UNCONFORMITY AND ENTROPY

Greyman Cries
Shaman Dies
Billowing Smoke
Beauty Evoked

ANISH KAPOOR

TURNER

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Shaman Dies
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ADAM LOWE
MICHAEL PERRY AND PIERS WARDLE

TEXTS BY ADAM LOWE
AND SIMON SCHAFFER

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Concrete printing technology developed by Factum Arte for Anish Kapoor

Concrete printer operated by Anish Kapoor with Adam Lowe, Michael Perry, Piers Wardle, Dwight Perry, Zac Russell, Mike Ward, Seth Pimlott, Otto Lowe, Isabel Perry, Jeroen Vercruysse, Ben Ashenden. With assistance from Anish Kapoor Studio, Jeff Dyson, Sophie Walker, Pablo Schmidt and Angus Miller

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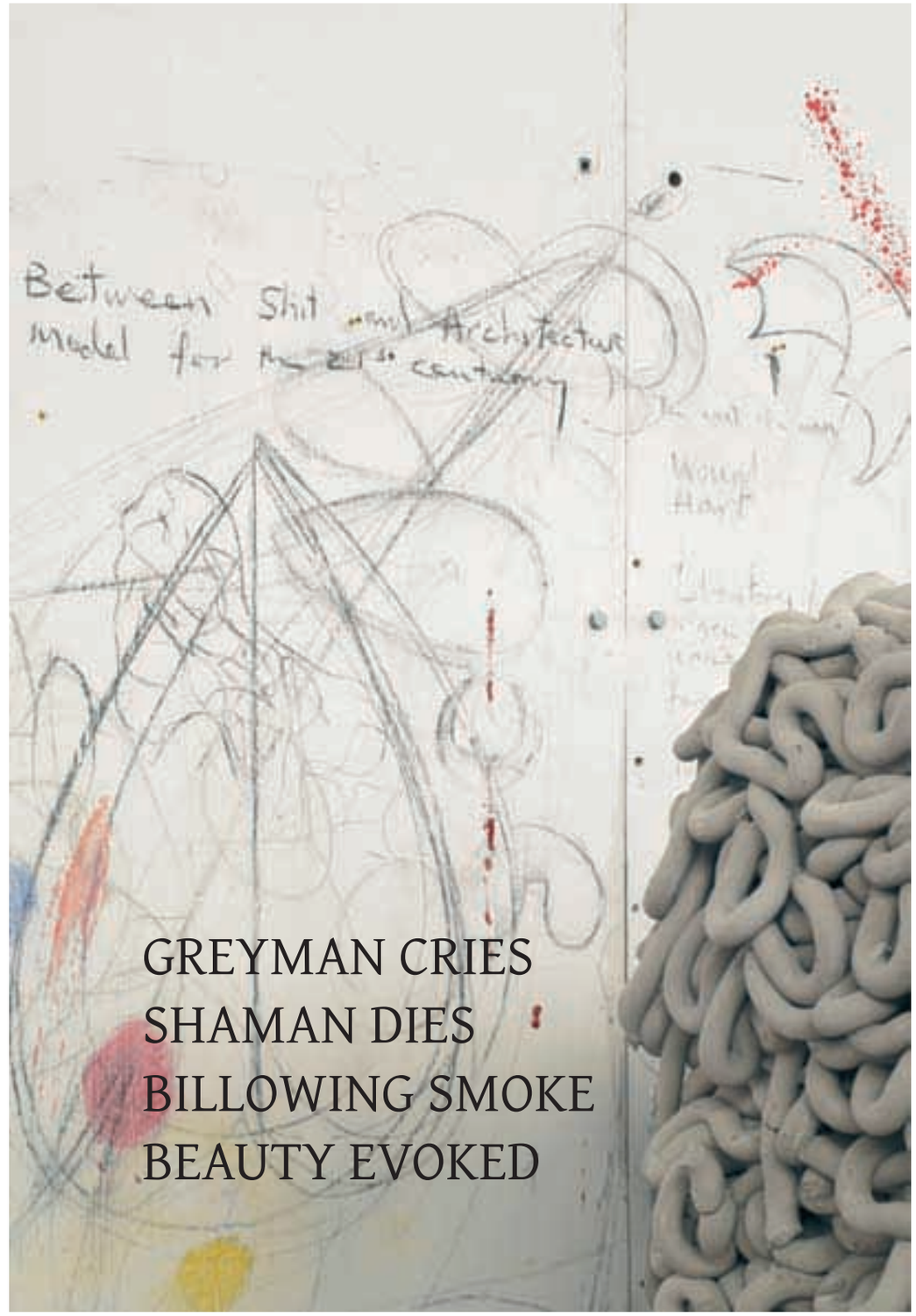

Between Shit and Architecture
Model for
GREYMAN CRIES
SHAMAN DIES
BILLOWING SMOKE
BEAUTY EVOKED

Anish Kapoor, *Greyman Cries*, model for The Royal Academy, London, 2009

Greyman Cries
Shaman Dies
Billowing Smoke
Beauty Evoked

ANISH KAPOOR

The hand of the artist is much estimated as the means by which the expression of Art finds a voice. To make Art without hand is a goal that sets art beyond expression.

Artists have found ways to subvert the means of production.

Some three years ago, Adam Lowe and I wondered if it were possible to make a machine that could generate form. The printing machine formed a model for the basis of our thinking. After much trial and error, we found a surprisingly simple way of making a workable engine.

Once we had started making objects, a new reality began to emerge.

These were objects like no others; they seemed to obscure the border between artifice and event.

These are objects that are more akin to natural things than to those made by design.

This is a state of matter that has mind. It keeps a loose relation to both intention and control. Closest in its formal considerations to the work of the Raku potters of Japan.

The Hyper-Materiality of these event-things gives them a physical presence that is bodily (shit, intestines, flesh) and the feeling of objects that might have been made by animal.

Technological methods give technological solutions. This is not the case here.

Geometry gives structure and architecture. Entropy and decay put geometry to trial.

There is no hierarchy of form, but form has a propensity to meaning. And meaning is the translation of art.

AN IDENTITY ENGINE

ADAM LOWE

An interest in the relationship between forms with an inherent resonance and the material transformations that these forms undergo is central to Anish Kapoor's work. Immaculately made and complex sculptures like *Inout (Infinity)* and *Sky Mirror* exist alongside more visceral forms such as *Blood Stick* and *Shooting into the Corner*. The new concrete sculptures belong in the second category, where intention, process, and materiality find their own equilibrium.

The development of *Greyman Cries, Shaman Dies, Billowing Smoke, Beauty Evoked* has been a gradual process with a complex and shared history. The original concrete printer was developed in 2006, but as it evolved in Kapoor's studio it has been through several incarnations. The current version is now referred to as the *Identity Engine*. This is in tribute to Charles Babbage's *Difference Engine*, a machine that also went through many incarnations, and exploited some simple principles of calculation to automate complex tasks. Babbage emphasised reliable repeatability; his concern was to prevent human error when reading the numbers the machine produced. Just as he increasingly saw humans as vaguely reliable machines, he started to treat his engines as possessed with intelligence, will and foresight. Data is entered into the *Identity Engine* in a regular and ordered form then the artist, the engine, the operators and various concrete mixes are allowed to take part in constrained random walks. Although a relatively simple machine, the many variables in play when digital data enters the physical world prevent predictable repetition. This uncomputability may help explain why these objects are so compelling – an artful balance between deterministic mechanics and free play. The resulting objects are artefacts with all the meanings this word implies: they feel as ancient as objects of geology or archaeology; they are certainly made by design; and they have slippage, noise and error.

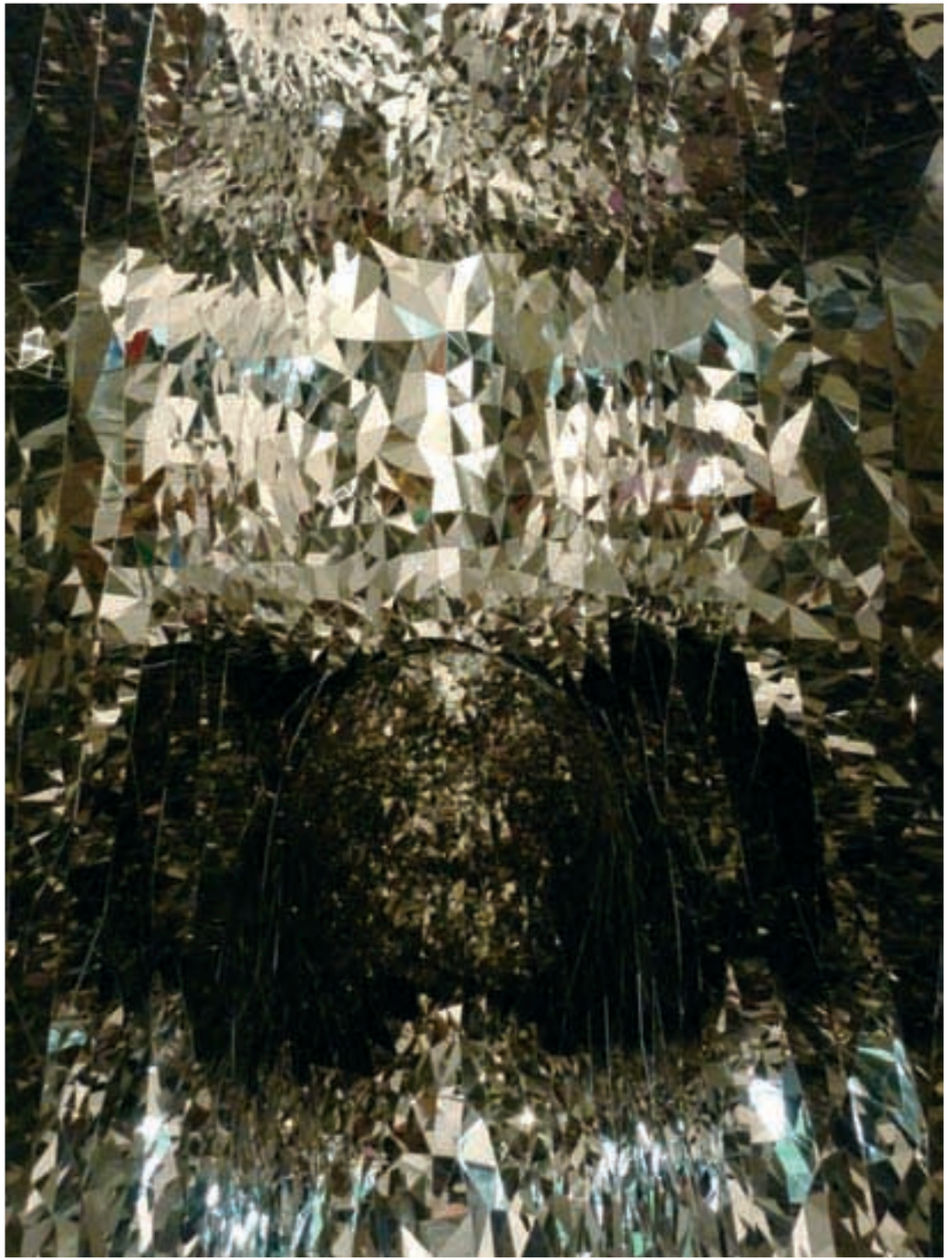
The concrete forms may look like an aesthetic departure for Kapoor but things that appear different can often be conceptually similar. Compare them to the exquisite and sensitive air bubbles trapped in acrylic that have filled one end of Kapoor's studio while the concrete forms have been spreading like cancerous growths over the studio floor. To make these acheiropoietic bubbles, collectively titled *Space as an Object,* the liquid acrylic is poured into a container and put into a vacuum chamber. As the air and gases are forced out of the liquid, some become trapped in or near the centre of the block and either

Anish Kapoor, *Space as an Object*; acrylic, air, space, 2008

The first printed forms made using the *Identity Engine*.

form coherent shapes, like one of Ernst Haeckel's organic art forms taken from nature, or more diffused clusters of bubbles resembling galaxies or cosmic rays. Individually, they are compelling; as a group their qualities assume a poetic dimension. The concrete forms also work as a group but their topological analogies are less concerned with the cosmos or the moment of conception and focus on more basic bodily functions: the *Identity Engine* is a shit machine that farts and craps its way along its ordained path, transforming a material that usually takes the form of its container into a stigmergic, self-organised structure. It is a mobile colon. Wounds and gashes, pleats and folds emerge at will and either self-heal or continue to rupture. Stigmergy is "a mechanism of spontaneous, indirect coordination between agents or actions, where the trace left in the environment stimulates the performance of a subsequent action". A mix of stigmergy and stratigraphy produces unconformities. Unconformity is a term used to describe breaks in the sedimentary geological record: in the *Identity Engine* we are interested in the unconformities of a much shorter period, discontinuities that happen from one moment to another.

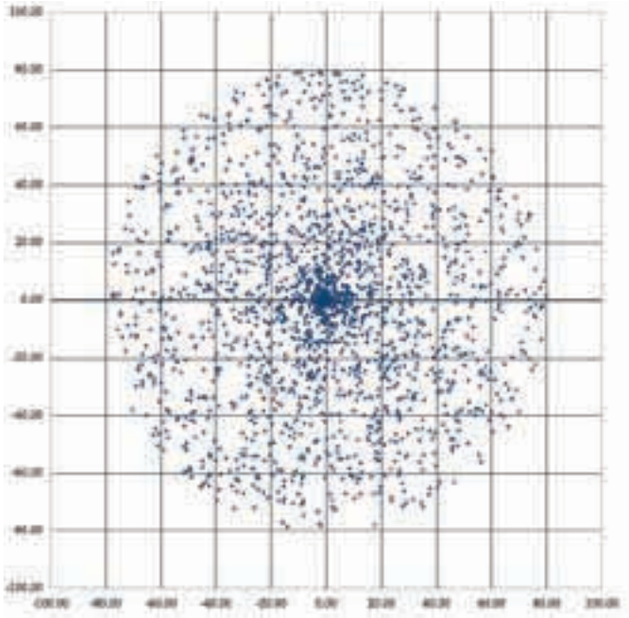
Perhaps it was reflection along these lines, while cross-breeding peas, that triggered William Bateson's notion that "the appearance of chromosomes is not suggestive of strings of beads of extreme heterogeneity, but rather with that seen, for example, in drying mud". But since Bateson coined the term "genetics" over a century ago, his science has become engrossed by the agency of DNA molecules, and has centred on a rival imagery of codes, chains, building

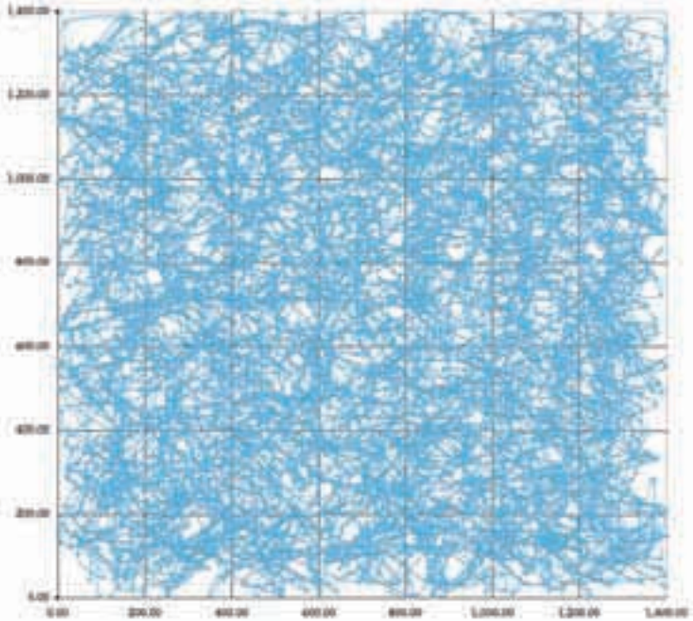


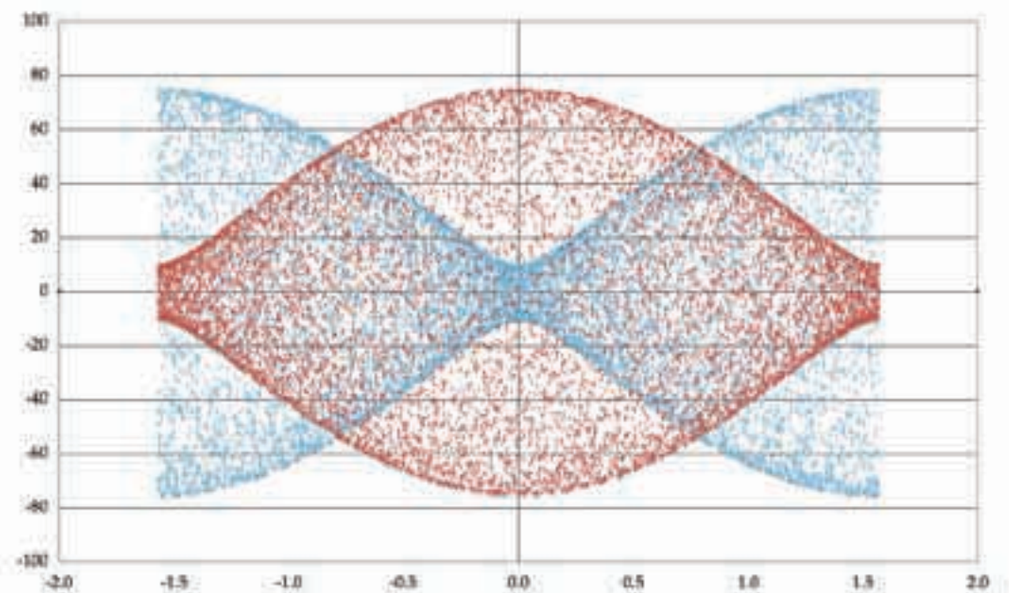
Anish Kapoor, *Inout (Infinity)*; laser-cut mirror-polished stainless steel, 2009

blocks and links, a LEGO world of assemblage. Molecular biology, in this version, goes along with reduction, concentrating on the discrete quality of fundamental units of chemical information. It's worth considering the opposite possibility, an imagery of fluid emergence, such as the setting of concrete, with basic molecules deforming, slumping and interacting with their environment. Anish Kapoor, the concrete mixes, the programmes and the operators all condition the range of forms that have emerged from the *Identity Engine*, a cunning machine which is not a passive agent but a vital performer in the act.

Once the intricately latticed concrete forms are dry they are moved into Anish's main studio where they are constantly shifted and re-located, like books on a bibliophile's shelf. There are very few rejects: the unfortunates are expelled usually because they have been evidently contrived and the human presence has become too visible. Gradually the studio filled up, each element relating to and conditioning those around it. In this context their true potential started to emerge and *Greyman cries* found its form.



