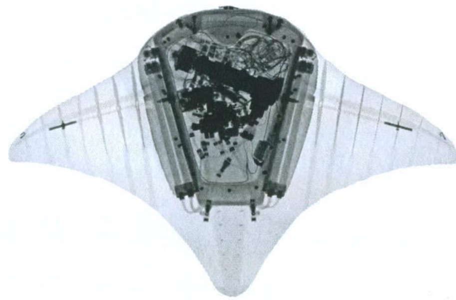
Jayden D. Harman (Australian, born 1949)
PAX Scientific, Inc. (USA, est. 1997)
Lily Impeller 1996
Stainless steel, 7 1/2 x 4 1/4" (19 x 10.8 cm) diam.
Manufactured by PAX Water Technologies, Inc., USA (2002)

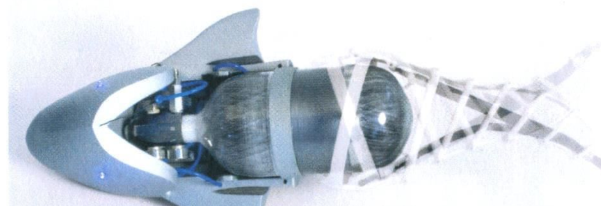
Biomimicry is the strategy that designers and engineers use to observe and learn from nature's sophisticated designs and then implement these lessons in artificial objects. The Lily Impeller is a mixer "designed using the elegant and effective geometries found in natural fluid flow," explains its designer. Its shape, based on the logarithmic curve known as the Fibonacci spiral and found in such objects as nautilus shells and whirlpools, allows liquids to flow centripetally through it with little friction. As a result the device is capable of circulating millions of gallons of water with a minimal amount of energy. Used in municipal reservoir tanks, the mixer prevents drinking water from stagnating, reducing the need for disinfectant additives.

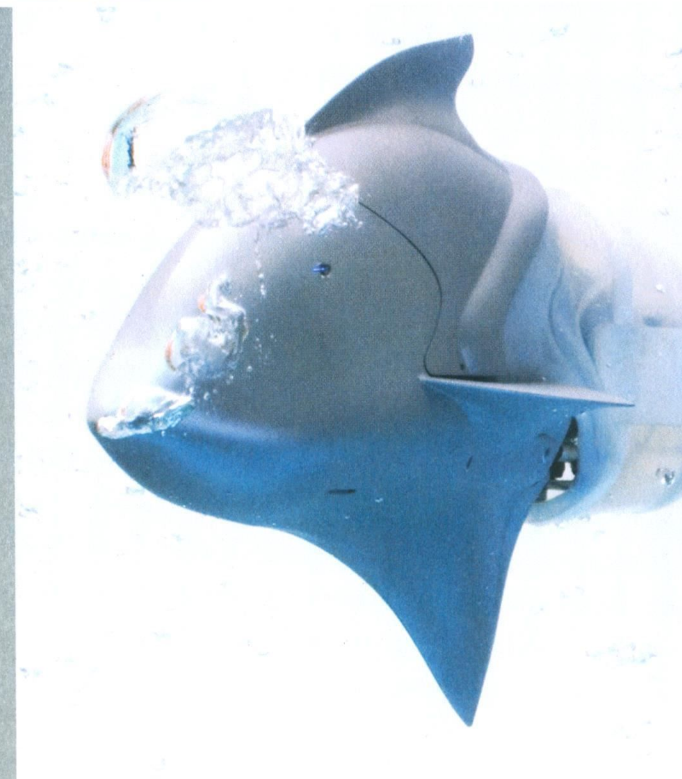
Rudolf Bannasch (German, born 1952) and Leif Kniese (German, born 1968) of EvoLogics GmbH (Germany, est. 2000)
Markus Fischer (German, born 1966) of Festo AG & Co. KG Corporate Design (Germany, est. 1925)

Aqua_ray Prototype. 2007

Fiberglass-reinforced plastic, CURV polypropylene sheet, polyamide resin with elastane skin, and Torcman brushless motor, 5 3/4 x 37 7/8 x 24 1/4" (14.5 x 96 x 61.5 cm)
Prototype by EvoLogics GmbH, Germany (2007)







Elias Maria Knubben (German, born 1975) and Markus Fischer (German, born 1966) of Festo AG & Co. KG Corporate Design (Germany, est. 1925)