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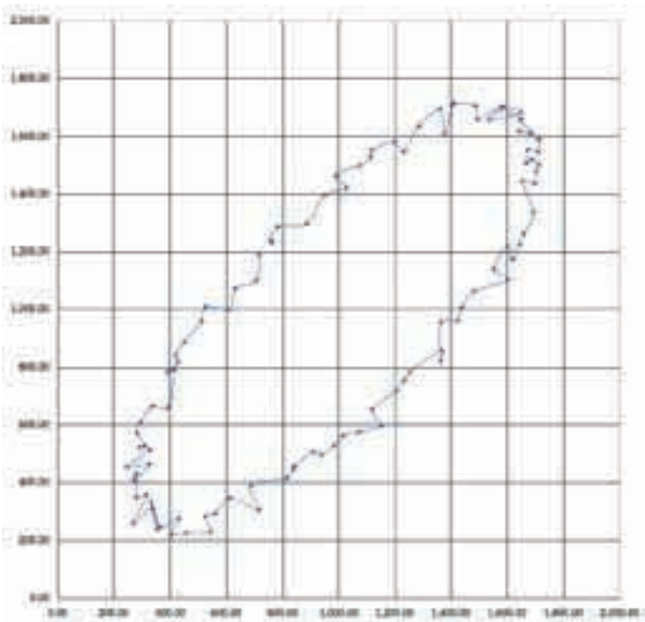

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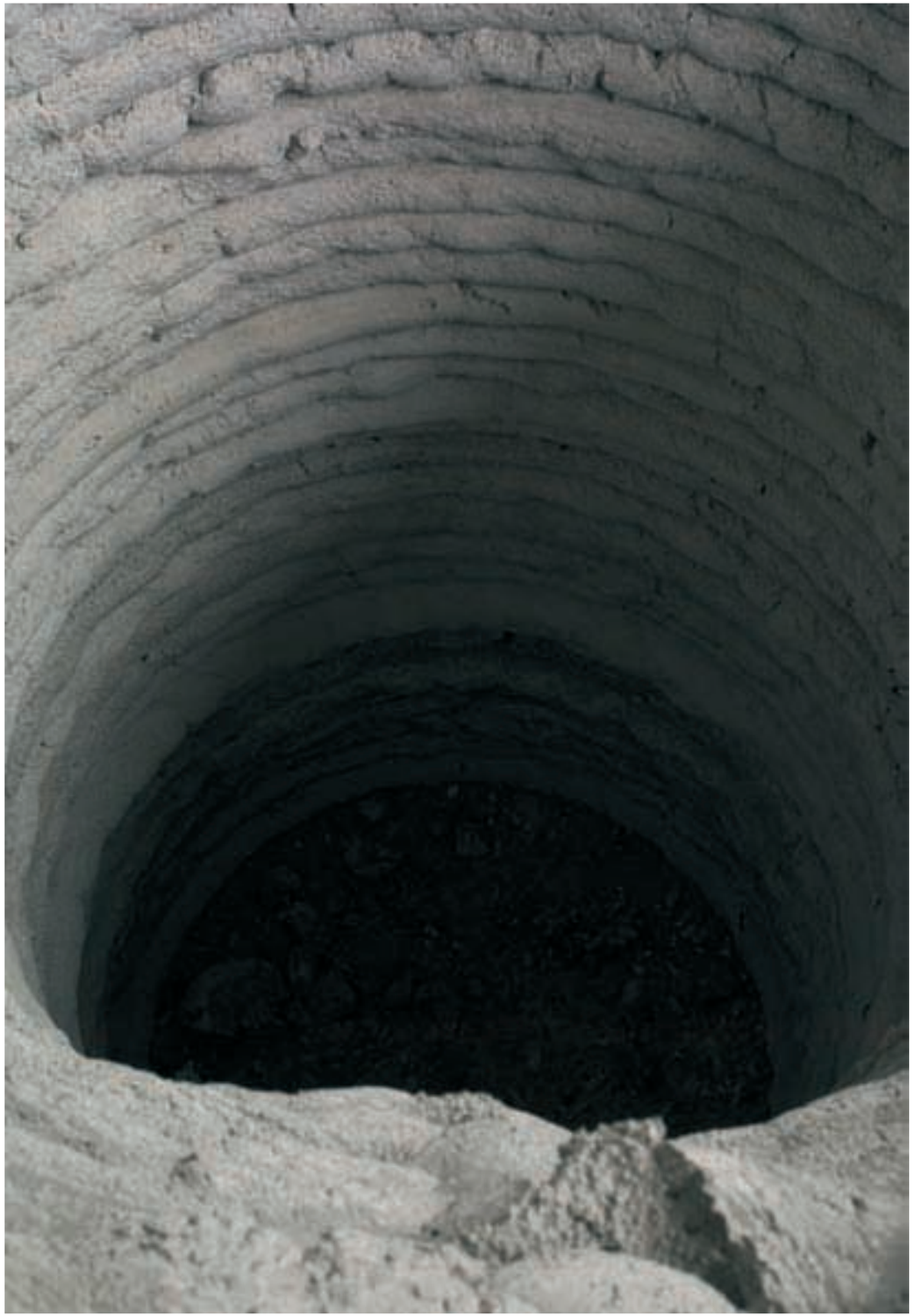
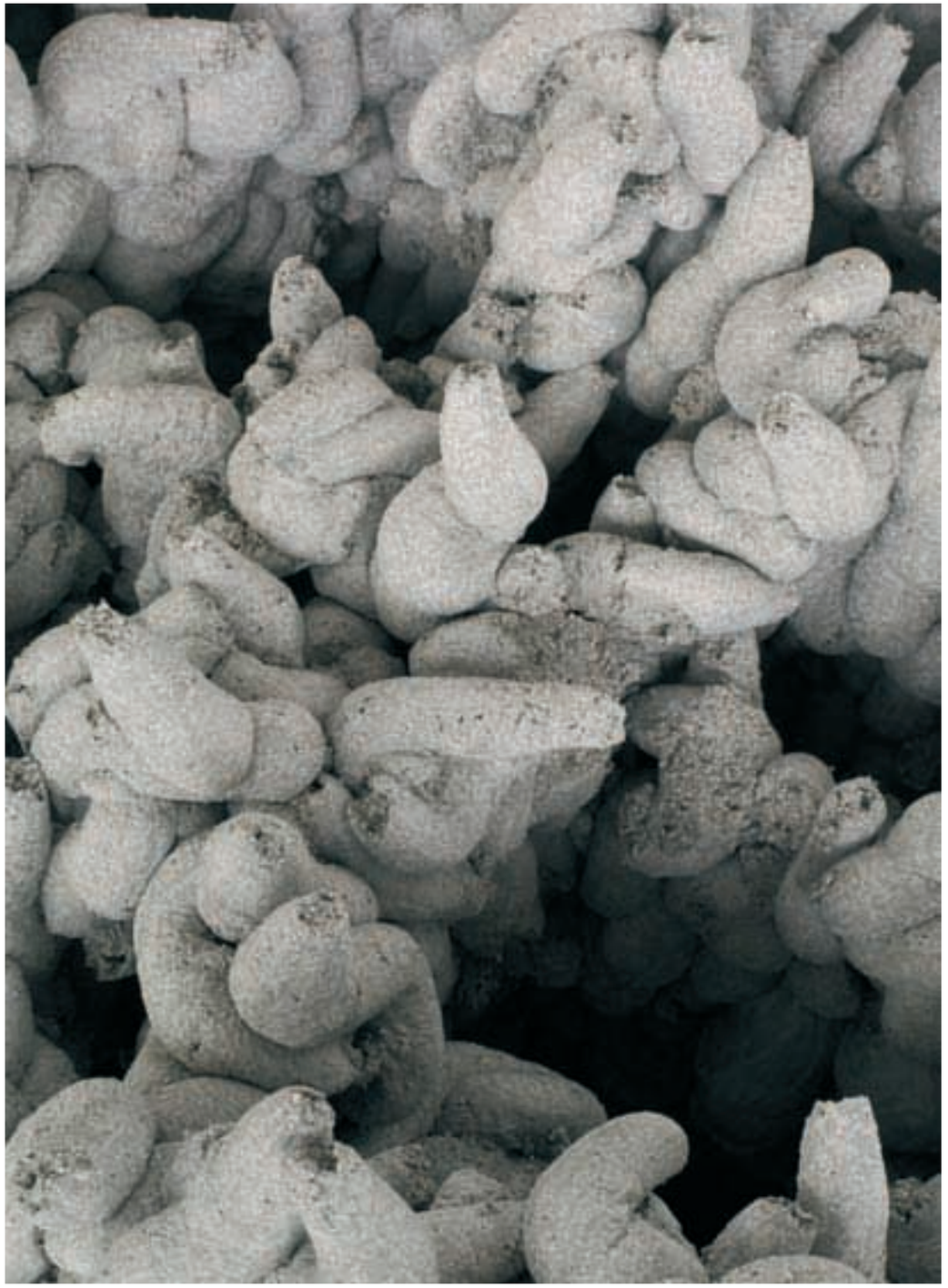
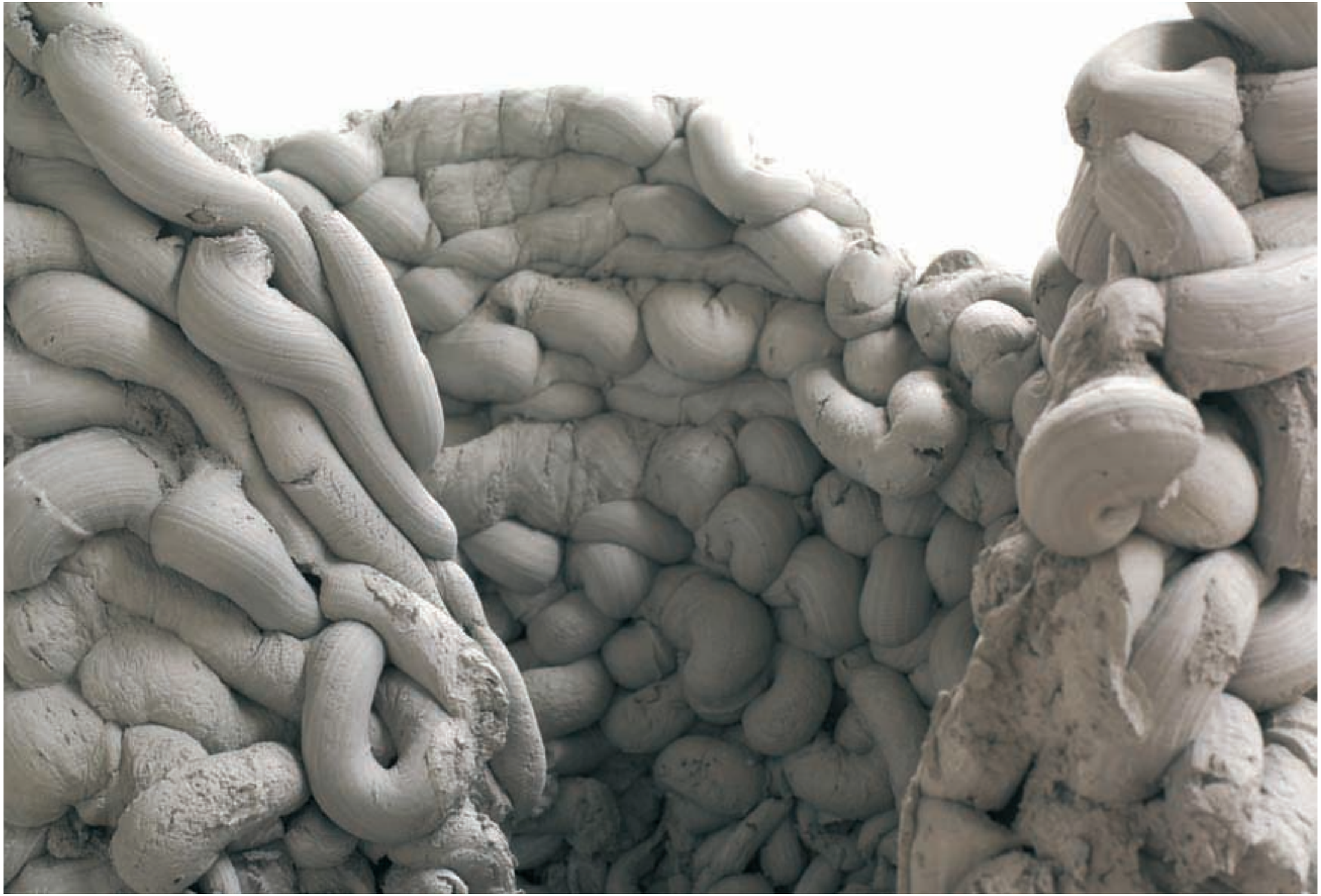
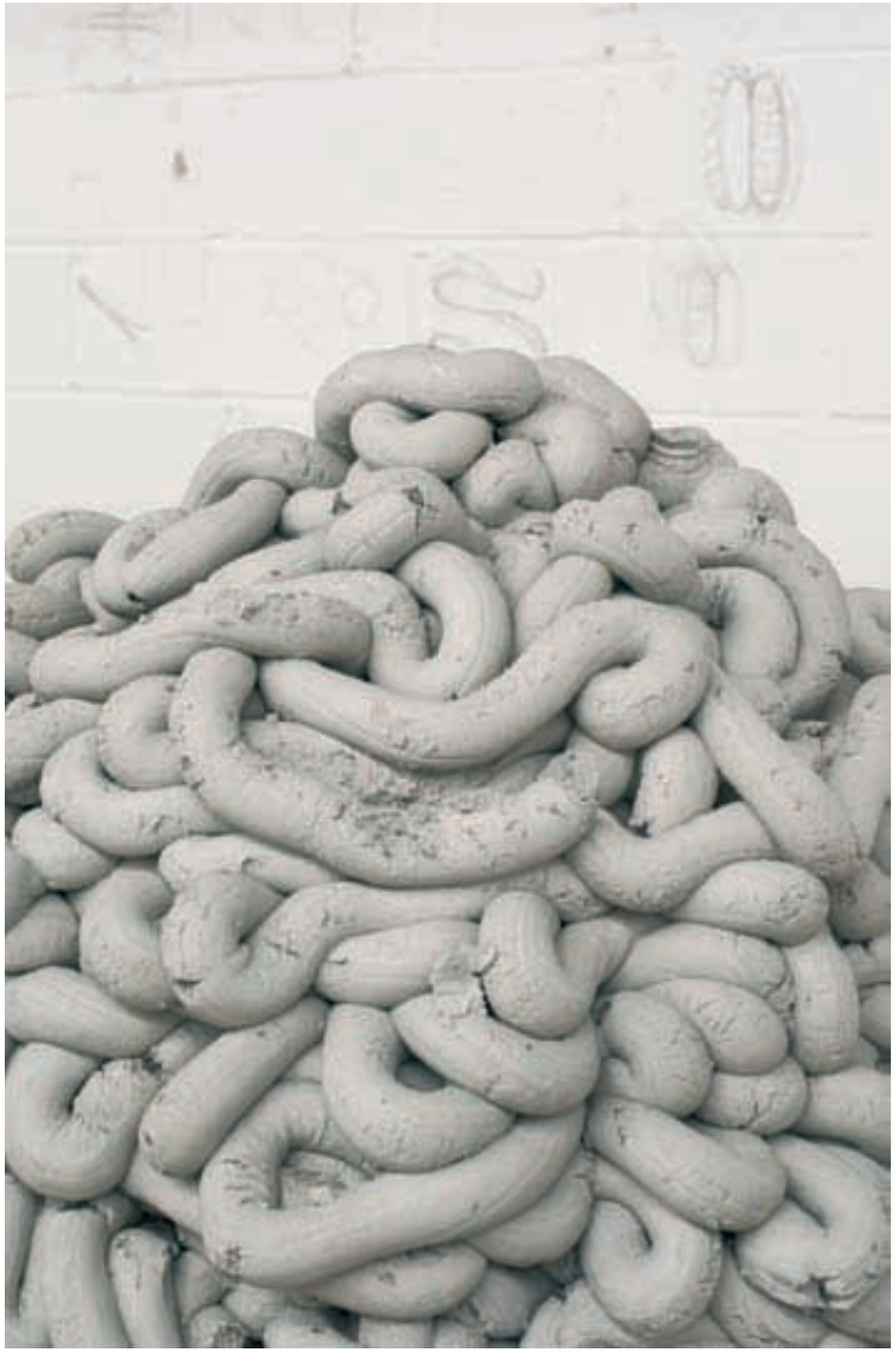
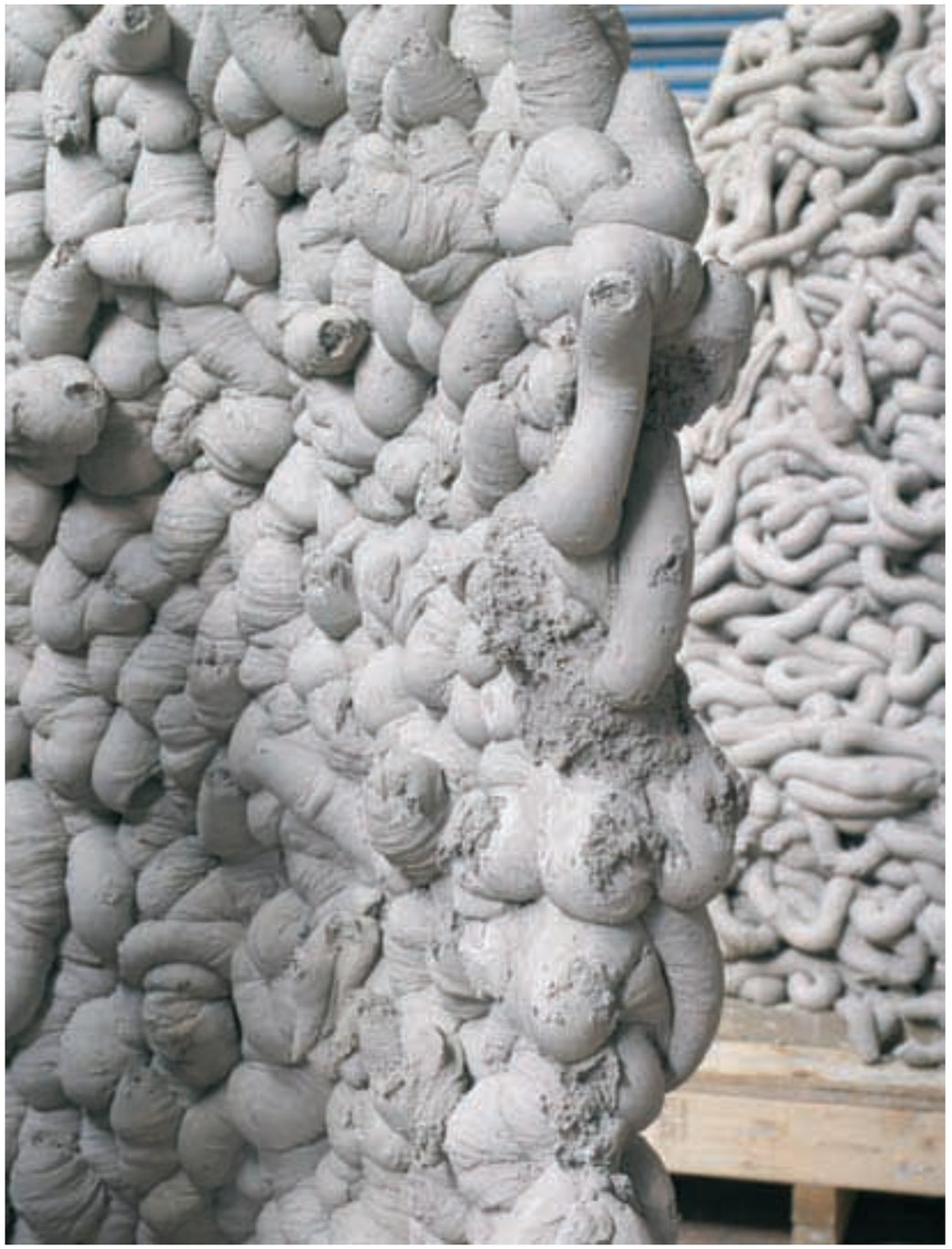
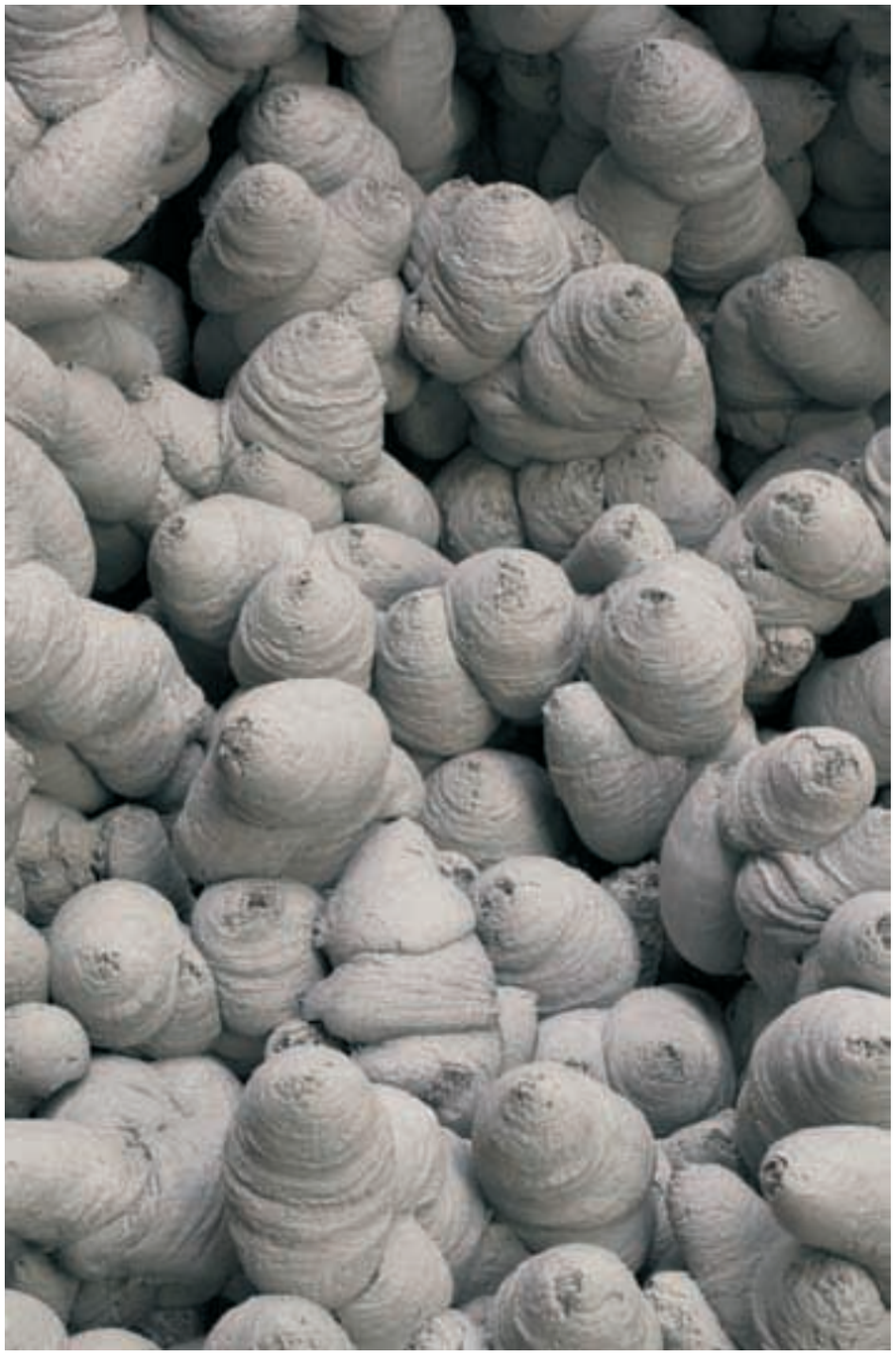