Airacuda Prototype. 2006

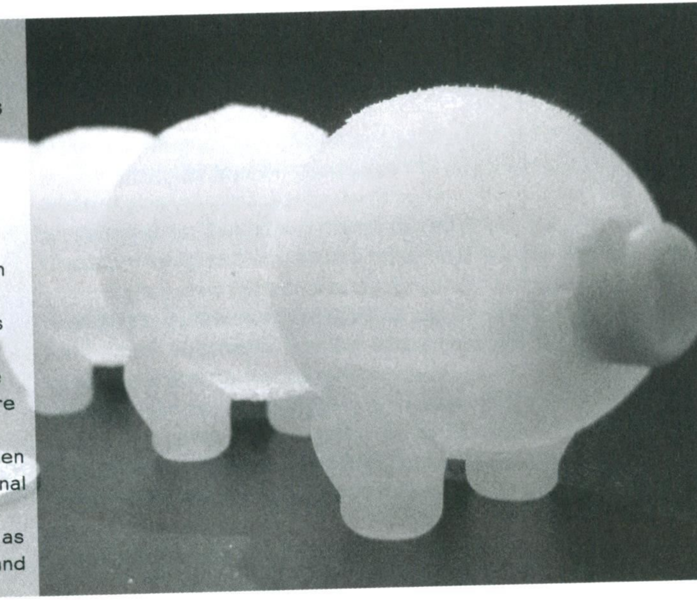
Polyamide and silicone, 17 3/4 x 11 x 39 3/8" (45 x 28 x 100 cm)
Prototype by Festo AG & Co. KG, Germany (2006)

The Aqua_ray and the Airacuda biomimetic robots are remote-controlled, pneumatically driven fish whose form and kinematics are modelled on the creatures that inspire their names. Flowing movements, achieved by the dynamic flapping of a wing, allow the Aqua_ray to be maneuvered precisely and efficiently. The Airacuda also moves easily through the water, balanced by an air bladder. The robots can be used in a wide range of oceanography applications without disrupting the natural environment. Translated from biological operating principles, both feature a key technology—a pneumatic "muscle" whose dynamics are similar to a real muscle, only operated using compressed air. The muscle consists of a hollow tube; when the tube is inflated its diameter expands as its length contracts, generating power. A pair of these pneumatic muscles, alternately pressurized and depressurized, causes the robot's fin or tail to move, propelling it through the water.

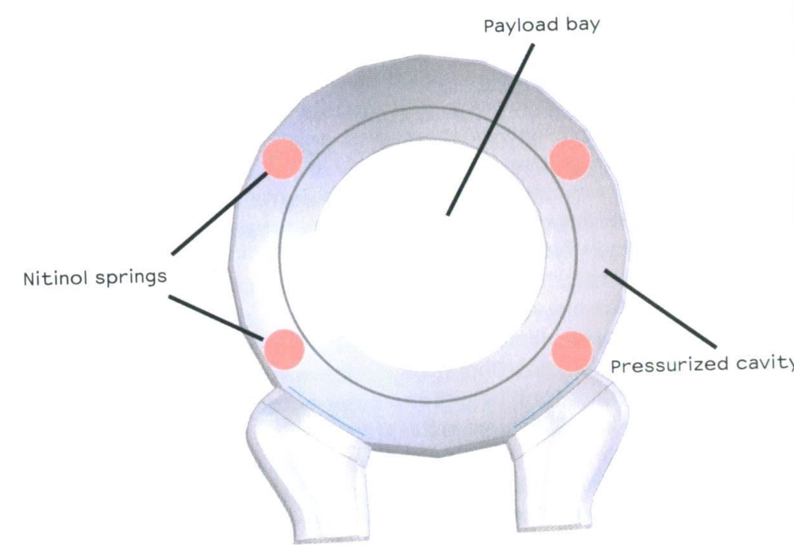
Barry Trimmer (British, born 1958)
Biomimetic Devices Laboratory (est. 2005), Tufts University (USA, est. 1852)