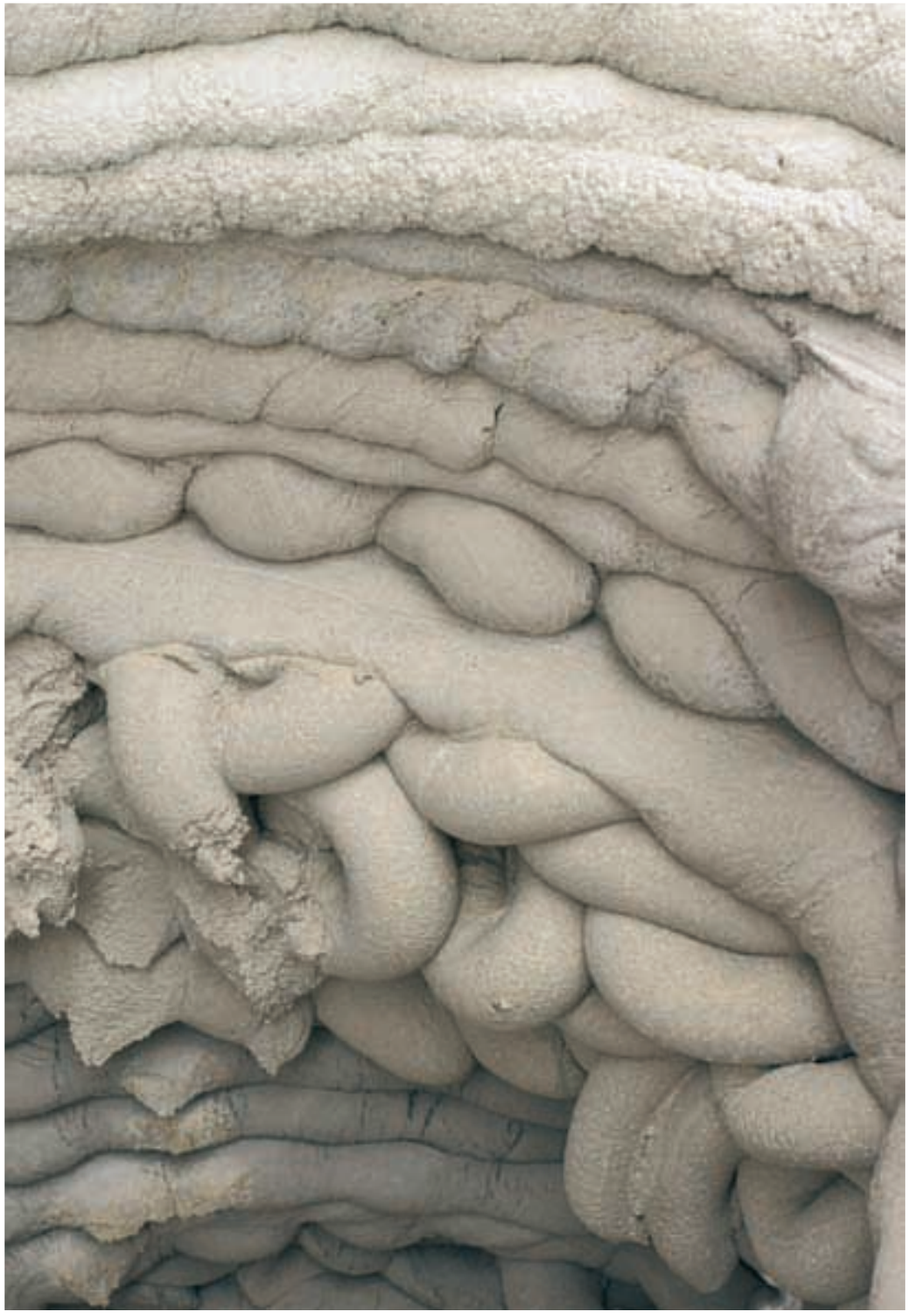


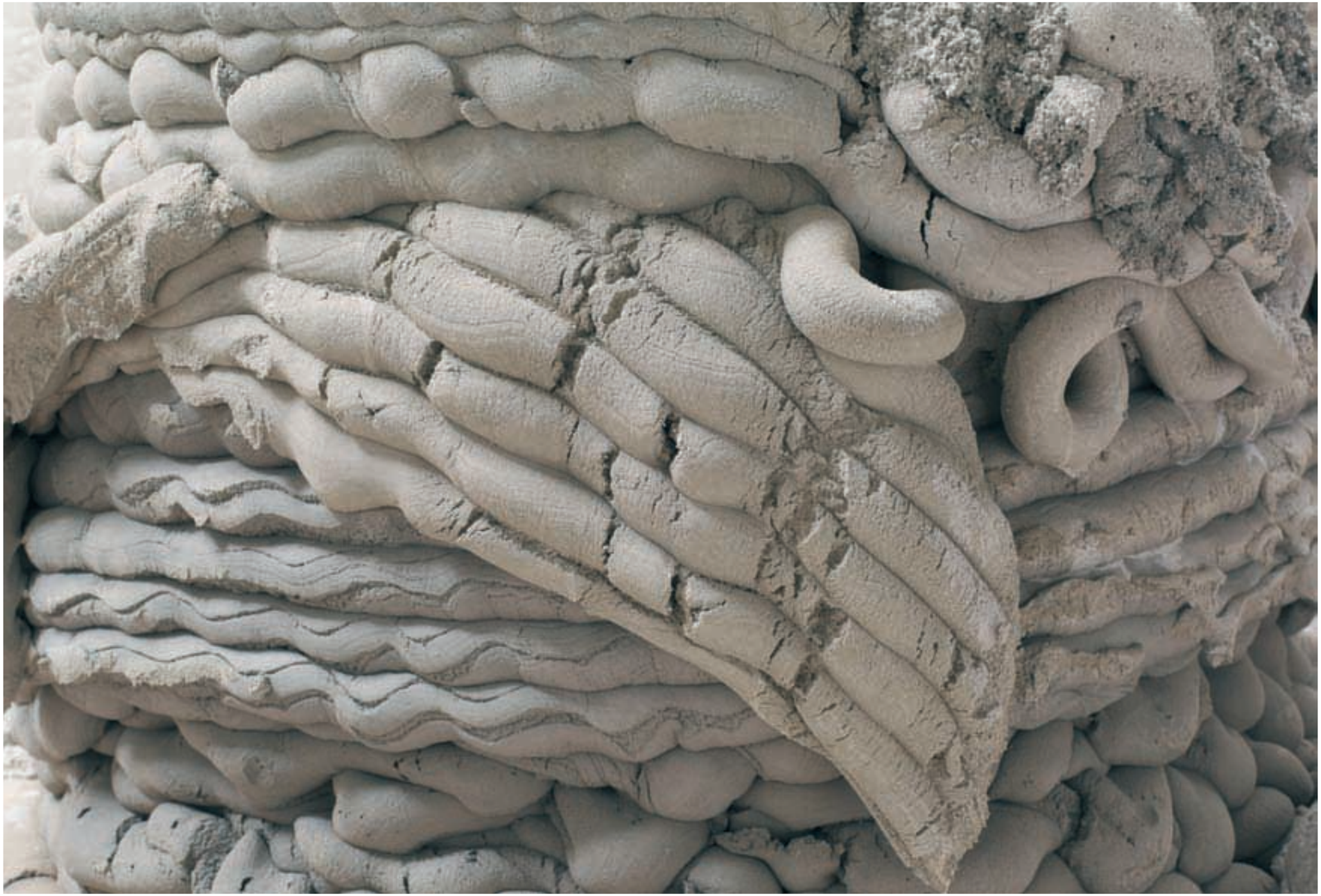


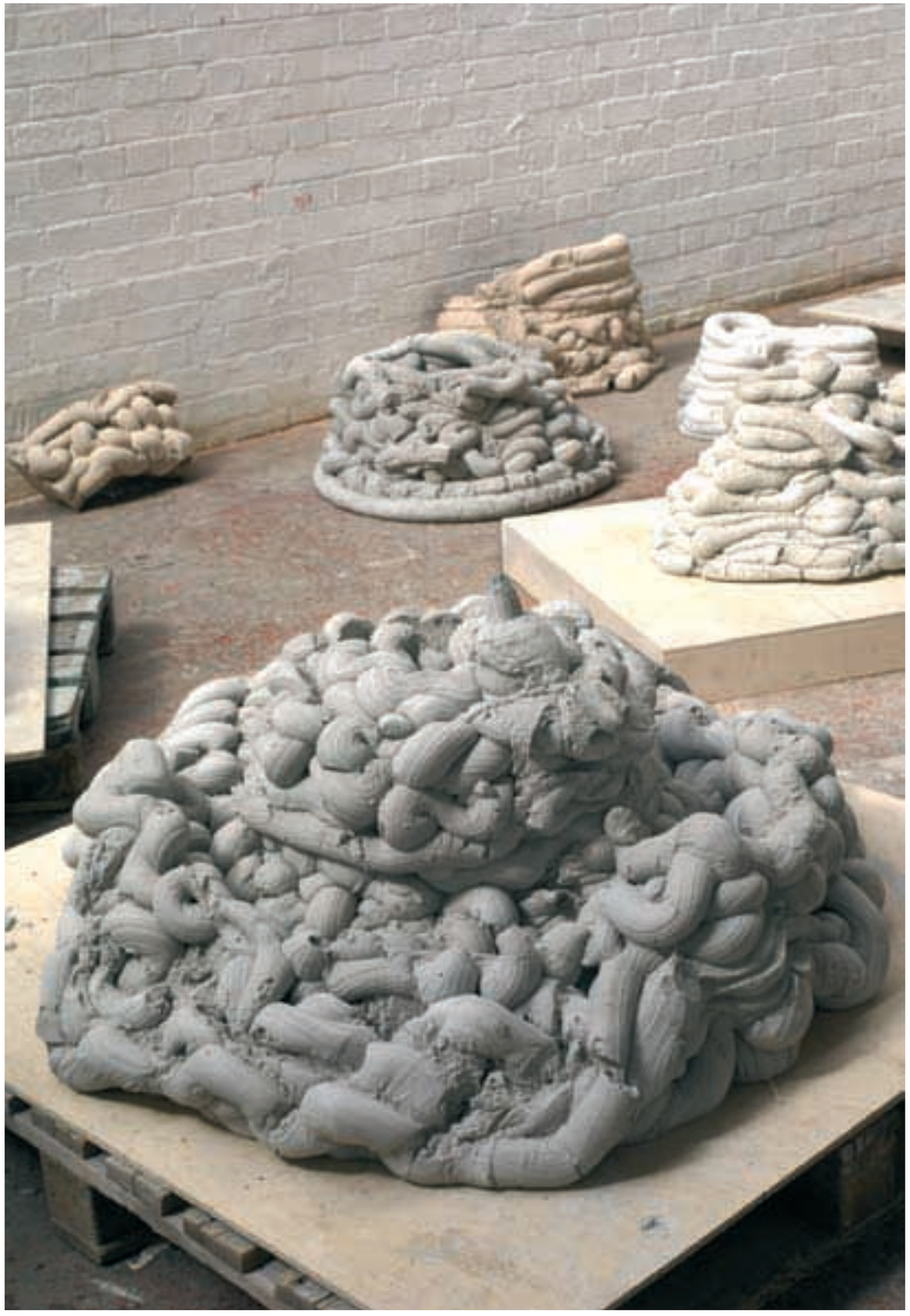












Anish Kapoor using the *Identity Engine* manually to make a corner piece.

SOFT MATTERS

SIMON SCHAFFER

The outputs of the *Identity Engine* are arranged on trestles in families and series, each platform displaying something like the scoured relics of former worlds, matter for an antiquarian archaeologist, perhaps, or even a speculative geologist. There are stratified layers in variably tilted sequences, their depths revealing their age and composition. They are marked often by what geologists call *unconformities*, where layers of sediment have been somehow deposited on lower series of strata, divided by signs of erosion and fragmentation. Such unconformities played vital roles in past stories of the planet's history, notably in the work of the wealthy Scottish entrepreneur and farmer James Hutton, who in 1795 published a theory of the earth which saw it as a kind of cyclical machine, oscillating like a steam engine or an animal between states of waste and repair. With the assistance of his close friend John Clerk, who provided striking images of unconformities along the Scottish borders designed to illustrate Hutton's claims about the sequence of uplift and sedimentation, the vision developed that much of the earth's surface had once been on the ocean floor, its rocks crystallised out from a molten fluid as it slowly cooled. In this eternal, rational, purposive pattern of composition, dissolution and restoration, the enlightened Hutton saw the marks of design and system; that what might seem random, or accidental, was in fact guided by a hidden hand.

The performances of the *Identity Engine* strike a similarly artful balance between design and chance. By oversight, a series of outlandish forms has apparently been left lying, slumped just as they have fallen. Subject to oversight in its opposite sense, they are also surely the outputs of minutely scrutinised rational planning as if painstakingly engineered. It's hard to make complete sense of the unconformities of random design performed by the Engine. Description here seems to demand an end, a sense of dimension. Otherwise, there is the predicament rendered in the infernal world of Flann O'Brien's *The Third Policeman:* "they had another quality that made me watch them wild-eyed, dry-throated and with no breathing. I can make no attempt to describe this quality. It took me hours of thought long afterwards to realise why these objects were astonishing. They lacked an essential property of all known objects. I cannot call it shape or configuration since shapelessness is not what I refer to at all. I can only say these objects, not one of which resembled the other, were of no known dimensions."

Anish Kapoor is concerned with the ways in which different materials make different performances possible. There is a class of materials peculiarly apt for the exploration of these startling and uncanny experiences, substances that shift form under everyday conditions and in mundane surroundings, but in ways that cannot easily be predicted simply by analysing their internal structure: pumice, soap, foam, blood, glue, paint, plastic, wax or concrete. Such soft matters are, very often, food and drink: cappuccino and soufflé, whipped cream and meringue, jelly and mayonnaise. Their component particles organise themselves into arrays such as suds or bubbles, whirlpools or vortices. Then it is just such intermediate and mobile forms that drive soft matter's puzzling behaviours. The Nobel laureate who helped define soft matter's properties, Pierre Gilles de Gennes, once compared its world to a frontier zone between empires, yet not a rigid, fiercely walled and defined boundary of bottlenecks, customs posts and border guards, but rather a labile territory of nomads and vagabonds, constantly shifting its controls and patterns, a provocative region that de Gennes saw as "mobile, diffuse and active". As it clots, coagulates and defecates, this is the ancient world on which the *Identity Engine* feeds.

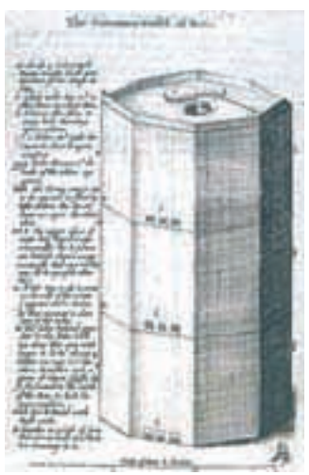
The tradition of breathless astonishment when faced with such dimensionless objects and analysed in the sciences of soft matter has a long history, in philosophy, science, engineering, cookery and art. This history might help set the *Identity Engine* in a story to which it surely belongs, of molten strata, patterned honeycombs and cunning demons. It can, for example, be traced back rather directly to one of the most celebrated of Descartes' *Meditations*, a founding moment in modern notions of perception, matter and form. The furniture of Descartes' seventeenth-century Dutch world included flickering wax candles and polished mirrors, cannon-balls and mechanical pumps, valves and syringes, visionary mechanical schemes and deceptive tricks of the light. These are also, recognisably, the inmates of Anish Kapoor's wonderful bestiary, with its trains and shotguns of reddened wax, its highly wrought reflecting surfaces and coagulated fluids. The artisans of the *Identity Engine* start their work with a printing device deliberately set in a Cartesian matrix. This is how their work defines the boundaries of the space in which the material will play, deform and orient itself. Descartes showed how such problems of geometry could be impressively solved by disposing shapes into so many co-ordinates set along orthogonal axes and transformed by rational algebraic computation. In self-imposed retreat in the Netherlands in the 1630s he also worked out methods he claimed would allow artisans to make lenses and mirrors that reliably brought light to a focus and generated perfect images of the world. He explained from reason the causes of marvels and wonders, a "science of miracles", as he called it, which demystified halos and rainbows, mirages and meteors. He argued that since the world was full of matter and since empty space was a contradiction in terms, the motions of bodies, from magnets to moons, were best to be seen as constrained paths traced through the spinning whirlpools and eddy currents of space.

In 1641 Descartes at last published a set of meditations, a form of spiritual journey designed to show the complete independence of mind from body and the deception to which human senses were inevitably subject. His favoured case, significantly, involved the deeds and sufferings of beeswax. The commonest model of the way the world affects human senses had long been taken from the imprint of a seal on molten wax. We were all, allegedly, stamped with experiences. Print culture was thus the way humans received impressions from the external world. But Descartes took that model to bits. On his table was a piece of wax, "quite fresh, having been but recently taken from the beehive; it has not yet lost the sweetness of the honey it contained; it still retains something of the odour of the flowers from which it was gathered". In order to use this substance for a wax seal with which to close up one of the many letters Descartes wrote, it had to be melted. "Let it be placed near the fire - what remained of the taste exhales, the smell evaporates, the colour changes, its figure is destroyed, its size increases, it becomes liquid, it grows hot, it can hardly be handled, and, although struck upon, it emits no sound. Does the same wax still remain after this change?" Surely it did, even though every single one of its properties had changed. So "this wax was neither the sweetness of honey, the pleasant odour of flowers, the whiteness, the figure, nor the sound". The aim here was to turn attention away from the imprinting of sense impressions and towards the powers of mind in the artful recognition of things in the world. Once afflicted by this habit, even other people might start to look weird. The meditative Descartes gazed out of his window at passers-by. "I do not fail to say that I see the men themselves, just as I say that I see the wax; and yet what do I see from the window beyond hats and cloaks that might cover artificial machines, whose motions might be determined by springs?" The knowledge that these street people were not automata and that this seal was still beeswax seemed to rely on some inner capacity, not on the experience of the world in which humans and other soft matters plied their trade.

Anish Kapoor's *Svayambh* exactly combines these two Cartesian themes of mutable wax and puzzling automata. Red wax mixed with Vaseline mechanically made mobile, it is named from the Sanskrit term for *self-made*. Its frictional wear and tear, and its effects on its milieu, are entirely characteristic of soft matter's performances. This is an object made such that it makes its surroundings. Like the *Identity Engine*, it is therefore a device – it is simultaneously a significant emblem and an ingenious machine. In the world of idols and icons, such devices were often treated as artefacts, entities made by another's hand yet worthy of affection because somehow self-sustaining. These automata mimicked life so well they could be treated as autonomous beings. Descartes and his

contemporaries were entirely familiar with machines worked by springs and pumps that moved, spoke, played music, or wrote. It was even reported by some that in his travels Descartes was always accompanied by a mechanical doll he named after his daughter. The machine was supposedly thrown overboard by a horrified Dutch sea captain. It was designed to show that animals were but machines. "Doubtless when the swallows come in spring, they operate like clocks," he wrote. "The actions of honey bees are of the same nature."

There were thus many telling connexions between soft matter, animal intelligence and automatic machinery. The mythic artist and engineer Daedalus had fabulously built ingenious machines including, so it was said, folding chairs and steam baths, as well as automata that seemed entirely life-like, if not divinely inspired. He notoriously used beeswax to seal the wings that were to carry him and, somewhat less successfully, his son Icarus, in their aerial escape from Crete. He manufactured a golden honeycomb so realistic it could scarcely be distinguished from the work of bees. Classical engineers' works imitated those of insects while the insects were seen as ideal engineers. This long remained a world in which many fables of the bees were recounted to teach lessons about the way the universe was ordered and how human bodies should be organised. Wax was long the material of choice for anatomical models, especially of women, where soft matter seemed most apt as substrate and the female proverbially sensitive to the impress of sense on this yielding substance.



Samuel Hartlib, *The Reformed Common-Wealth of Bees*, London, 1655. Sir Christopher Wren's first published design for a three-storey glass beehive.