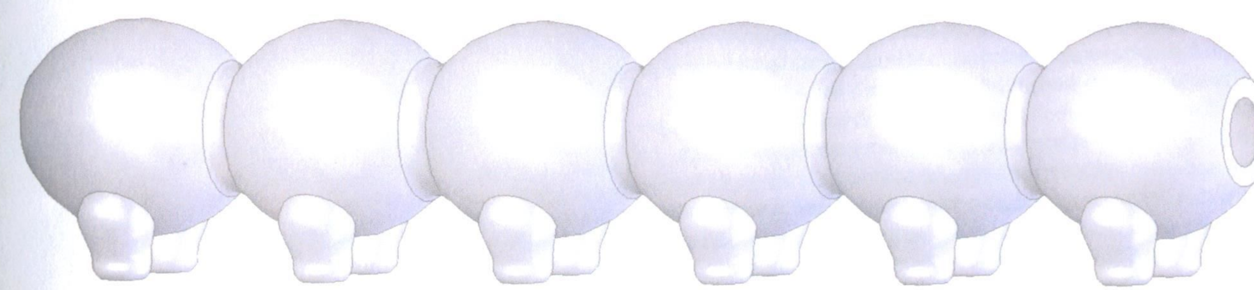
SoftBot from the **Biomimetic Soft-Bodied Robots project** Prototype. 2005–07

Silicone elastomer and nitinol shape-memory alloy, 9 1/2 x 1 5/8" (24 x 4 cm) diam.



The Biomimetic Devices Laboratory at Tufts University is working on robots that will lead to a new approach to motion control, based on biological materials and the adaptive mechanisms of animal movement. The SoftBot, which takes its inspiration from the tobacco hornworm caterpillar, was built to test ideas about controlling movements using very simple commands. Silicone rubber segments, which form the body, are lined with shape-memory alloy wires that contract when a current passes through, causing the rubber to bunch up. When the current is switched off, the rubber returns to its original shape, moving the robot forward. According to its inventor, the SoftBot "will have direct applications in robotics—such as manufacturing, emergency search and retrieval, and repair and maintenance of equipment in space—and in medical diagnosis and treatment, including endoscopy and remote surgery."