Philosophers and experimenters meditated often on the ways of the hives from which they gathered wax and honey. In the mid-seventeenth century, glass hives were built so that bees' behaviour and the amazing structures they built could be studied directly. Preachers delivered sermons on "the discipline of bees and the rare fabric of honeycombs". Christopher Wren's very first published architectural image (made in 1655) displayed a tower-block beehive three stories high well designed to let keepers watch the ideal commonwealth at work. Though bees had long been lauded for their subjection to a monarch, in this revolutionary epoch it was their mutual co-operation and shared natural virtue that seemed more apt. Under the rule of Oliver Cromwell,

books appeared with titles such as *The Reformed Common-Wealth of Bees* and *The Theatre of Political Flying-Insects.*

Amongst bees' most salient skills was their ability at calculation. This was a republic whose citizens could do sums and build temples. The social insects possessed "the greatest knowledge of geometry", able to design and construct hexagonal cells of such perfection that their angles barely differed from the ideal size calculated by mathematicians. Descartes had reckoned animals were automata. It was puzzling to see how such machines, devoid of reason and programmed to fulfil their allotted tasks, achieved such marvels of mathematical and architectural sophistication. Similarly wild-eyed, dry-throated amazement was evident in the reports on termite mounds sent back to the Royal Society of London in the late eighteenth century from the slave stations of west Africa by the traveller Henry Smeathman, who saw in these amazing structures clear evidence of design, and a model for human ambition and liberation. "The immensity of their work sets the boasted magnitude of the ancient wonders of the

world in a most diminutive point of view, and gives a specimen of industry and enterprise as much beyond the pride and ambition of men as St Paul's Cathedral exceeds an Indian hut." Not all reformers were so convinced that insects manipulating mud and wax were the evident superiors of human design. "The spider conducts operations that resemble those of a weaver, and a bee puts to shame many an architect in the construction of her cells. But what distinguishes the worst architect from the best of bees is this, that the architect raises his structure in imagination before he erects it in reality." So Karl Marx wrote of the labour process in *Capital*. This is the provocation of the *Identity Engine's* constrained random walk. In producing such complex forms, what is the relation between the mechanical play of forces and the device as work of art?

Marx's contemporary Charles Darwin also had to face this problem of the origin of form quite directly. Honeycombs were the most celebrated example of design in nature. Hive bees' "inimitable architectural powers", so he argued in *On the Origin of Species*, involved "the most wonderful of all known instincts". He worked for years gathering data from his correspondents and watching bees at first hand to understand the gradual evolutionary steps through which the instincts that drove solitary bumble bees to make roughly rounded wax cells to stash honey, eventually prompted the sophisticated and sociable hive bees to engineer their magnificently precise hexagonal combs with ends shaped like rhomboid pyramids. "I have come to heavy grief about my bee cells," he told his son, reporting that he'd started work with a carefully designed observation hive.

Some of his correspondents shared more homely illustrations of how such geometrical structures could be formed by blind forces. A friendly architect, expert designer of London's fire stations, told Darwin that he'd just eaten a perfectly spherical plum pudding with the fruit so precisely aligned and the crust so justly thin and tenacious that "the plums laid the foundation without any instinctive knowledge of a series of regular hexagonal combs". A north London journalist and keen beekeeper taught Darwin how to track insects at work on crude wax blocks inserted in the hive, then to stain the wax with red dye, so as to watch the soft matter diffuse unevenly through the cells. In *On the Origin of Species* the great naturalist reported how the bees spread the red wax around "as delicately as a painter could have done with his brush". "The work of construction seems to be a sort of balance struck between many bees," their adaptive instincts prompting them to "stand on opposite sides and push and bend the ductile and warm wax (which as I have tried is easily done)," all in order to produce an architecture in which the maximum volume was built using the least amount of wax.

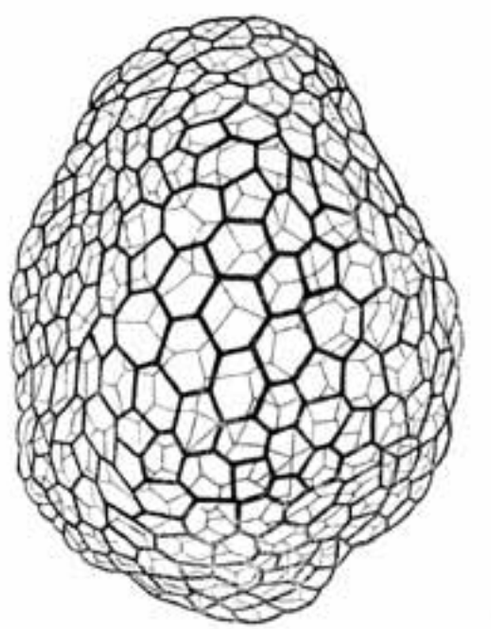


Fig. 220. "Reticulum plasmatique." (After Carnoy.)

D'Arcy W Thompson, *On Growth and Form*, Cambridge, 1917

Many thought this nonsense. One devout Cambridge mathematician had a ready explanation of the hexagonal form and perfect angles of the cells, attributing them entirely to the fact that bees have three eyes. In 1917 the brilliant Scottish mathematician, classicist and biologist D'Arcy Wentworth Thompson was even more severe. He reckoned it "certain" that "the beautiful regularity of the bee's architecture is due to some automatic play of the physical forces", and that it was "fantastic to assume that the bee intentionally seeks for a method of economizing wax". He mocked Darwin's artful insect-masons, pushing and shoving their red-stained wax till desirable perfection was reached. Warm wax is soft matter, he argued, acting under the same surface forces that guide soap bubbles and viscous fluids. There was no need to appeal to animal instinct nor to evolutionary adaptation to explain the geometry of the honeycomb nor the architecture of froth and foam.

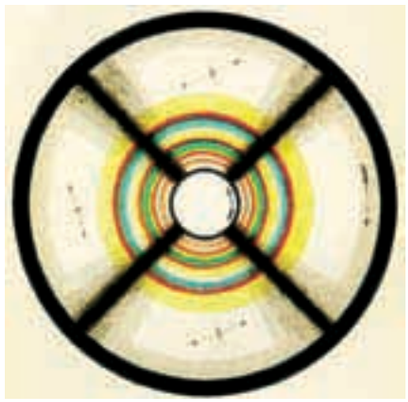
D'Arcy Thompson's arguments against Darwin's biology depended on a scientific and aesthetic appreciation of the powers of soft matter. When he turned his microscope on the host of radiolaria, remarkable animal plankton celebrated through the stunning images produced by the great German biologist Ernst Haeckel as evidence of nature's arts, Thompson at once saw the precise analogy of form with the complex bubbles easily manufactured by dipping wire frameworks into soap solutions. "A very beautiful series of forms may be made by introducing successive bubbles within the film system." Hosts of organisms took on forms dictated not by purpose and instinct but, so he claimed, by the beautiful principles of short-range forces that governed soft matter's dispositions. These forms grew not through adaptation nor through utility

but through the tolerances of dynamics. Victorian scientists were passionate about these dynamics and devoted enormous attention to the behaviour of froth, foam, bubbles and vortices, convinced that here lay clues to the constitution of matter and life. Thus Thompson's colleague, the eminent Cambridge biologist William Bateson, plant breeder and geneticist, explained hereditary mechanisms by helping himself to the best local physics of vortex atoms, stable structures in a space-filling ethereal fluid. "A living thing is not matter," Bateson claimed. "It is a system vortex, through which matter is passing. If you watch an eddy run along the dust, or through water, you will see a system."

Bateson's sources for these views of the patterns of eddies, mud and water in living beings included eminent physicists such as the genial Scottish natural philosopher James Clerk Maxwell, who wrote lovingly of the "poetry of bubbles" and the movement of vortices and smoke rings. This was a culture that mixed graphic imagery and the reasons of the engineers. Maxwell himself was a kinsman of the same John Clerk who so skilfully drew Hutton's stratigraphic unconformities. They were trained to think in terms of the physics of molten wax, calf's foot jelly or rubber bands, then extended this behaviour to Creation. Analogy and metaphor was a favoured tactic. In clouds of steam and gas, they argued, particles must constantly collide, so it was impossible to follow each of their paths and no exact account of an individual track was possible. Maxwell recalled that beekeepers marked their own bees by "throwing handfuls of flour at the swarm". Imagine that only the bottom half of the swarm had been whitened. After a time, the white bees would be equally distributed throughout the swarm. This would happen not because of the flour, but because of the bees' irregular flight. And in general natural processes worked like that, turning order into disorder, spreading a marked group throughout the swarm of molecules. Of course molecules could not quite be marked, but there were processes that allowed them to be followed around. Maxwell compared Saturn's rings, which he claimed were composed of such an array of particles, with the

air round Sebastopol during a ferocious cannon bombardment. He decided to "abstain from asking the molecules where they last started from, avoiding all personal enquiries which would only get me into trouble".

So the idea was to study molecules statistically as vast populations, not individually as agents with biographies and characters. The approach paid rich dividends but also generated a big puzzle. His colleagues had shown that in any closed system the amount of available, useful, energy would tend to dissipate. This was the principle of entropy, the tendency of sealed systems to lose order in time. Maxwell now realised that this principle had the same "degree of truth as the statement that if you throw a tumblerful of water into the sea, you cannot get the same tumblerful of water out again". But imagine a "very intelligent and neat-fingered being" stationed at a door between two compartments containing equal numbers of particles. Imagine that this being could do what humans couldn't, "not being clever enough": it could follow each molecule around. If this being let quicker particles into one compartment and an equal number of slower ones into the other, the two zones would end up at different temperatures without any work being done and entropy would have decreased. One Glasgow professor called Maxwell's being a "demon", Maxwell himself thinking of it rather as a humble railway pointsman. He mocked physicists who tried vainly to turn the statistics of entropy into a dynamical theorem, labelling one who attempted the task as an Icarus "flapping his waxen wings in cloud cuckoo land". He pointed out that the world was full of causal but incalculable events, "singular points", as Maxwell called them, that set severe limits to the predictability of the universe and left a space for tolerance and free will in a world of system and law. "Both Moral and Intellectual Entropy are Noble Subjects." An entire research programme in these problems of morphogenesis, the spontaneous emergence of form, was canvassed just after the Second World War by Thompson's admirer the brilliant mathematician Alan Turing, otherwise famous for his wartime computer engineering and startling analysis of the ways in which machine intelligence might develop.



The Life of James Clerk Maxwell,
Campbell and Garnett,
London, 1882.
Diagram showing the colours revealed in a polarimeter by a plate of gelatin when exposed to a torsional shear.

Pierre de Gennes had a rather moving image for these startling moments of sudden transition in the slippages of soft matter: "when I was a child, I was taught some English, in a book called *The Wind in the Willows*. Thus I like to describe the situation by saying that if the wind is mild, the willows are not too perturbed, but if the wind is strong, the willows bend."

To claim that there is order and purpose within a system where there's none is to suffer from a kind of paranoid delusion. This was rather the point of D'Arcy Thompson's artful criticism of natural selection. No evolved instincts nor special purposes were needed to explain the wonderful beauties and intimate forms found in much of nature, from cells to snowflakes. There's a hard word that names this kind of delusion: *apophenia*, a fifty-year-old term for the tendency to see patterns in meaningless data. But sometimes the patterns are real, though hard to make out out. To recover or generate order and form from more chaotic and randomly distributed material is perhaps the role of an artist of soft matter, the cunning pointsman of Maxwell's fable engaged in constant battle against *entropy*. The *Identity Engine* is this kind of device. A hybrid of Cartesian oversight and ingenious manipulation, its performances rely on the balance of constraint and chance that help produce its slumps, slips and strata. Such a notion, Maxwell once explained, "would not occur to a being who could not turn any of the energies of nature to his own account, or to one who could trace the motion of every molecule and seize it at the right moment." It is just because Anish Kapoor's artistry and the Engine's artisans can exploit some of its energies, but cannot quite follow nor seize its every slippery movement, that it can so movingly generate its endless forms.

Sources

Yve-Alain Bois and Rosalind Krauss, *Formless: A User's Guide* (New York, 1997)

Bruce Clarke, *Energy Forms: Allegory and Science in the Era of Classical Thermodynamics* (Ann Arbor, 2001)

Rainer Crone and Alexandra von Stosch, *Anish Kapoor: To Darkness: Svayambh* (Munich, 2008)

Lucia Dacome, "Women, wax and anatomy in the century of things", *Renaissance studies 21* (2007)

Lorraine Daston (ed.), *Things That Talk: Object Lessons from Art and Science* (New York, 2004)

Sarah Davis, "Darwin, Tegetmeier and the bees", *Studies in History and Philosophy of Biological and Biomedical Sciences 35* (2004)

Margreta de Grazia, "Imprints: Shakespeare, Gutenberg and Descartes", in Terence Hawkes (ed.), *Alternative Shakespeares 2* (London, 1996)

Starr Douglas and Felix Driver, "Imagining the Tropical Colony: Henry Smeathman and the Termites of Sierra Leone", in Felix Driver and Luciana Martins (eds.), *Tropical Visions in an Age of Empire* (Chicago, 2005)

Stephen Gaukroger, *Descartes: an Intellectual Biography* (Oxford, 1995)

Pierre Gilles de Gennes, *Soft Interfaces* (Cambridge, 1994)

Adrian Johns, "The Identity Engine: Printing and Publishing at the Beginning of the Knowledge Economy", in Lissa Roberts, Simon Schaffer and Peter Dear (eds.), *The Mindful Hand: Inquiry and Invention from the Late Renaissance to Early Industrialisation* (Amsterdam, 2007)

Anish Kapoor, with essays by Homi K. Bhabha and Pier Luigi Tazzi (Berkeley and Los Angeles, 1998)

Bruno Latour and Peter Weibel (eds.), *Iconoclash: Beyond the Image Wars in Science, Religion and Art* (Cambridge, Mass., 2002)

Sidney Perkovitz, *Universal Foam: From Cappuccino to Cosmos* (London, 2001)

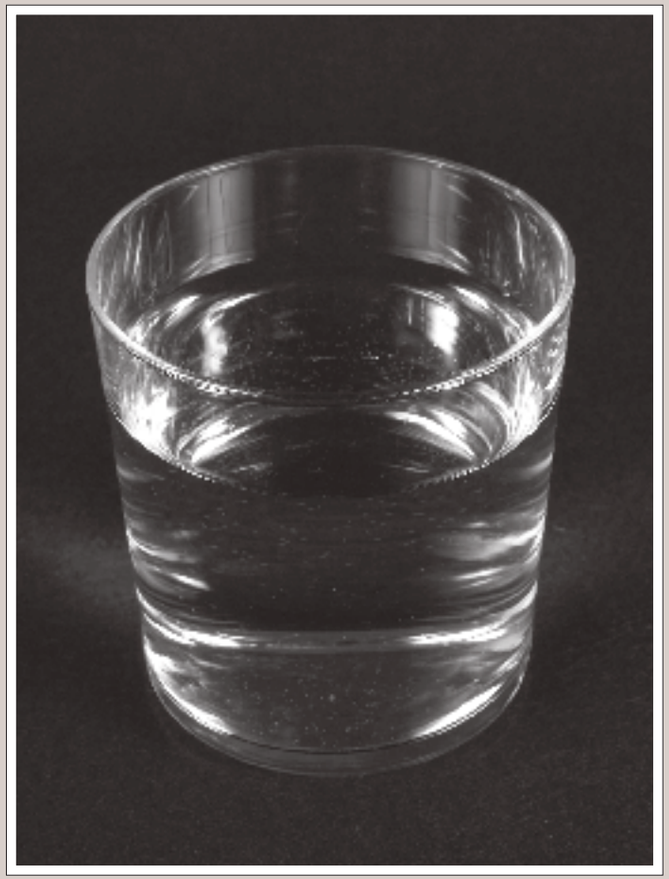
Timothy Raylor, "Samuel Hartlib and the Commonwealth of Bees", in Michael Leslie and Timothy Raylor (eds.), *Culture and cultivation in early modern England* (Leicester, 1992)

Martin Rudwick, *Bursting the Limits of Time: the Reconstruction of Geohistory in the Age of Revolution* (Chicago, 2005)

Crosbie Smith, *The Science of Energy: A Cultural History of Energy Physics in Victorian Britain* (London, 1998)

D'Arcy Wentworth Thompson, *On Growth and Form* (Cambridge, 1917)

Like energy, entropy is in the first instance a measure of something that happens when one state is transformed into another.



But I think nevertheless, we do not feel altogether comfortable at being forced to say that the crystal is the seat of greater disorder than the parent liquid.

P.W. Bridgman,
The Nature Of Thermodynamics

APOPHENIC APPENDIX

PICTIC BALLS
3000BC
PLATONIC SOLIDS CARVED IN STONE

AN1927.2727 KINCARDINESHIRE, SCOTLAND
AN1927.2728 MARNOCH, ABERDEENSHIRE
AN1927.2729 AUCHTERLESS, SCOTLAND
AN1927.2730 ABERDEEN CITY (NEAR), SCOTLAND
AN1927.2731 FYVIE, SCOTLAND

Mathematical objects are perverse. Their shapes seem passively moulded by the forces impressed on them. Yet surely they also help give pattern to their surroundings. It has often been supposed that the basic building blocks of the cosmos must display mathematical order as though the world itself could be made up of numbers and geometries. Plato is associated with the claim that the five perfect solids, with each side exactly the same size and shape, stood for the five elements of which the world is made.

These granite forms, from well documented Scottish archaeological sites, represent Platonic solids. They are about five thousand years old, so twice as ancient as Plato. Carving granite without iron tools presents a serious physical challenge. Positioning and carving points on a sphere requires an intellectual agility. The two things together represent a triumph of the human mind.

They are mathematical constructions of spectacular beauty. But are they a human projection onto the world or the results of an understanding of that world cleaned of its dross? Instead of seeing the contents of the world as irreducible building blocks, see how such forms give the world the manifold and fluid shapes it has. In the twenty-first century this atomic view is giving way to more complex field theories as exponentially increasing computing power assists and reformats perceptions of mathematical beauty.

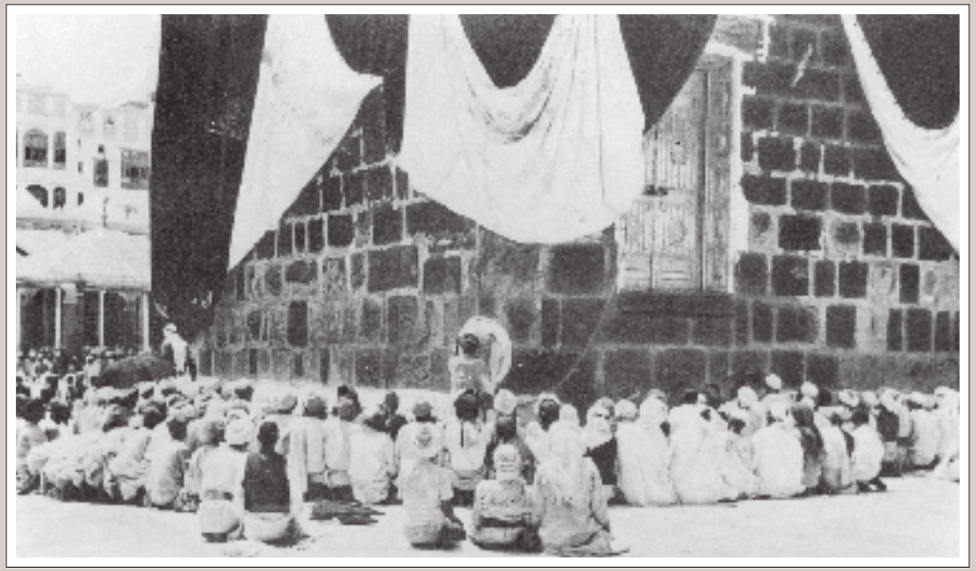
In his book *The Lightness of Being: Mass, Ether and the Unification of Forces* the Nobel prize-winning physicist Frank Wilczek writes: “Through patchy clouds, off in the distance, we seem to be able to glimpse a mathematical Paradise, where the elements that build reality shed their dross. Correcting for the distortions of our everyday vision, we create in our minds a vision of what they might be: pure and ideal, symmetric, equal and perfect.”

METEOR ON THE EASTERN CORNER OF THE KAA'BA, MECCA

DIMENSIONS OF THE KAA'BA 13.10M BY 11.03M BY 12.86M
ORIGINAL DIMENSIONS OF THE METEOR: ABOUT 30 CMS IN DIAMETER

The Kaa'ba in Mecca stands at the holiest centre of Islam. At its eastern corner, set into a silver surround, is a black meteor. Now hollowed by repeated touch, this obsidian-like stone was formed into a spherical shape as it hurtled through space. A magical object of mathematical purity untouched by human hands, the *al-hajar-ul-aswad* was broken into a number of pieces in the Middle Ages before being re-united and set into its silver mount. It is believed to be a meteor that fell to earth at the time of Adam and Eve, and tradition has it that the rock was once snowy white, and has darkened over time through exposure to human sin. The English traveller Richard Burton, disguised as a pilgrim, took the *haj* to Mecca in 1853 and touched the stone: he judged it a meteorite, a mix of nickel and iron, slowly tarnished not by sin but by contact. He also noted the coloured concrete mortar in which it was fixed; and remarked on past attacks on the stone by iconoclasts, who banned any devotion to objects made by humans. The stone, however, was surely no artefact.

The East was long seen by westerners as a source of the sacred, the curative, the exotic and the powerful. Arabia and Eden, India and Cathay, were taken to be sources both of spices and jewels, and of the stones and balms that could turn dross to gold and death to life. For some alchemists, these were the substances that could under artful manipulation redeem the fallen state of humanity. The link between Renaissance passion about the spice islands and Iberian voyages to the new world was closely tangled with these tales of Eastern salvation through charismatic objects of fluid, indeterminate, and malleable form. It was claimed that Adam's tears were the real source of the precious spices and strangely shaped stones that now healed and comforted his descendants. There were tales, too, of the elixir passed on to the faithful by the Virgin from the place where she rested on her flight into Egypt. A vital sign of such objects' power was their strange, often inchoate, shape – as though the powers of nature were best locked up in entities hard to describe, impossible to map and difficult to obtain.