Index

Photograph Credits

//////// fur //// art entertainment interfaces, 33 (lower left and lower right); Alex Adai, 132; AEDS, 70; Akishima Laboratories (Mitsui Zosen), Inc., 65; Aranda/Lasch, 86, 94, 95, 96–97; Jon Ardern, 29 (bottom); © Julien Arnaud, 174 (top); Atlas Gloves, 38 (top); James Auger, 35 (bottom); James Auger/Jimmy Loizeau, 176, 178, 185; James Auger/Onkar Kular, 177; Bad Math, 168 (upper left); Cecil Balmond and Jenny E. Sabin, 85; Poppy Berry, 44; Beta Tank, 42; Blender Foundation, 166; © United States Postal Service. All rights reserved. Used with permission, 53; Eyal Burstein, Beta Tank, 64 (top); Michael Burton, 29 (middle), 107, 108; Samuel Cabot Cochran, 81; Elio Caccavale, 32, 113 (top); © Cambridge University Press, 124–25; Webb Chappell, 73 (top); Raúl Cárdenas-Osuna, Bernardo Gutiérrez, and Shijune Takeda, 148; Charlie Nucci Photography, 77; chicagocrime.org, 169 (lower left); Kapono Chung, Chuhn Chung, Jesse Shapins, Leslie Clague, Cynthia Connolly, and Google, 169 (upper left); Guido Clerici, 40; Ingmar Cramers, 180 (bottom); matali crasset, 74; Daimler AG, 76; Davies and Starr, 152; Brendan Dawes, 143; Erik Demaine, 60 (bottom); Martino d'Esposito, 35 (top); Digital Image Design Incorporated, 137 (bottom); Bill Dimm, Hot Neuron LLC, 46 (bottom); François Doury, 64 (lower left and lower right); © Eames Office LLC. From the collections of the Library of Congress, 46 (top), 47, 48, 49, 50–51; École cantonale d'art de Lausanne (écal)/Milo Keller, 27; The Family Planning Association of Hong Kong, 153; Frans Feijen, 181 (top); Flickrvision, David Troy; Flickr photos provided by Flickr (Yahoo)/Flickr members, map image provided by Google, 169 (bottom right); Walter Fogel, Carl-Zeiss, 3-D Metrology Services, 78 (upper left and upper right); Walter Fogel and Oliver Meckes, 78 (lower left and lower right); © Felice Frankel, 99; Front, 67; Ben Fry, 12–13, 141, 142; fuseproject, 162; Michele Gauler, 184; Yann Gibelli, 109; Maps by Google, bathroom images by anonymous contributors, 168 (upper middle left); Maps and satellite data provided by Google through agreements with their mapping providers, topo map imagery provided by Microsoft, 168 (lower middle left); Google.com and Morgan Clements, 168 (lower right); Graffiti Research Lab, 16–17; GustavoG, 135 (bottom); Jonathan Harris, 57; Jonathan Harris and Sep Kamvar, 136 (middle and bottom); Simon Heijdens, 118; Bas Helbers, 71 (upper right); Robert Jan de Heer, 169 (upper middle right); Hoberman Associates, Inc., 37; Frans Holthuysen, 84, 88, 89, 90–91, 92–93; Ingrid Hora, 31, 112, 113 (bottom); Human Beans, 165; © Véronique Huyghe, 45, 172, 173, 181 (bottom); Young Hyun and Bradley Huffaker, 133; Imaginary Forces and NASA satellite image, 175; Institute of Bioengineering and Nanotechnology, Singapore, 100; Anab Jain, 146 (bottom); Agata Jaworska, 87; Stephan "ST" Kambor, 33 (top); Tobie Kerridge, 111; James King, 103, 106; Aaron Koblin, 135 (top); KVA MATx, 183 (top); Janne Kyttänen, 68, 69; Robert J. Lang, 58, 59, 60 (top); Joseph W. Lauher, SUNY Stony Brook, 52; Jürg Lehni, 62; Henry Leutwyler, 19 (top); Golan Levin, 137 (top); Roma Levin, David Cameron, and Toby Hadden, 30; Tomáš Gabzdil Libertíny, 117; Amir Lipsicas, 101 (bottom); Loop.pH, 119, 180 (top); Barrett Lyon, 120–21; Thomas G. Mason and Carlos J. Hernandez, 101 (top); Materialise, 66; Eriko Matsumura, 38 (bottom); Jacqueline McBride. Credit is given to the University of California, Lawrence Livermore National Laboratory, and the Department of Energy, under whose auspices the work was performed, and editor Arnie Heller, 61; David McNamara, 169 (upper right); Mikael Metthey, 104, 105; Microsoft Corporation, 146 (top); Miquel Mora, 41 (right), 147; NASA and Google, 168 (upper right); NASA, Google, and Ian Spiro, 168 (lower middle right); NASA, JPL, GSFC, and Arizona State University, 169 (lower middle right); William Ngan, 54–55; Nikon Corporation, 22, 22–23; Michiko Nitta, 145; NTT DoCoMo/NEC, 39 (bottom); Opel, 71 (bottom right); Adam Opel GmbH, 71 (bottom left); Neri Oxman, Materialecology, 75; Tapani Pelttari/Opte, 155; Pentagram Design, 134, 163; © Plastic Logic Limited, 41 (bottom left); © Matt Pyke and Karsten Schmidt, 144; realities:united, 179; Stanford Richins, 183 (bottom); Paul W. K. Rothemund, 82, 83; Sagmeister Inc., 56; Keith Schwab, 98; SENSEable City Laboratory, 149; Bharani Setlur, 164; Seymourpowell, 18, 18–19; Maura Shea, 171; Frimmel Smith, 156–57; Susana Soares, 43, 110; Spatial Information Design Lab, Graduate School of Architecture, Planning and Preservation, Columbia University, 130–31; © Stamen Design, 136 (top); Courtesy Stuart Karten Design, 115 (bottom); Courtesy Swarovski, 4, 24–25; © Vatsana Takham, 174 (bottom); Terraswarm with Natalie Jeremijenko, 128–29; © The New York Times, 126–27; Frank Thurston, 34; Per Tingleff, 28; The Tissue Culture & Art Project, 114; Barry Trimmer, 79; Troika, 39 (top), 150, 151, 160–61; David Troy, Twitter data provided by Twitter, map image provided by Google, 168 (bottom left); Demetrie Tyler, 139; Ronald Usery, Duke Photography, 20–21; Hans van der Mars, 158–59; Visual Communication Lab, IBM Research, 38; Filatova Elena Vladimirovna, 29 (top); Andrew Walkinshaw, 167; Martin Wattenberg and Marek Walczak/Turbulence.org, 140; Anna Weber, 170; Jeff Weber, 73 (bottom); Mark Weiss, 26; Christopher Woebken, 102; Philip Worthington, 63; Tomoaki Yanagisawa, 36; Dr. Keijiro Yamamoto, 72; Miro Zagnoli, 182; Photo by Gerald Zugmann; © Haus-Rucker-Co., 154; Ionat Zurr, 115 (top); Viktor Zykov, © IEEE, 116.