The eastern corner of the Kaa'ba in Mecca, silver gelatine print from the collection of Robert Shapazian.

Anonymous, pencil drawing of the meteor, now heavily eroded by human touch, in its silver mount.

HELICAL COLUMN
FROM THE CHURCH OF SAINT LAZARE, AVALLON
FACSIMILE IN THE PALAIS DE CHAILLOT, PARIS

The Eglise de Saint Lazarre in Avallon dates from the twelfth century. It was built on the site of an earlier church dedicated to Notre Dame; its re-dedication to Saint Lazare (Lazarus) was prompted by the acquisition of a relic of the saint, identified firmly as the brother of Mary Magdalene by the thirteenth century "Golden Legend", but possibly considered as such as early as the third century. Huge numbers of pilgrims flocked to the site in the medieval period, in order to witness the fragment of Saint Lazare's skull which was believed to have the power to fend off leprosy.

The Church has a Romanesque facade carved with signs of the zodiac and musicians of the apocalypse. This carved column is a tour de force of conceptual and practical skill and a reflection of the complexity of the medieval mind. Helical columns twisted into sacred forms were linked by tradition with the original structure of the most ancient temples, such as the Temple of Solomon itself. The pair of columns which it was said stood before the Temple were understood by Freemasons as symbols of sacred power in radical contrast to the orders of classical design. The great Baroque architect and businessman Johann Fischer von Erlach, responsible for the introduction of a couple of early eighteenth-century British obsessions, freemasonry and steam engines, into the Austrian empire, designed such spiralling columns for his remarkable Karlskirche in Vienna, built between 1715 and 1737 to commemorate an epidemic of bubonic plague that ravaged the city.

Photograph by Lara Baladi

Crick and Watson's DNA molecular model, 1953
The Science Museum, London. Science and Society Picture Library

Right: Turned ivory object, 16th or 17th century, in the Axel Vervoordt Collection
Photograph by Laziz Hamani

JUSTO GALLEGO'S CATHEDRAL

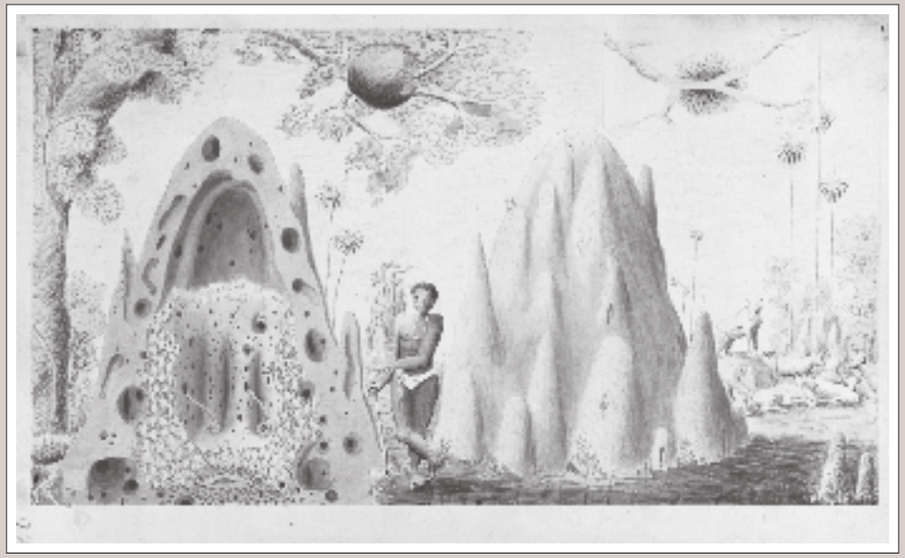
MEJORADA DEL CAMPO, MADRID
1960'S - PRESENT

About 45 years ago Justo Gallego began work on the construction of a cathedral on a plot of land he owned in Mejorada del Campo, near Madrid. Justo has no formal training in either architecture or engineering. Without permission from either the church or the local authorities and without any financial support he has worked on this epic undertaking single-handed for all of this time. The dome, built without cranes or heavy lifting gear, is 30 metres above the floor. The columns that rise at each corner under the dome are made of cast concrete using old olive oil containers as the moulds. The use of materials, — donated, re-cycled or rejected — has resulted in many lateral and exceedingly creative innovations. The bricks, from local brick factories, often deformed as a result of over-firing, give the walls an illusion of fluidity.

While Justo works from divine inspiration, generating his own iconographic and organic architectural style, mainstream European architecture is also embracing fluid forms as a direct consequence of the possibilities offered by computer aided design (CAD) coupled with a revolution in material technologies and an emphasis on intelligent eco-friendly buildings. In a computer-designed world the next logical step is to move straight from the digital models to 3D printed buildings.

In the past few years Justo has become a reluctant celebrity. He receives several thousand visitors a week who wonder at both his faith and the scale of his achievement. Their donations, both in kind and money, have accelerated the construction work.

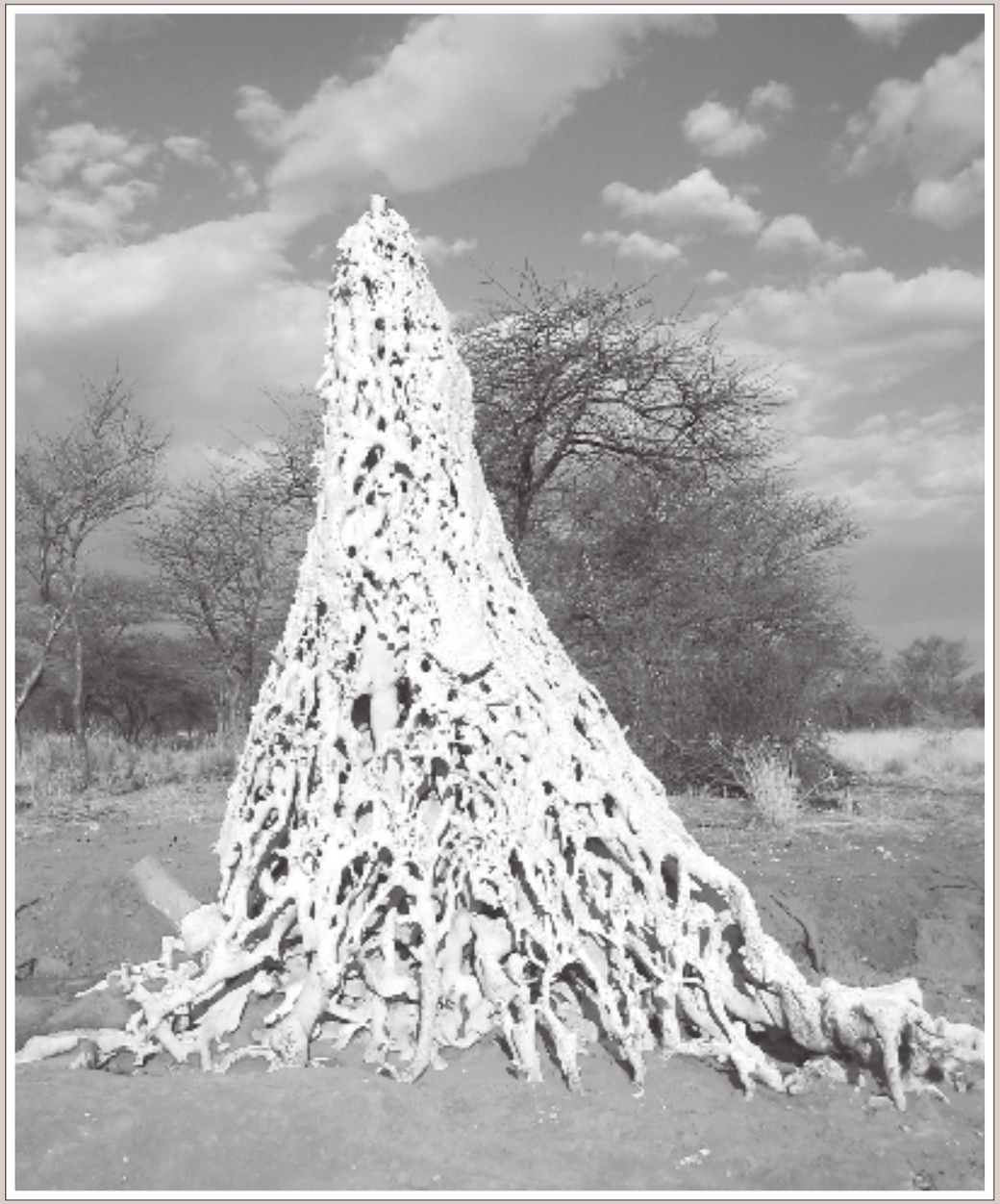
Photograph by Jane Cameron



HENRY SMEATHMAN
SOME ACCOUNT OF THE TERMITES...
LONDON
1781

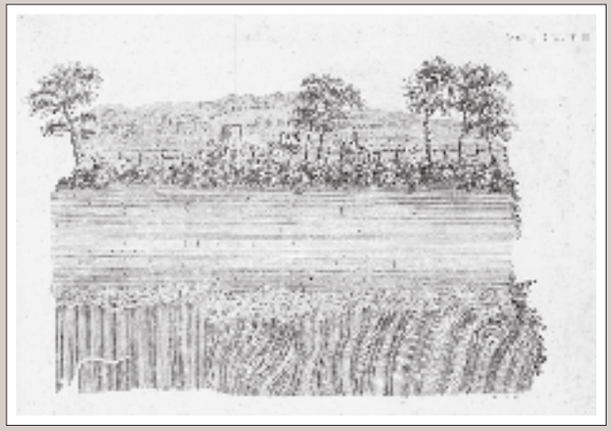
Termites have long been vital agents in tropical ecology and attracted the interest of Europeans, such as the travelling virtuoso Joseph Banks, the moment they saw them. One of the very first printed accounts of tropical termites was sent to Banks by the Yorkshire naturalist, elocutionist and enthusiastic balloonist Henry Smeathman, who worked in British slave colonies in west Africa in the 1770s, earning himself a local wife and the nickname of "Flycatcher". His detailed studies of the architecture of termite mounds and rapturous images of "the good order of their subterraneous cities, as most closely imitating mankind in provident industry and regular government" won him praise as the Father of Termitology. What might seem "a shapeless lump of clay", Smeathman showed, was in reality an orderly system of magazines and nurseries, turrets and courts. This good order in an Africa that many Europeans dismissed as chaotic helped convince him that Sierra Leone could become a successful colony for freed slaves and a means to salvage hope and spirit from the terrors of the Middle Passage.

Top: Termite hills in Sierra Leone, original illustration for the paper *Some Account of the Termites...* by Henry Smeathman, 1781
The Royal Society, London



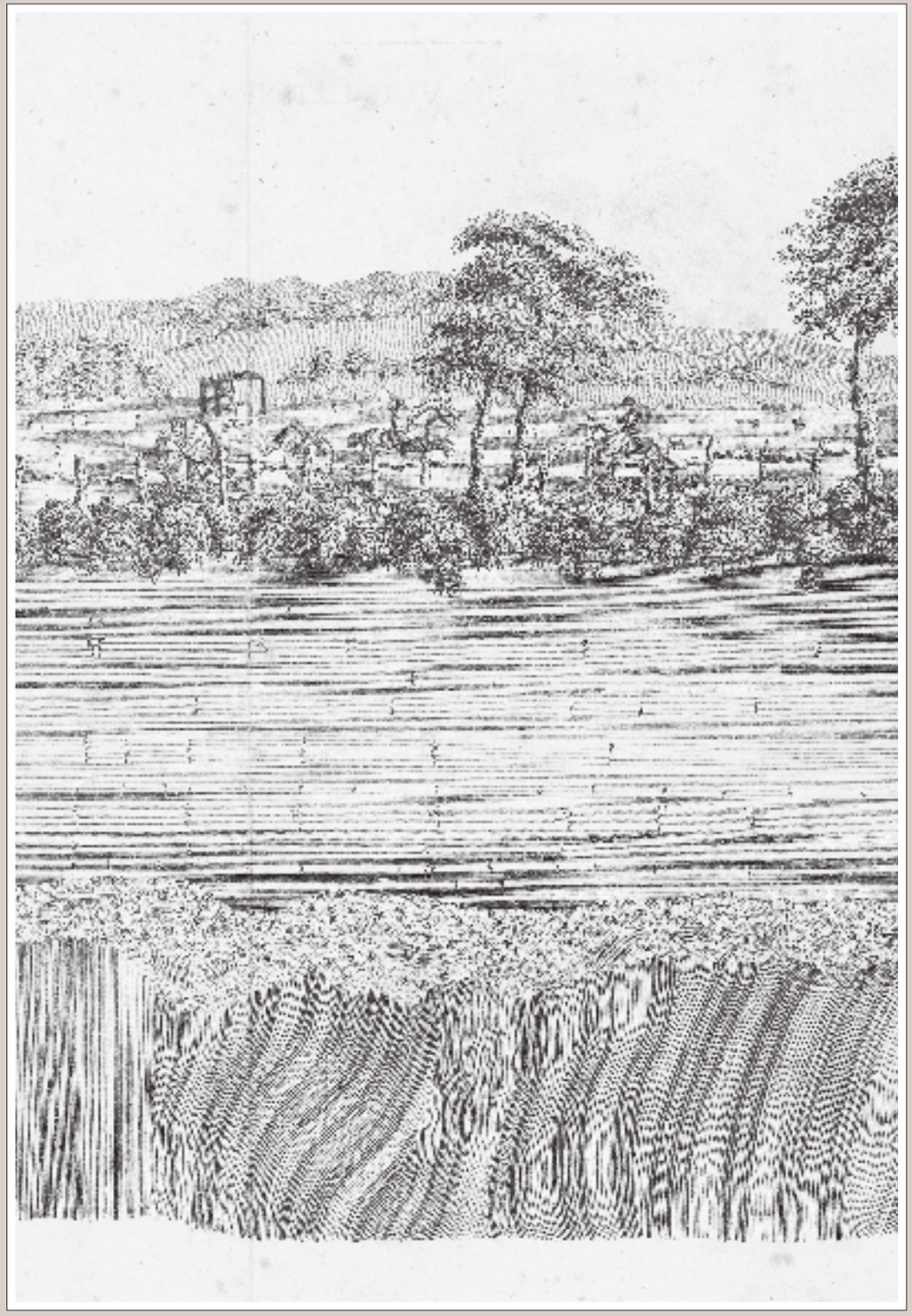
Photograph by Rupert Soar

A macro-termite mound in Namibia.
These particular mounds have a single spire leaning northwards as the termites build towards the sun, which is rarely overhead during the wet season when building activity is at its peak. To reveal the myriad internal channels and ducts, a mound was first filled with plaster of paris, allowed to harden, and the mound mud washed away carefully. Doctors Rupert Soar, Eugene Marais and Professor J Scott Turner of The Termes Trust Namibia have now proved that not only is the structure seen as complex as the branching channels and ducts in our own lungs, but, incredibly, it functions in the same way as a true respiratory system (three phase tidal flow and penduluft enhanced diffusion). Instead of muscles to drive respiration in air breathing animals, the termites construct the mounds to resonate at specific frequencies which set up the "breathing" phenomenon.



JAMES HUTTON
THEORY OF THE EARTH WITH PROOFS AND ILLUSTRATIONS
THE JEDBURGH UNCONFORMITY FROM AN ENGRAVING BY JOHN CLERK
EDINBURGH
1795

This planet writes some of its most important history through long sequences of layers of sedimented rocks. Where two sets of layers meet, one upon the other, geologists find *unconformities*. Debris from a lower, presumably older, set of layers deposited in one direction divides them from higher, more recent, strata laid in a different direction. In 1787-1788 the wealthy Scottish farmer James Hutton searched for these junctions between sets of layers to prove his theory that the Earth had seen eternal cycles oscillating between periods when strata were laid down in ancient sea beds and periods when inner heat and pressure had forced them upwards and changed their direction. Along the Scottish borders and the Berwickshire coast, he found the unconformities he needed: one deep set of layers set at an angle and divided by rubble from more recent layers. In the striking relation between orderly patterns of layered deposit and epochs of chaotic uplift and disturbance he read lessons of the immense past of the Earth. According to one of his travel companions, who sailed with Hutton along the coast seeking unconformities and found signs of "that immeasurable force which has burst asunder the solid pavement of the globe, the mind seemed to grow giddy by looking so far into the abyss of time."



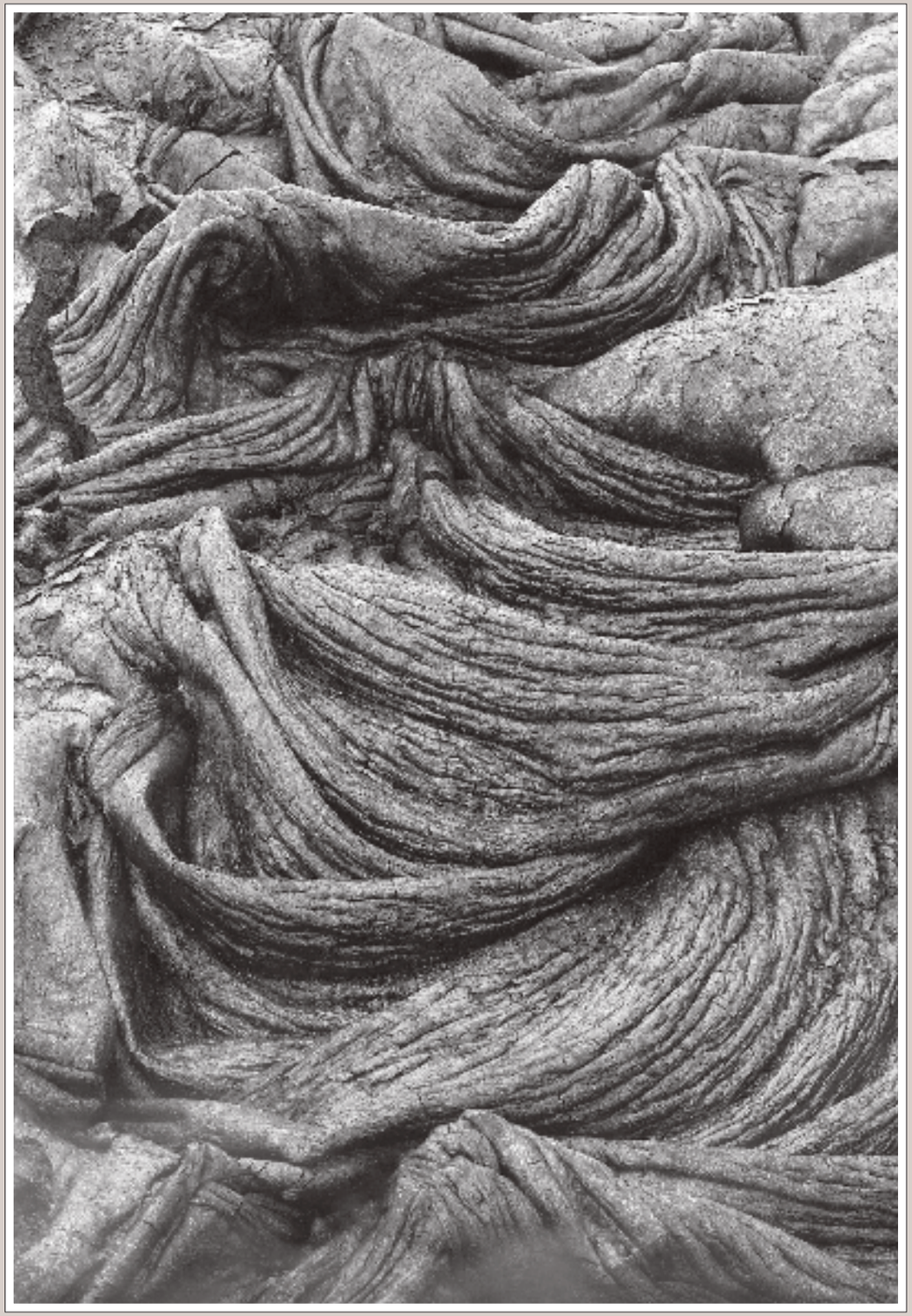
ALOIS AUER
THE POLYGRAPHIC APPARATUS
PRINTING PROCESSES PATENTED BY
THE STATE PRINTING WORKS
VIENNA
1853

Alois Auer patented a number of printing processes during his time as director of the State Printing works in Vienna. These patents, based on subtle mediation and control over the physical properties of the materials he was working with, played an important role in the explosion of photomechanical reproduction that took place in the mid-ninteenth century. One of the most innovative processes he patented was nature printing, and its close relative mineralographie. In both of these processes a physical specimen is transformed using lead and galvanisation into a printing plate. In the case of mineralographie one type of direct impression is mediated to produce another.

Fossils are shadow imprints of former life from deep time. They are rocky negatives of the positive organic structures of past worlds. But Philip Gosse, son of a Worcester lady's maid, expert naturalist of Canada and Jamaica, promoter of the Victorian aquarium craze and authority on butterfly genitalia, argued that fossils and tree rings had been ingeniously placed in creation by the divine Creator. Writing just before Darwin's *On the Origin of Species*, Gosse urged that such marks of development and growth, of immemorially ancient life, were no evidence for a very ancient world. Rather, they were signs of the match between divine intelligence and the reasons of emergent form. God left His creation full of the marks of the processes now in action around us, even if He'd not used these processes to make our world. The best such signs were the spiral and convoluted structures of fossils, their complex patterns testimony to the benevolent ingenuity of all powerful wisdom.