The following are registered trademarks of the companies or products mentioned in the text and captions: Babel Blocks™, Colloidia™, Corian®, CURV®, E Ink®, LithoParticle™, Pevolon®, PlayPumps™, Pyrex®, Somos®.

Acknowledgments

In the planning of this book and of the exhibition Design and the Elastic Mind, I relied on a wide network of extraordinarily elastic, lively, and generous minds. A diverse team of colleagues, volunteers, friends, and accidental consultants contributed immeasurably to the realization of both undertakings, and I will be forever indebted to them.

On behalf of The Museum of Modern Art, I wish to thank all the designers, engineers, artists, scientists, and manufacturers featured here for their cooperation and enthusiasm. I also wish to thank the sponsors for making this endeavor possible, and the lenders for agreeing to part, temporarily, with their possessions.

We in the field of design are in the concept business, and concepts need endless discussion and reconsideration. Together with my co-organizer, Patricia Juncosa Vecchierini, Curatorial Assistant, Department of Architecure and Design, I would like to thank our closest friends and partners, who so often became sounding boards. Larry Carty, first and foremost, and Lisa Gabor, Jane Nisselson, and Jordi Magrané Fonts were the moving targets for our whole team's lucubrations and doubts. Thank you.

In the research phase, Adam Bly, founder and editor-in-chief of the magazine Seed, was our precious resource and interlocutor. He taught me about science and helped me find unexpected shared interests and objectives between science and design. Along with my colleagues and with Meg Rand from his office, in December 2006 we initiated a monthly salon in which designers and scientists were free to discuss and brainstorm topics that then became pillars of the thesis behind the show. Some of the participants, including Benjamin Aranda and Chris Lasch, Felice Frankel, Ben Fry, and Jonathan Harris, are included here and in the exhibition, but all of them should be considered contributors to our enterprise.

A number of authoritative and imaginative advisors suggested some of the works included in the show. I would like to thank them one by one, but space limitations make it impossible. I would, however, like to mention Janine Benyus and Bryony Schwan from the Biomimicry Institute, Steve Sacks from bitforms gallery, Bruno Giussani, and Twan Verdonck, as well as Shumon Basar, Katy Borner, John Calvelli, Curro Claret, Dalton Conley, Elyssa Da Cruz, Niles Eldredge, Neil Gershenfeld, David Imber, Alan Kay, Sulan Kolatan, Sylvia Lavin, Liane Lefaivre, John Maeda, Alexandra Midal, Louise Neri, Enrique Norten, Alice Rawsthorn, Michael Rock, Stefan Sagmeister, Jukka Savolainen, David Schafer, Arne Sildatke, Cornelia Spillmann-Meier, Paul J. Steinhardt, Matt Taylor, Brian Tempest, Maholo Uchida, Luis Villegas, and Garth Walker.

Many of the designers and artists featured in this book also contributed invaluable suggestions. I would like to thank in particular Jon Ardern, Laurene Leon Boym, Anthony Dunne, Felice Frankel, Peter Frankfurt, Ben Fry and Casey Reas, Chuck Hoberman, Agata Jaworska, James King, Lisa Strausfeld, and Moritz Waldemeyer.

This book comes from the hyperelastic mind of one of the most inventive and perceptive designers in the world, Irma Boom, who was able to straddle space and time to produce an amazing visual synthesis of ideas. In MoMA's Department of Publications I wish to thank Christopher Hudson, Publisher; Kara Kirk, Associate Publisher; David Frankel, Editorial Director; Marc Sapir, Production Director; Elisa Frohlich, Associate Production Manager; Libby Hruska, Editor; and Rebecca Roberts, Senior Assistant Editor, for their efforts in bringing the book to light. Interns Isabel Bohrer, Jamieson Bunn, and Lilit Sadoyan provided vital assistance as well. I also wish to thank Joshua Roebke, Associate Editor, and Laura McNeil, Deputy Editor, at Seed Media Group for their help with editing some of the most scientific bits of the volume. Thanks are due as well to David Lo and Martijn Kicken for their valuable technical advice.