Coprolites, literally “dung stones”, are fossilised animal faeces. Large quantities were found in Cambridge and Suffolk in the nineteenth century. Cambridge University benefited from many donations from private fortunes made from Coprolite mining. Fisons opened a factory in Ipswich to turn the fossilised dung into fertiliser. During the First World War the factory was reopened to provide phosphates for munitions.
Natural History Museum, London

Right: Intricate designs formed in cooled lava are scattered throughout the lava fields of Hawaii Volcanoes National Park.
Photograph by Mark Philbrick, Brigham Young University

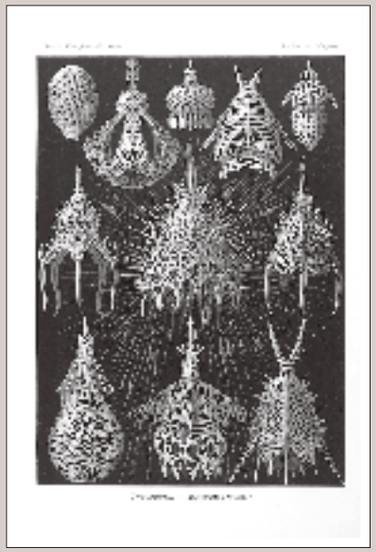


ROBERT SMITHSON
ASPHALT RUNDOWN
ROME, ITALY
OCTOBER, 1969

In 1969 Robert Smithson carried out three entropic site-specific pours. The first was *Asphalt Rundown* in Rome. This was followed by *Concrete Pour* in Chicago and *Glue Pour* in Vancouver. For Smithson the intellectual challenge of entropy concerned time and space and was essentially non-visual. He became a kind of experimental geologist, using the terraforming techniques pioneered by Enlightenment landscape gardeners, such as William Kent or Capability Brown, to reproduce the phenomena of crustal movements first described by James Hutton and Charles Lyell.

The following year he completed *Spiral Jetty*, a work that has become immortalised by the aerial photographs of the landform built in the shallow waters of Utah's Great Salt Lake. This bird's eye view of the work presents "a journalistic gestalt" of the object - not the object itself. The documentation he preferred was a 32 minute film, about which he wrote:

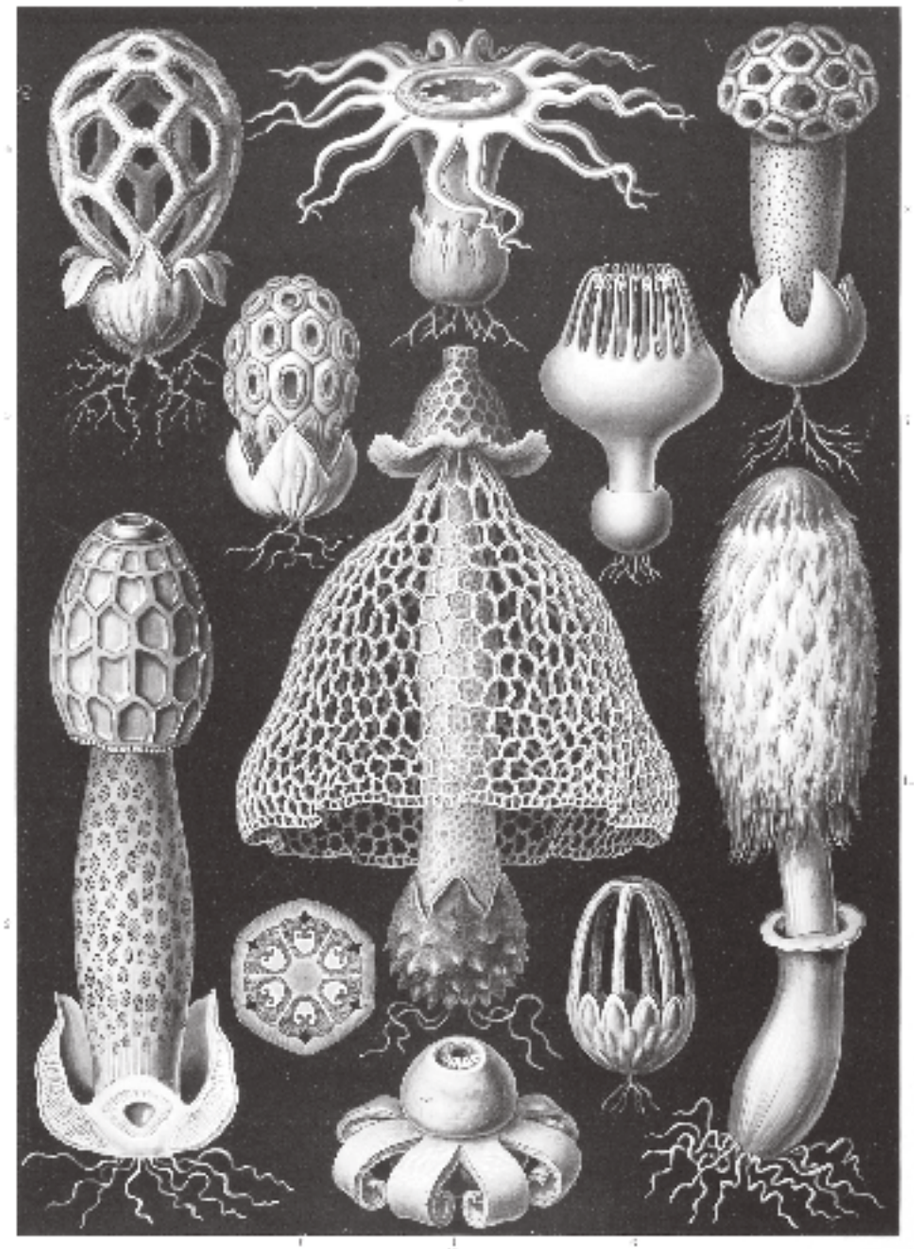
"The movie began as a set of disconnections, a bramble of stabilized fragments taken from things obscure and fluid, ingredients trapped in a succession of frames, a stream of viscosities both still and moving. And the movie editor, bending over such a chaos of "takes" resembles a paleontologist sorting out glimpses of a world not yet together, a land that has yet to come to completion, a span of time unfinished, a spaceless limbo on some spiral reels". (*The Spiral Jetty*, 1970, published in *Robert Smithson: The Collected Writings*, edited by Nancy Holt, New York University Press.)



ERNST HAECKEL
ARTFORMS OF NATURE
LEIPZIG
1904

In 1904 the famous German biologist Ernst Haeckel, expert on anemones and worms, publicist and racist, produced his astonishing book *Art Forms in Nature*. An admirer and erratic interpreter of Darwin, whom he met in person in 1866, Haeckel wanted to show that the evolutionary history of life results in ever more complex forms of structure and pattern. His aim was not to argue against superb design in nature but to reveal it as the consequence of evolutionary process. He was a brilliant draughtsman, working in the field with notebook and sketchpad whenevever he examined organic specimens. His career barely survived ferocious and persuasive charges of fraud against several of his embryological sketches: his defence was that all such images were reconstructions. His imagery of organic form proved invaluable for those who sought to naturalise the arts. From Paris metro stations to Tiffany jewels, such aesthetics dominated the culture of the time. Part of Haeckel's aim, too, was to show how seemingly psychological facts, such as the human sense of beauty, were a result of evolution: the best way to do this was to show that evolved forms are beautiful.

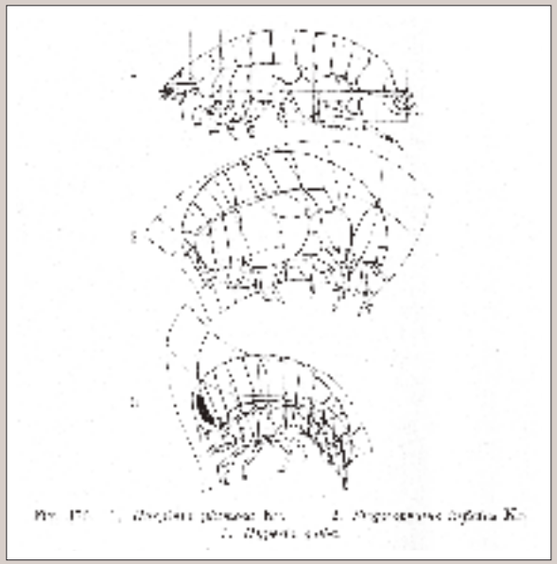
From the collection of Zucker Artbooks, New York



LEOPOLD AND RUDOLPH BLASCHKA
CLATHRULINA ELEGANS, RADIOLARIAN
GLASS MODEL
CIRCA 1889

"An artistic marvel in the field of science and a scientific marvel in the field of art": the natural history models made in Saxony by Leopold and his son Rudolf Blaschka in the late nineteenth century started as German aristocratic amusements, adapted from the makers' work on jewelry and glass eyes. Leopold was first inspired to make glass jellyfish by the creatures he saw on a transatlantic voyage, then gained inspiration from the impressive works of Philip Gosse on sea anemones and of the Blaschkas' patron and admirer Ernst Haeckel on radiolaria. They exploited a purpose-built aquarium to store specimens, or drew from memory. Obsessed by his own handicraft, Rudolf spent his honeymoon at a glass factory in Bohemia. Their work represents a luminous riposte to entropic dissipation, a determined attempt to stop change and capture it forever. Their project especially focused on what seemed the most vulnerable creatures, those barely capable of being stuffed, dried or skinned. The aim was to make a simulacrum of perfect visibility: no other quality of living beings survived their attentions. These structures, melted over wire frames or glued, painted and enamelled, mimic in the most exquisite detail the minutest aspects of a vast range of organic forms. Sometimes bits of real shell were included. Some critics reckoned the models were good for nothing but "for hoodwinking a credulous plutocracy". Even keeping them the same stays a challenge: during the Second World War it was proposed that the Harvard glass flower collection be put in a special bomb-proof shelter.

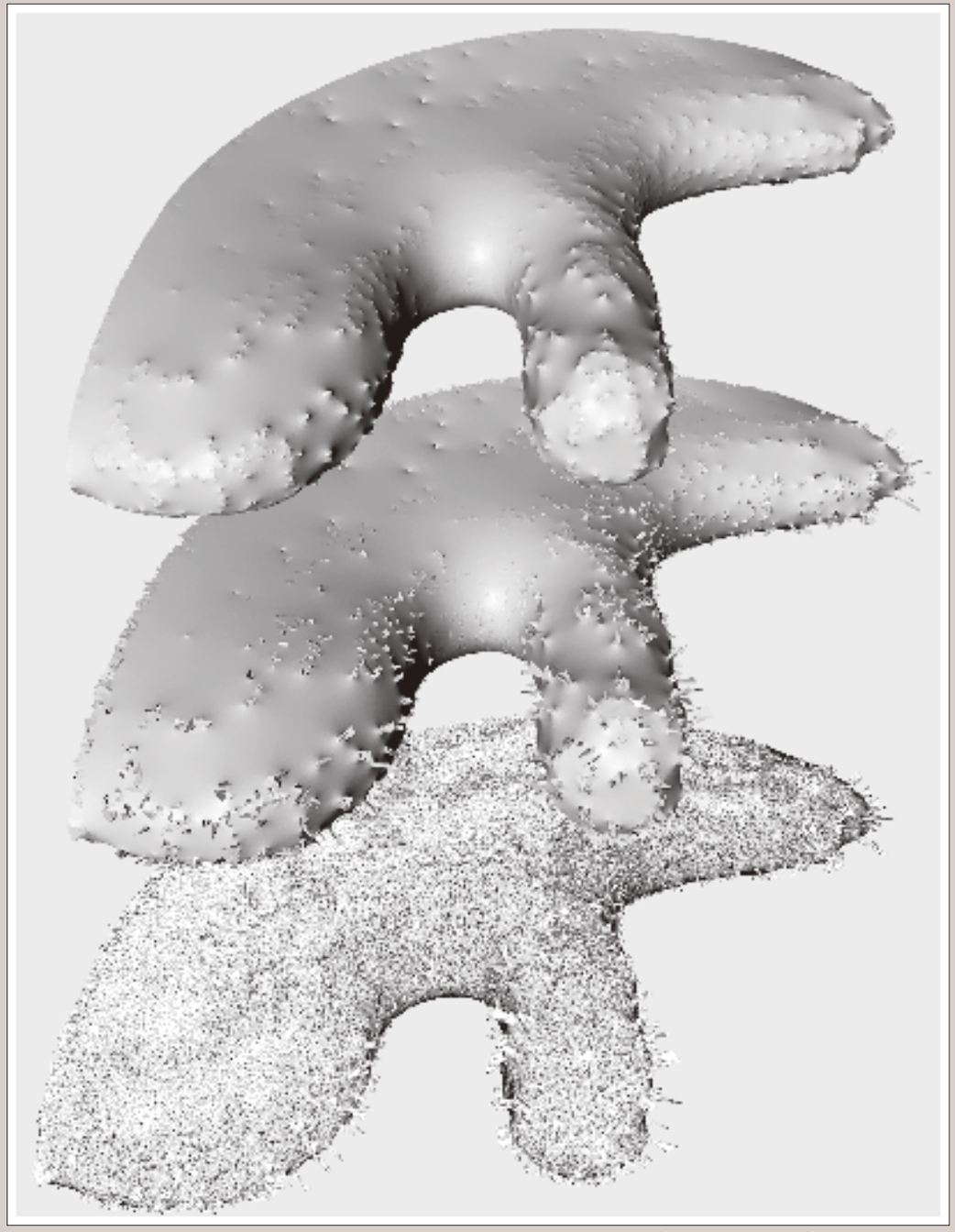
Courtesy of Natural History Museum, London
Featured in the exhibition "Art Forms from the Ocean"
curated by National Glass Centre 2008
Photograph by Colin Davison



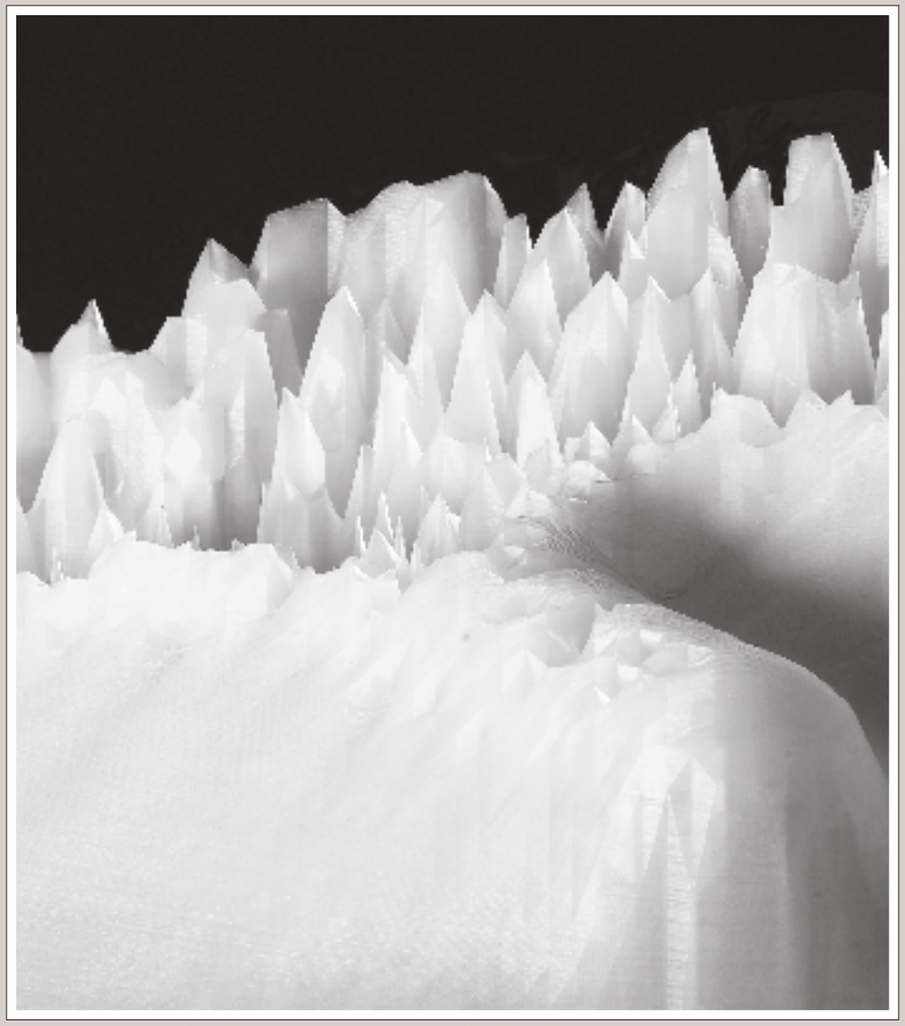
D'ARCY WENTWORTH THOMPSON
ON GROWTH AND FORM
CAMBRIDGE
1917

D'Arcy Thompson was a brilliant Scottish biologist and classicist who wrote one of the greatest literary works in twentieth century science, *On Growth and Form*. He urged that the principles of physical structure and force play a decisive role in the forms of organic beings. Larger beings would be subjected to forces acting on their volumes, such as the agencies of gravity and weight. He made comparisons, therefore, between mammal skeletons, bridges and cranes. Smaller beings, with much higher ratios of surface area to volume, would be subjected to the principles of viscosity and surface tension. So he compared the shapes of cells and protozoa to those of bubbles and splashes. There is a special family of forces that mainly work on surfaces – surface tension and viscosity, and the glories of the honeycomb seemed a fine example. Thompson claimed, against Darwin, that bees did not design honeycombs to economise on wax, but instead that "the walls assume their configuration when in a semi-fluid state while the watery pulp is still liquid under the high temperature of the crowded hive".

Top: Transformations "drawn roughly" by D'Arcy Thompson of Harpinia plumosa, Stegocephalus inflatus and Hyperia galba.
Right: Anish Kapoor, *Anamorphic Inout 1*, 2006

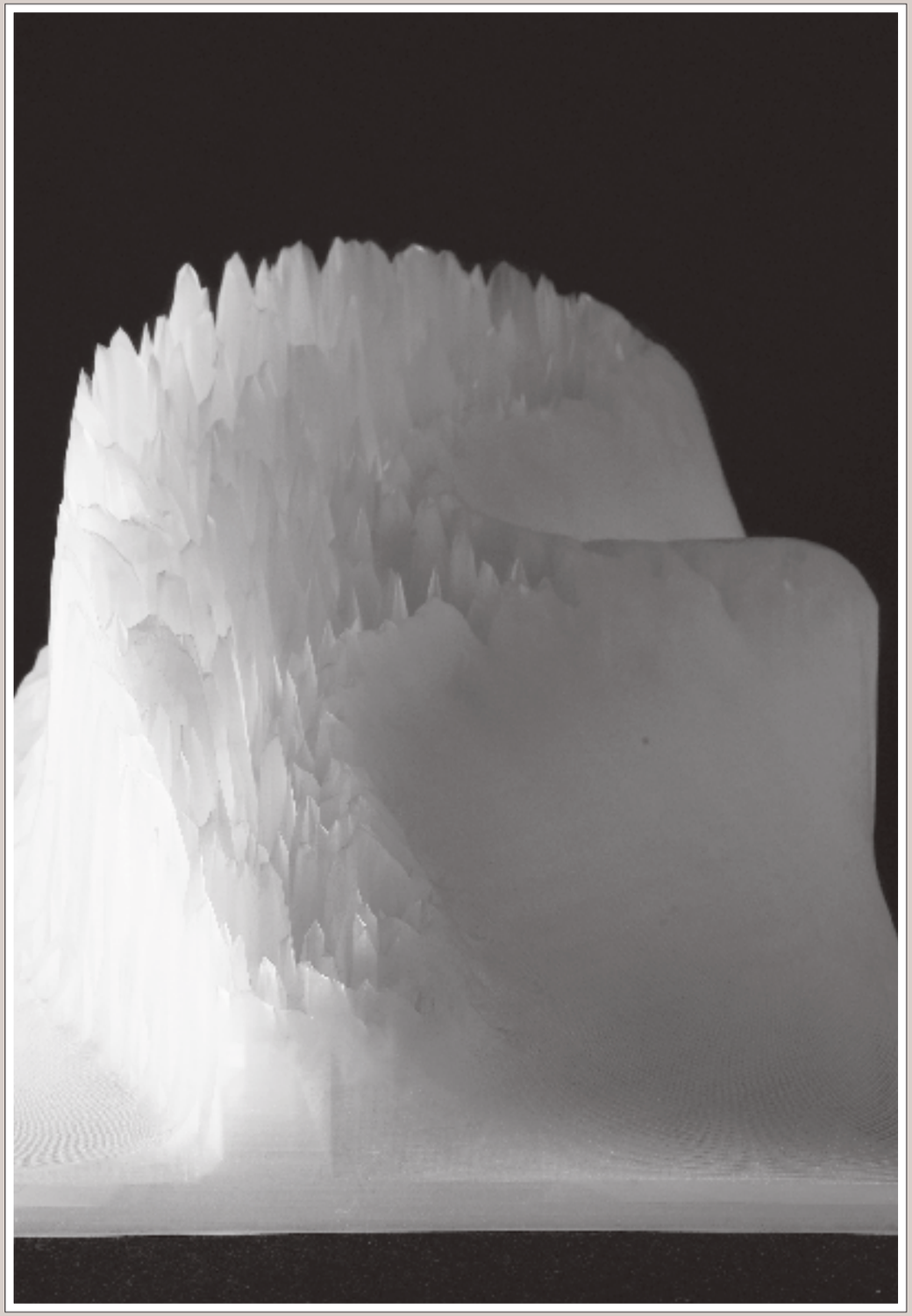


3D imaging by Grégoire Dupond, Factum Arte



A physical cast of Anish Kapoor's *Inout* was scanned with a white light scanner to produce an accurate 3D model of the complex form. During the recording a number of the triangles that describe the surface were in the wrong orientation with regard to the surface. When a smoothing operation was applied to the file these triangles appear as acne type growths. A different transformation applied to the same form produces a spiky, crystalline object.

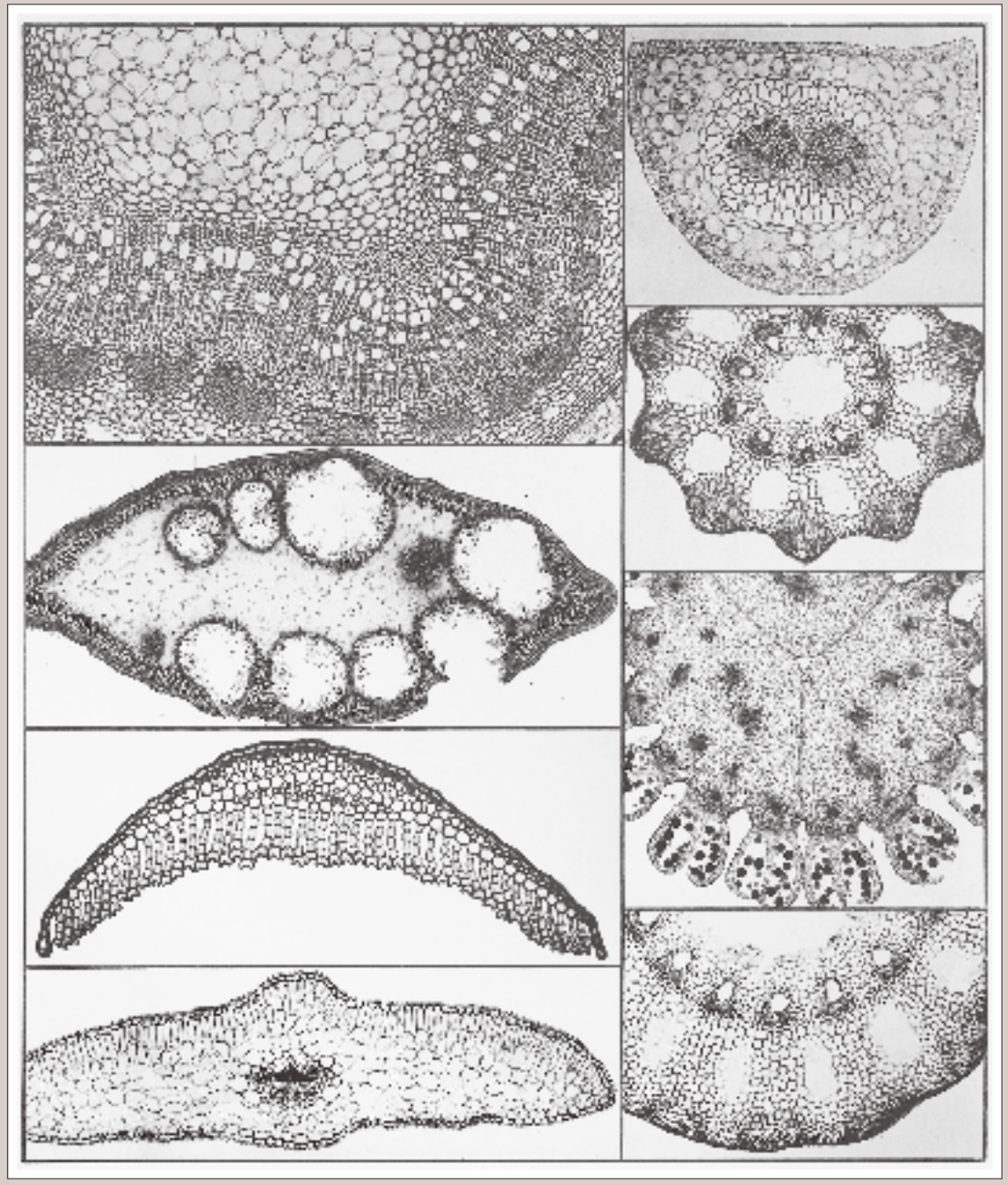
Anish Kapoor, *Anamorphic Inout 2*, 2006
Stereolithographic print from a "draped" surface covering the original cloud point of the 3D scan
37 x 22 x 18cm; translucent resin



MARTIN GERLACH
THE WORLD OF FORMS FROM NATURE
WITH MICROSCOPIC ENLARGEMENTS BY HUGO HINTERBERGER
CROSS SECTIONS OF STALKS
COLLOTYPE
VIENNA AND LEIPZIG
1902-04

Martin Gerlach (1846-1918) was a publisher and active promoter of the popular and decorative arts. His publications ranged from detailed studies of popular decorative flower festoons to typographies of chimneys. The publication he produced between 1902 and 1904 with the microscopic photographer Hugo Hinterberger, *The World of Forms from Nature*, was intended as a sourcebook to inspire an aesthetic appreciation of decorative abstraction. Inspired by his contemporary Haeckel, Gerlach sought to present in photographs and microphotographs what Haeckel had done with his pencil and team of skilled draftsmen. Each specimen is photographed in isolation against a neutral background in order to focus attention on its true nature. The more complex nature of the relationship between the form and its environment was not his primary concern. This relationship between figure and ground was to become the object of inquiry of Roger Caillois and Robert Smithson who, when thinking about entropy in the late 1960's, found a potent metaphor in the Praying Mantis. This ultimate mimetic animal can not only become visually indistinguishable from its environment but is able to take the strategy of playing dead to new limits by continuing to carry out the functions of life after its death. The female Mantis has been observed decapitating the male and eating it during copulation. This act has only been observed in captivity where a quantifiable increase in the duration of copulation among males who are cannibalized was observed, in some cases doubling both the duration and the chance of fertilization.

The collection of photographic collages printed on individual sheets in *The World of Forms from Nature*, elaborately designed and laid out, utilised the continuous-tone quality of collotype printing, another of the beautifully physical print processes developed by Alois Auer in Vienna. To make a collotype print a glass plate is coated with sensitised gelatin and exposed under a negative. Light passing through the negative hardens the gelatin causing it to absorb less water than the unexposed material. Alois Auer realised that this difference in absorbtion in a hydroscopic material like gelatin could be used to produce a relief surface which, when mixed with the principles of lithography, was capable of producing a print quality unmatched by any process except its close relative, the woodburytype process.



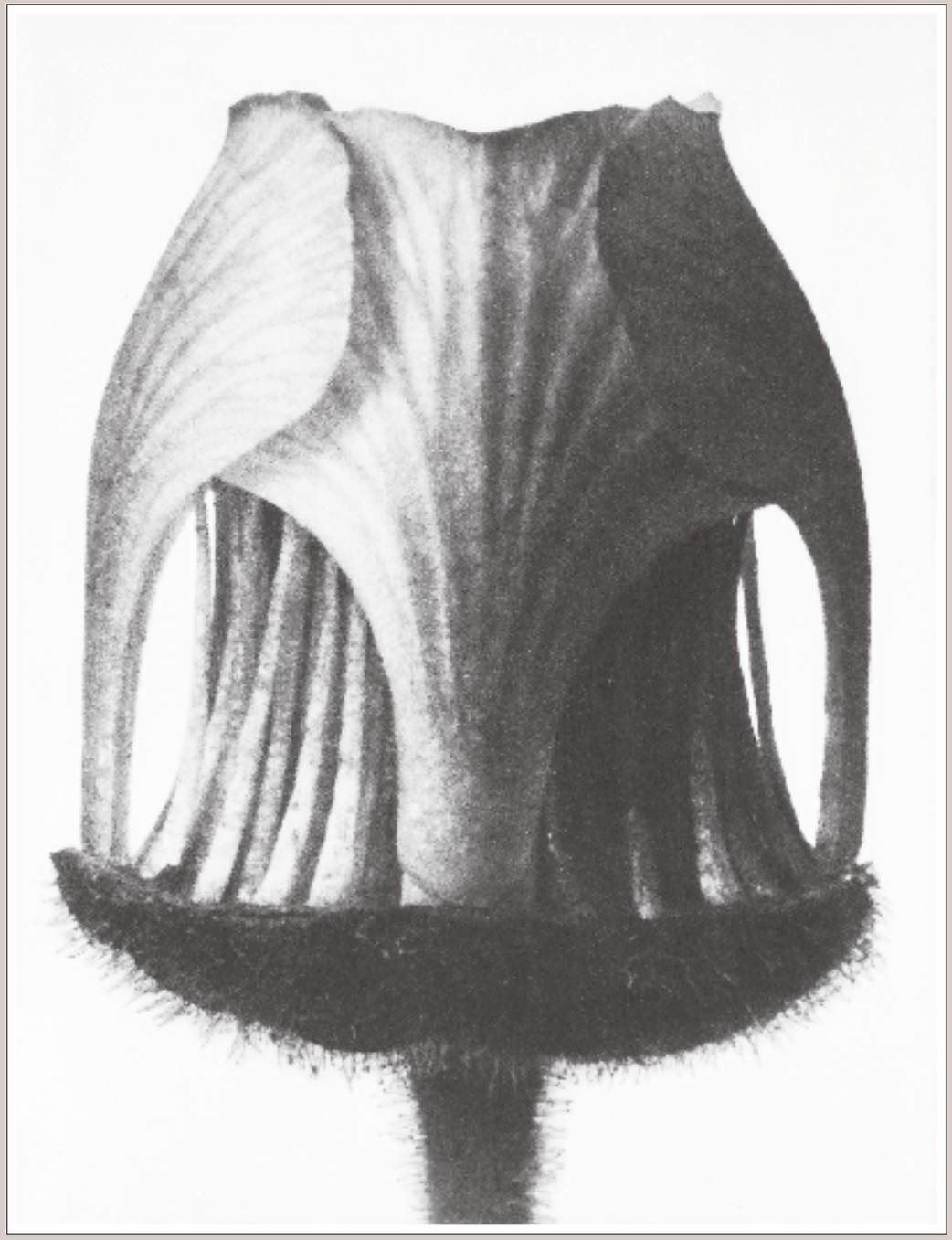
KARL BLOSSFELDT
PRIMORDIAL ART FORMS
GEUM RIVALE
PHOTOGRAVURE
BERLIN
1926

Karl Blossfeldt (1865 -1932) was concerned with the photographic recording of plants and living forms but he began his working life in an iron foundry before moving to study at the Royal Institute of Arts and Crafts in Berlin. Between 1890 and 1896 he had the good fortune to go to Rome and work with Moritz Meurer collecting, drawing, casting and systematically photographing botanical specimens. In 1896 Meurer published a book on the Acanthus and its influence on ancient art in which two of Blossfeldt's photographs are reproduced.

The passionate faith that intimate recording of the real would produce a new objectivity became a characteristic German obsession transmitted through a lineage connecting Ernst Haeckel, Martin Gerlach, Karl Blossfeldt, Albert Renger-Patzsch, Bernd and Hilla Becher to the current generation of German photographers, including Andreas Gursky and Thomas Ruff. They developed a mechanical objectivity that presented objects in isolation and placed a complete confidence in photographic recording.

Blossfeldt published two important collections of photogravure prints from his photographs of plant forms: *Urformen der Kunst* (1926) and *Wundergarten der Natur* (1932). Both of these publications contain black and white images of extreme beauty and are concerned with the fundamental structures of the natural world and their influence on our understanding of artistic and architectural form.

Karl Blossfeldt Archive – Ann and Jürgen Wilde, Zülpich 2009



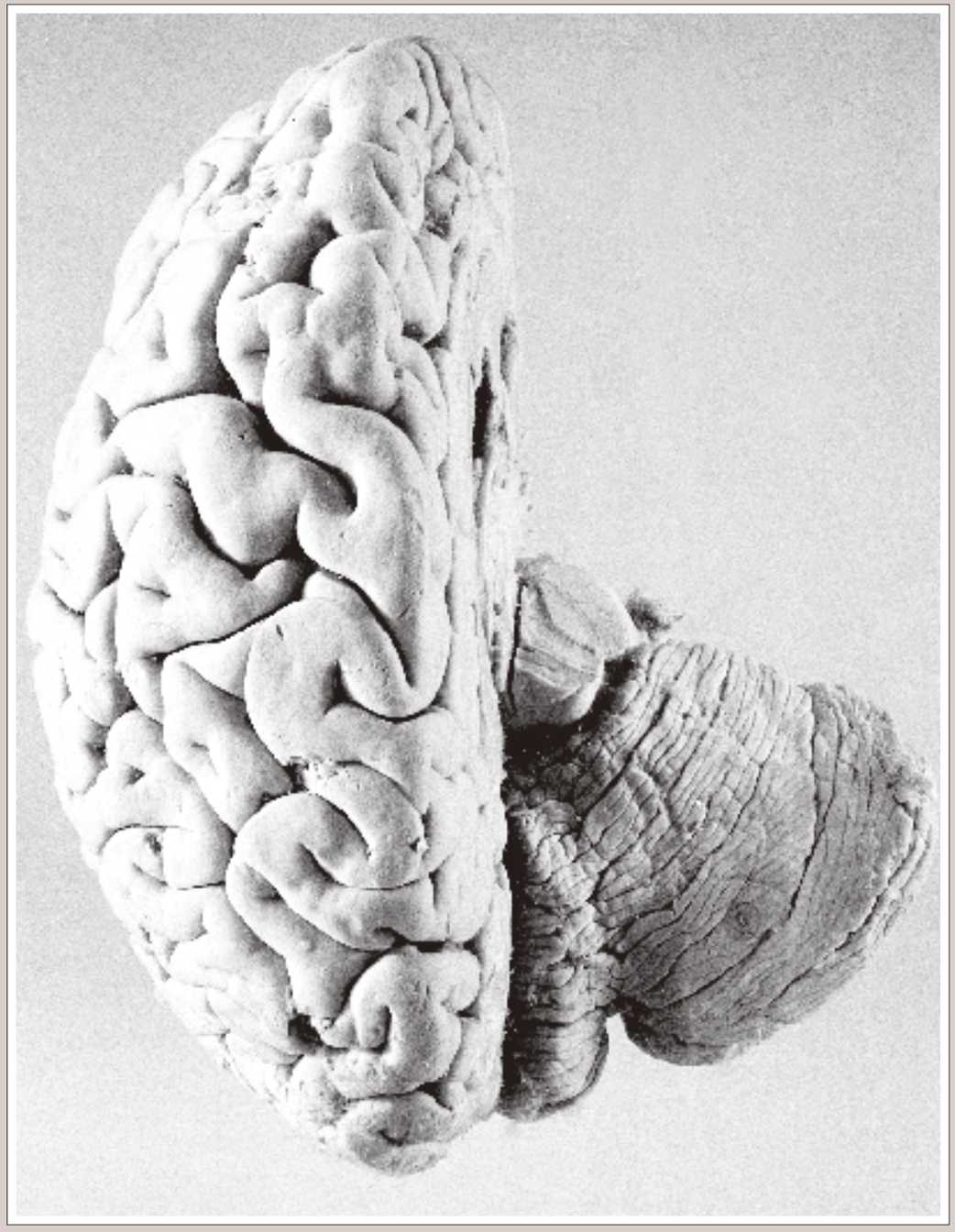
KLEIN BOTTLE
A SINGLE SURFACE MODEL MADE BY ALAN BENNETT IN BEDFORD
GLASS
1995

Model makers around the end of the nineteenth century realised that their models' translucent and airy forms could make real what till then might have seemed invisible abstractions: their faith rested in the possibility of turning geometry into artefacts. So, at Goettingen and other major research centres in mathematics, students were encouraged to contemplate, handle and design ever more exotic forms as part of their training in the realities of higher geometry. In 1882 their master, the mathematician and entrepreneur Felix Klein, designed a three dimensional form which seemed to have but one surface – it came to be known as the Klein bottle. At least as interesting as its formation is its dependence on the malleable materials of which it is made. The plasticity of glass and related substances was decisive for many of the great scientific advances of a century ago, for by manipulating and twisting such substances into elegant and manageable form, technicians were able to design objects which not only helped make abstractions real, but also aided the scientists of microphysics and the subatomic world perform trials which first showed the existence of rays which could penetrate matter and particles smaller than atoms: radiation tubes, radiometers, cathode ray instruments. The magnificent glass works of the labs and workshops of the Belle Epoque showed the world how it was made.

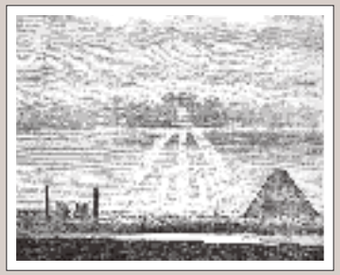
The Science Museum, London. Science and Society Picture Library

CHARLES BABBAGE'S BRAIN
EXTRACTED IN 1871

The brilliant and irascible Victorian mathematician and engineer Charles Babbage hated disorder: everything worth making, he reckoned, could be manufactured by rules. Somewhere in human and mechanical brains were the laws of thought. When he died in 1871, Babbage's brain was removed, pickled and given to the Royal College of Surgeons: "I quite assent to the idea of preserving the brain. The brain should be known as his and disposed of in any manner most conducive to the advancement of human knowledge and the good of the human race," agreed his son. Others tried to make themselves immortal: Babbage's ally, the London visionary reformer Jeremy Bentham had his whole body preserved for posterity's benefit (his brain and guts were removed and the head subsequently decayed). Meanwhile, Babbage's most famous advance was his brilliant and abortive designs for a series of mechanical calculating engines. He won a medal for trying to get rid of computers, the people on whom Victorians relied to perform calculations. His favourite trick with his own calculating machines, the difference engines whose design was based on his conception of human reasoning, was to make a difference engine print out exactly the same number ten thousand times, then suddenly change its output. Onlookers of this West End party trick were impressed, thinking the sudden output discontinuity a miracle. But Babbage, the engine's master, then revealed he'd programmed the startling discontinuity in advance. Perhaps all miracles are really prearranged changes like this? Charles Darwin, a guest at Babbage's house parties, certainly thought this implied that even the *"mystery of mysteries"*, the origin of species, could thus be explained entirely by natural laws.