Members of the Museum's Board of Trustees deserve special acknowledgment. In particular, I wish to thank Ronald S. Lauder, Honorary Chairman, and Agnes Gund, President Emerita, knowledgeable and enthusiastic fans of design; David Rockefeller, Honorary Chairman; Robert B. Menschel, Chairman Emeritus; Donald B. Marron, President Emeritus; Jerry I. Speyer, Chairman; and Marie-Josée Kravis, President, for their passionate support of the Museum's curators. Glenn D. Lowry, Director, provided early and unwavering support that was crucial to the realization of the exhibition. Jennifer Russell, Senior Deputy Director for Exhibitions, Collections, and Programs, and Peter Reed, Senior Deputy Director, Curatorial Affairs, were integral in successfully bringing this huge ship to port.

I also wish to thank Maria DeMarco Beardsley, Coordinator of Exhibitions, and Randolph Black, Associate Coordinator of Exhibitions, for working out the complicated administrative details; Ramona Bronkar Bannayan, Director, Collection Management and Exhibition Registration, Susan Palamara, Registrar, Exhibitions, Allison Needle, Assistant Registrar, Exhibitions, and Ellin Burke, Project Registrar, for keeping track of the diverse loan items; and Eliza Sparacino, Manager, Collection and Exhibition Technologies, and Ian Eckert, Assistant, Collection and Exhibition Technologies, for helping us keep all our information in order. I would also like to extend thanks to Linda Zycherman, Conservator, and Roger Griffith, Associate Sculpture Conservator, for caring for all the objects.

The installation was indeed a challenge even for our heroic Department of Exhibition Design and Production. Jerry Neuner, Director, and Lana Hum, Production Manager, designed the installation, and their incomparable crew built it, as usual, to perfection. My gratitude goes to them and to Charlie Kalinowski, Media Services Manager, A/V, and to K Mita, Director, Technology Services, and his whole team, who performed miracles in order to ensure that the technology worked smoothly and effectively. The exhibition also lives on the Web, thanks to the magic touch of Allegra Burnette, Creative Director, Digital Media, and Shannon Darrough, Senior Media Developer, Digital Media.

I also thank Todd Bishop, Director, Exhibition Funding; Mary Hannah, Associate Director, Exhibition Funding; and Lauren Stakias, Senior Associate, Exhibition Funding, in the Department of Development and Membership, for securing the necessary funding, not a negligible feat. I thank Kim Mitchell, Director of Communications, and Daniela Stigh, Manager of Communications, for brilliantly condensing the whole show to get the press irresistibly interested, and Peter Foley, Director of Marketing, for promoting it.

I thank the whole Department of Education for their invaluable suggestions on how to communicate the show to the public, in particular Wendy Woon, Deputy Director for Education; Pablo Helguera, Director, Adult and Academic Programs; and Associate Educators Larissa Bailiff, Laura Beiles, Sara Bodinson, and Lisa Mazzola, and I also thank Jennifer Tobias, Librarian, Reader Services, and David Senior, Acquisitions Coordinator, Library, for their enthusiastic assistance with our research.

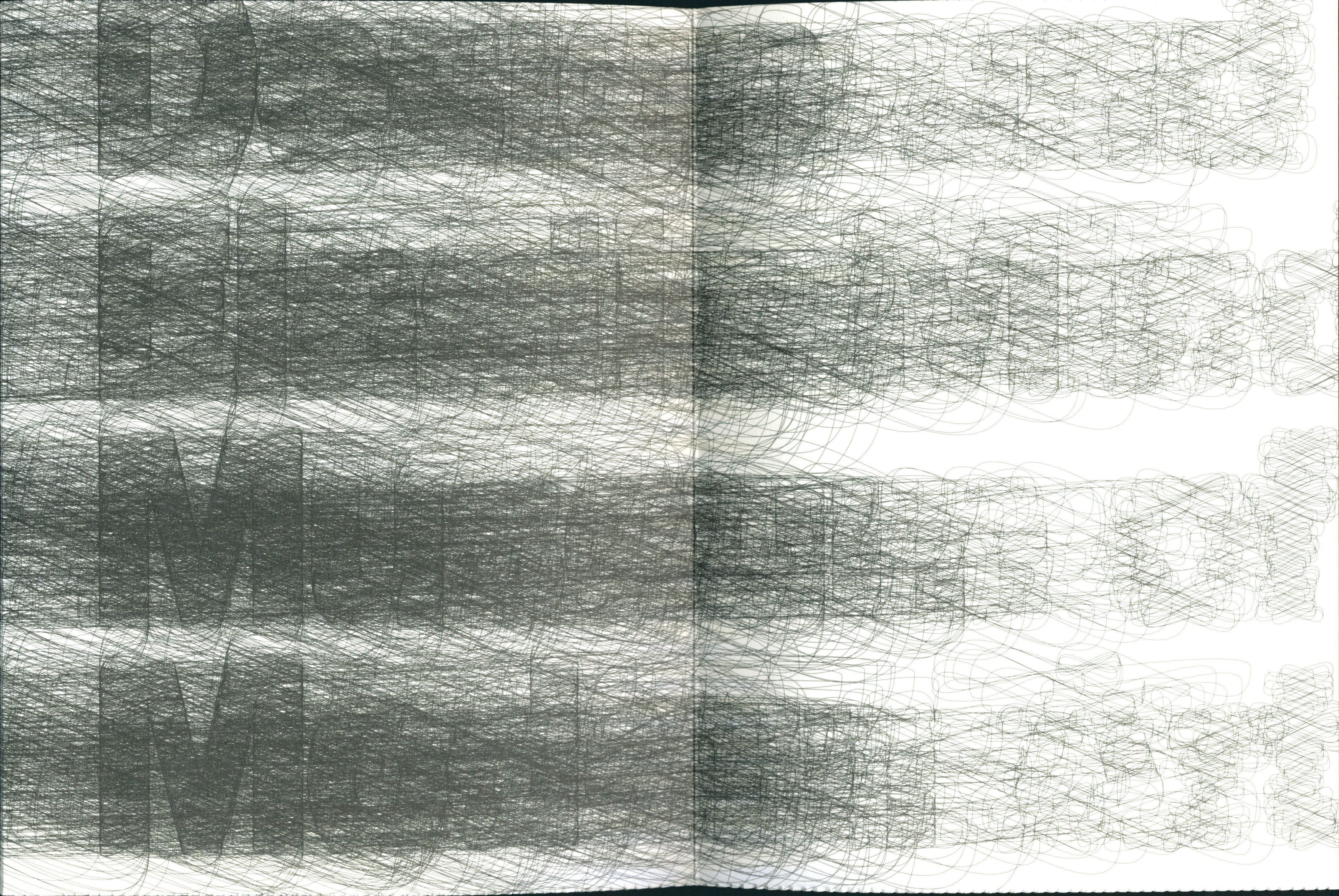
In the Department of Architecture and Design, I am deeply grateful to Barry Bergdoll, The Philip Johnson Chief Curator of Architecture and Design, who believed strongly in the exhibition and offered his support throughout the project. The entire department was helpful and encouraging and I thank each of its members, especially Peter Christensen, Curatorial Assistant, who participated in the organization of the show in the beginning. A special mention goes to Linda Roby, Department Coordinator, and Candace Banks, Department Assistant, for their untiring assistance. Several brilliant interns worked on this project; I wish to thank Andrea Lipps, Catharine Rossi, and Nadine Stares. Special thanks also go to Hideki Yamamoto, who helped us secure many loans in Asia and contributed ideas, texts, and invaluable criticism.

Lastly, I would like to thank the person with whom I shared this adventure, Patricia Juncosa Vecchierini. Yet another adventure, I should say, and once more she has proved to be the most valuable partner. I am very lucky to have had so many chances to work with her.

Design and the Elastic Mind celebrates the endless and restless curiosity of human beings and praises design as an expression of creativity and an affirmation of life. For this reason, I would like to dedicate this book and this show to the late Herbert Muschamp, who certainly knew what I am talking about.

Paola Antonelli
Senior Curator, Department of Architecture and Design

Design and the Elastic Mind



Over the past twenty-five years, in tandem with the introduction of the personal computer, the Internet, and wireless technology, we have experienced dramatic changes in our relationships with time, space, the physical nature of objects, and our own essence as individuals. Design and the Elastic Mind focuses on the responses of designers to the momentous advances in technology, science, and social mores that have characterized the last quarter-century and presents their projects that convert these developments into useful concepts and objects—from nanodevices to full-size vehicles, home appliances to building facades, pragmatic solutions to provocations. Designed by Irma Boom, this book features essays by Paola Antonelli, senior curator of architecture and design at The Museum of Modern Art; design critic and historian Hugh Aldersey-Williams; visualization design expert Peter Hall; and nanophysicist Ted Sargent.

9 780870 707322

Antonelli

Design and the Elastic Mind

MoMA