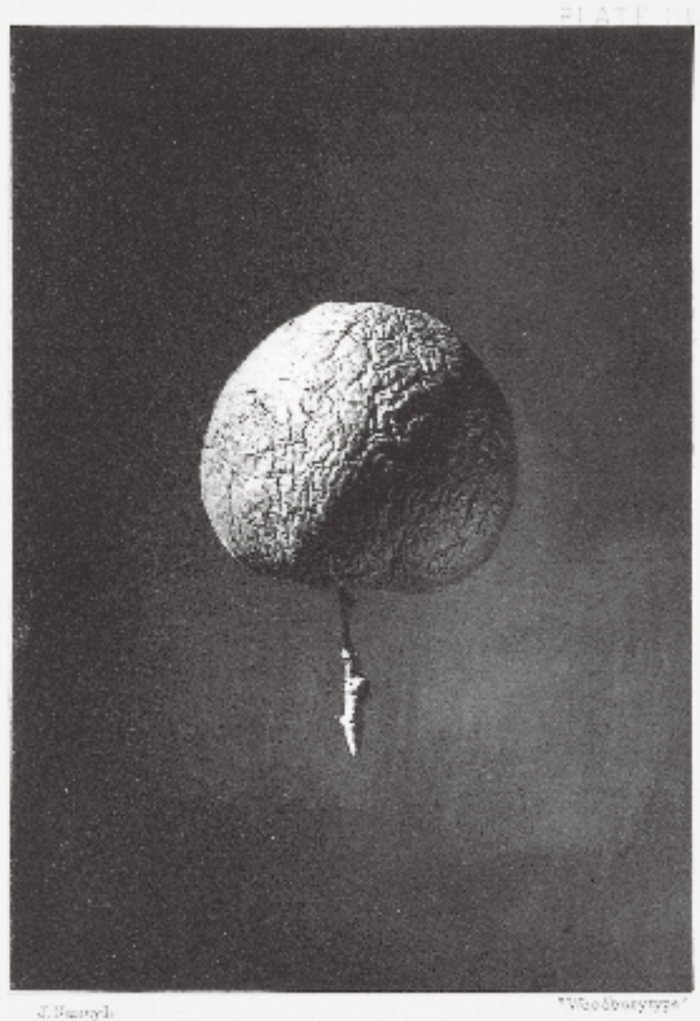
Courtesy of the Royal College of Surgeons of England



JAMES NASMYTH
THE MOON: CONSIDERED AS A PLANET, A WORLD AND A SATELLITE
BY J NASMYTH AND J CARPENTER
WOODBURYTYPE PRINT
1871

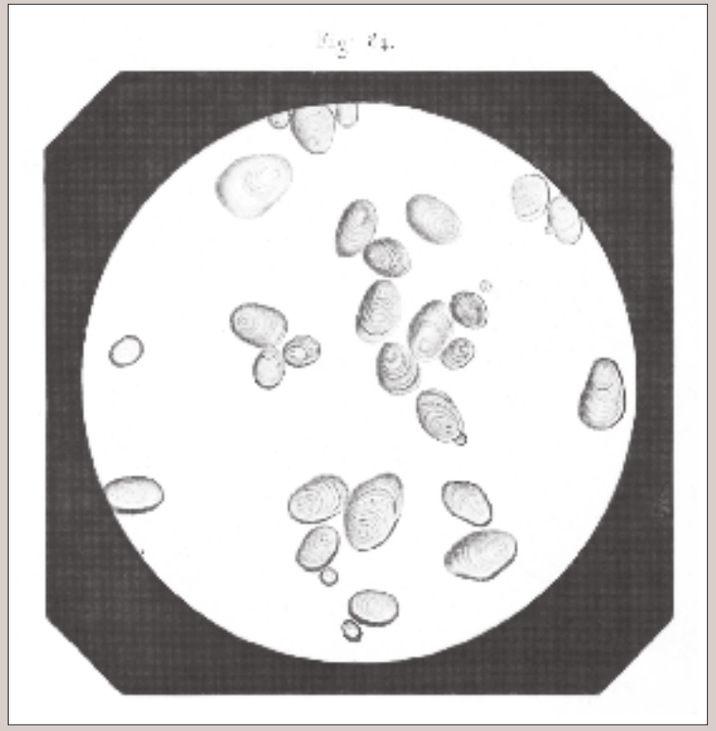
"The eyes and the fingers, the bare fingers, are the two principal inlets to sound practical instruction. I have no faith in young engineers who are addicted to wearing gloves. Gloves, especially kid gloves, are nonconductors of technical knowledge." So wrote James Nasmyth, Scottish engineer and astronomer, a Victorian hero who designed huge steam hammers, immense but precise machines that he claimed let engineers "think in blows". Powerful enough to crush steel and a key part of his struggle with a recalcitrant workforce, "the hammer could be made to give so gentle a blow as to crack the end of an egg placed in a wine glass on the anvil". He became obsessed by such cracks. His immense fortune let him retire to a comfortable Kentish estate he named Hammerfield, where one of his favourite subjects was what he called *the origin of forms*. The Sun's rays streaming through clouds, he argued, explained the shapes of the Egyptian pyramids, while "the single vertical ray suggests that of the obelisk". But his attempts to show the Moon's forms were frustrated by his cameras' slow exposure times. So he built artificial models of the lunar surface, then made photos of these elegant structures to show that their "cracks, projections and hollows" were wrinkles, which he immediately analogized with other wrinkled objects, such as "the old earth, an old apple, an old hand". Light, age, engineering and form combined to make some of the greatest Victorian images of these seductive unconformities.

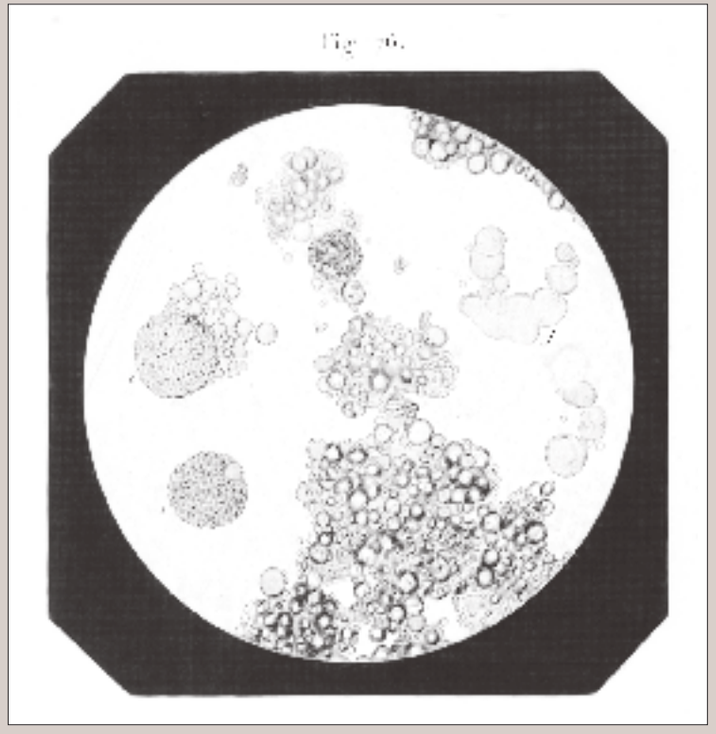
Top: James Nasmyth, *Autobiography*, London 1883
Nasmyth's sun-ray theory of the origin of pyramidal forms combined his astronomical passions with his admiration for Ruskin and Turner.



ALFRED DONNÉ AND LÉON FOUCAULT
MICROSCOPY COURSE CARRIED OUT FROM NATURE
WITH A DAGUERRE MICROSCOPE
ENGRAVINGS BY M. OUDET
PARIS
1845

Alfred Donné was a wealthy Parisian medical teacher and keen advocate of breast-feeding. He was also devoted to microscopy, despite current orthodoxy, which doubted microscopes' role in diagnosis and distrusted optical devices that turned physicians' attention away from real patients towards barely visible minutiae. To show his many students such microimages, he employed various projectors using sunlight, limelight and electricity with help from the young medical student Léon Foucault as his lecture assistant. The first production of daguerrotypes was covered by Donné in his science journalism, and he made one of the very first portrait photographs in Europe. He and Foucault soon produced a remarkable (and expensive) Atlas of engraved versions of micro-photographs of blood, mucus, eggs, sperm, starch and various crystals originally taken in bright sunlight. The Atlas was not a success. Its imagery failed to convince audiences that newfangled photochemical and optical technologies provided trustworthy images of unseen worlds. Yet the project also led at once to astonishing results in image science: photography of the Sun, estimates of comparative brightness using photography, and, most decisively, one of the first detailed analyses of the means through which daguerrotype images were formed. Foucault's combination of scientific photography and photographic science was decisive in making these microimages believable and extending the realm of the visible.

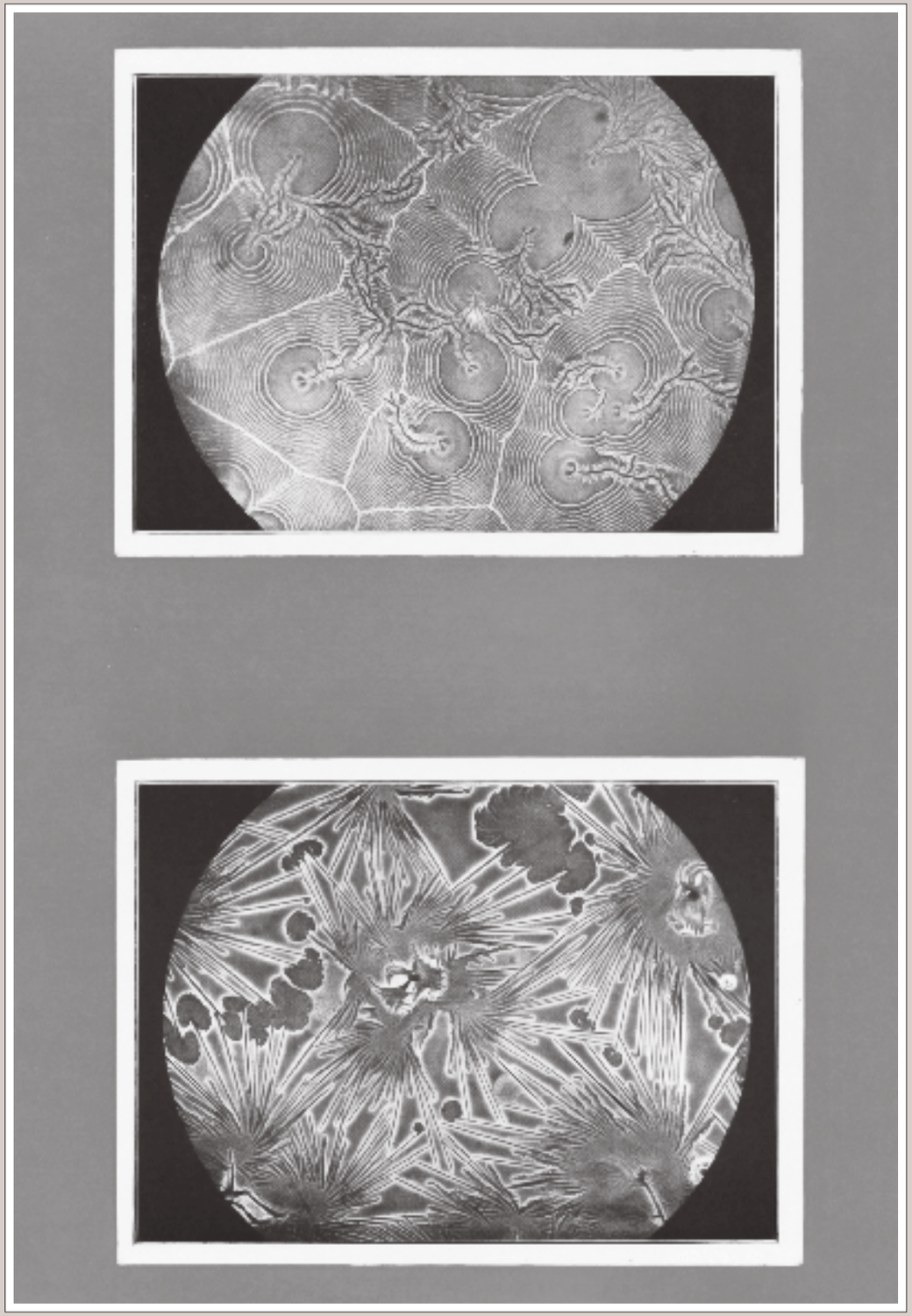


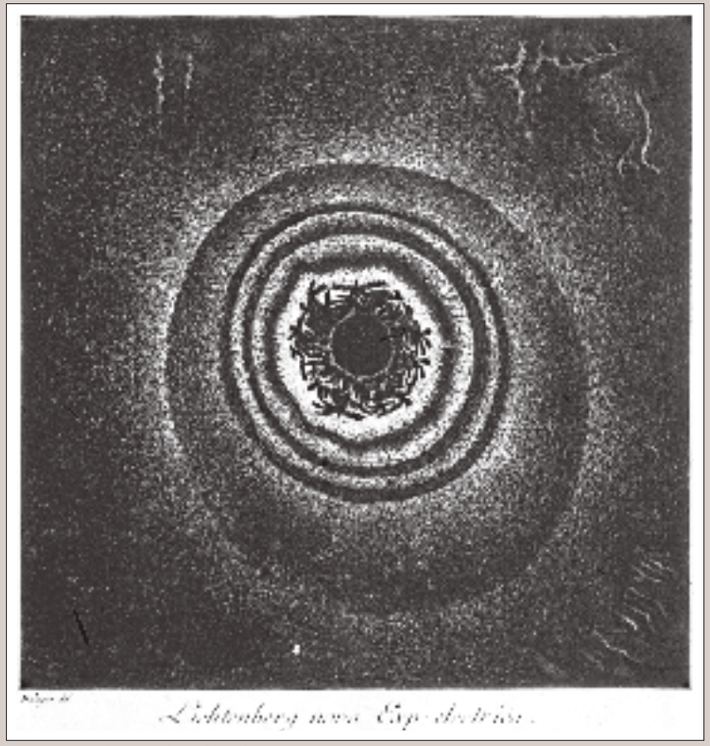


H. SCHENK
NATURAL FORMS: MICROSCOPIC MODELS OF CRYSTAL FORMS
96 PLATES OF MICROSCOPIC PHOTOGRAPHS OF CRYSTALS
STUTTGART
1910

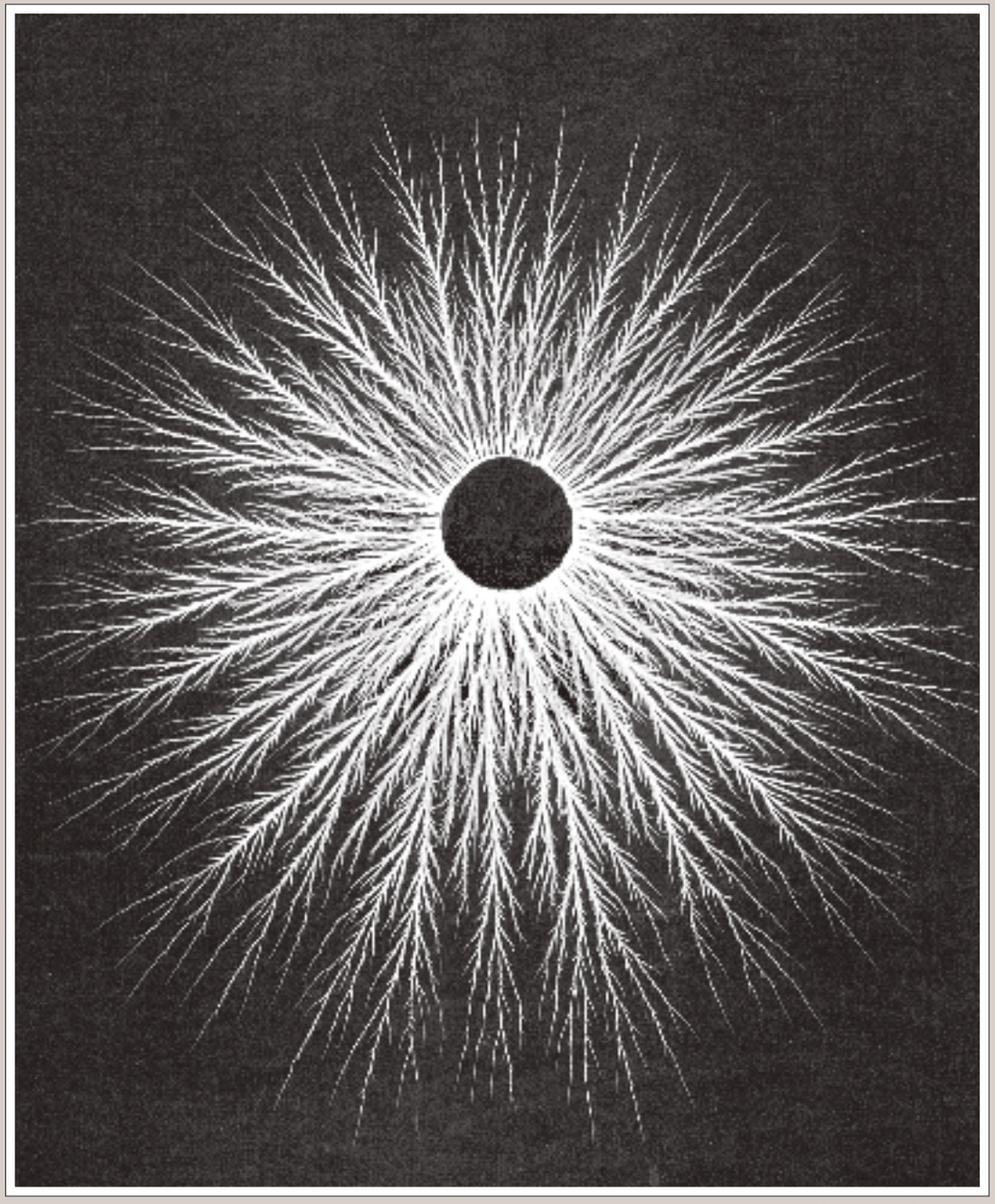
Crystals are solids in more or less ordered forms. According to the International Union of Crystallography a crystal is simply any solid that gives a discrete X-ray diffraction pattern, so crystals are defined by how they look and their history is the story of how they are observed. The microscopic photographs of crystal forms by H. Schenk, published in 1910 with an introduction by K. Schmoll von Eisenwerth, the Austrian *fin de siècle* painter, were intended primarily for aesthetic contemplation and are beautifully printed in pairs with screenprinted surrounds of a subtly modulated grey green. Two years after this relatively obscure publication, the physicist Max von Laue (after an illuminating conversation in the English Garden in Munich) worked out that since high frequency X-rays would be scattered in characteristic patterns by atoms set in regular crystal lattices, it ought to be possible to use them to map crystal structures. X-ray crystallography became a key technique for this kind of microanalysis of substances.

Crucial in the application of this visualisation technique to biological molecules was the team around the vivacious Communist scientist Desmond Bernal, one of whose collaborators, Dorothy Hodgkin, ingeniously used X-ray analysis to describe the structures of cholesterol in 1937 and penicillin in 1954. According to Bernal, however, some of the "most beautiful X-ray photographs of any substance ever taken" were made by the superbly competent and painstaking crystallographer Rosalind Franklin, based at King's College, London. Her photographs, made with a very high resolution camera she designed and improved, and analysis of DNA structure produced between 1951 and 1953, were crucial data for the double helix model designed by Crick and Watson, though this was without Franklin's immediate knowledge. "The instant I saw the picture my mouth fell open and my pulse began to race," Watson reminisced. Franklin's contributions were not always fairly acknowledged, while her tragically early death from ovarian cancer deprived her of the honours she deserved.



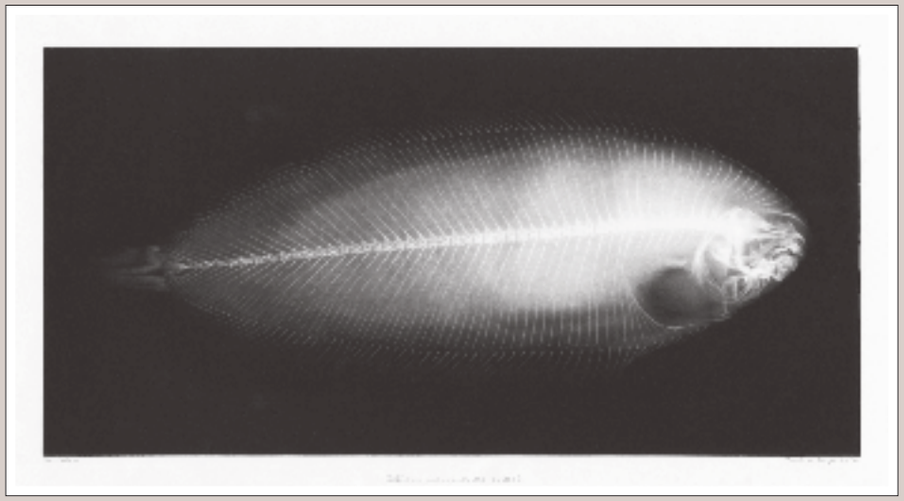


Georg Christoph Lichtenberg
In 1777 Lichtenberg experimented with patterns produced by electrical discharge through glass. They are cited as the origins of photocopying.



Birmingham City Library

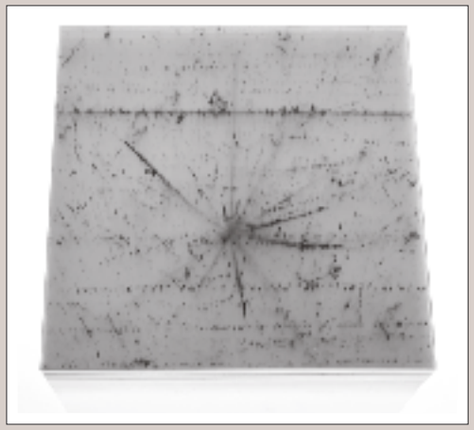
William George Armstrong
In 1897, in collaboration with the photographer John Worsnop, Lord Armstrong published a remarkable study of patterns made by discharging electricity across photographic plates.



ANONYMOUS
ARTICULATION OF THE KNEE OF A 14 YEAR OLD
AN ALBUM OF X-RAY PHOTOGRAPHS
FRANCE
LATE C19TH - EARLY C20TH

From the mid-nineteenth century physicists knew that electric currents travelling through partially emptied glass tubes would produce a strange glow that varied in shape, colour and direction. By the 1890s these cathode rays were a topic of major interest, perhaps revealing a new state of matter akin to the phenomena of spiritualism or the ether. A middle-aged engineer and physicist, Wilhelm Roentgen, worked on these rays in his lab at Wuerzburg to examine what happened when they leaked out of the tube. By the end of 1895 he had discovered an entirely new kind of ray, which he named X radiation, that could be used to make photographs and that seemed to penetrate solid bodies. His paper, carrying an X-ray photo of his wife's hand, soon produced "Roentgen mania" worldwide. Thomas Edison announced his intention to make an X-ray photo of a living human brain; Canadian medics used the rays to locate a bullet in a patient's leg; the rays were even used as therapy, to remove lesions and moles, though one of Edison's glassblowers, who routinely tested X-ray tubes on his own hands, soon died of cancer.

Top: Dr J.M. Eder and E. Valenta, *Experiments on Roentgen-ray Photography*
Photogravure, Vienna, 1896
This extraordinary collection of X-rays was made within a few months of the discovery of the ray by Wilhelm Roentgen.



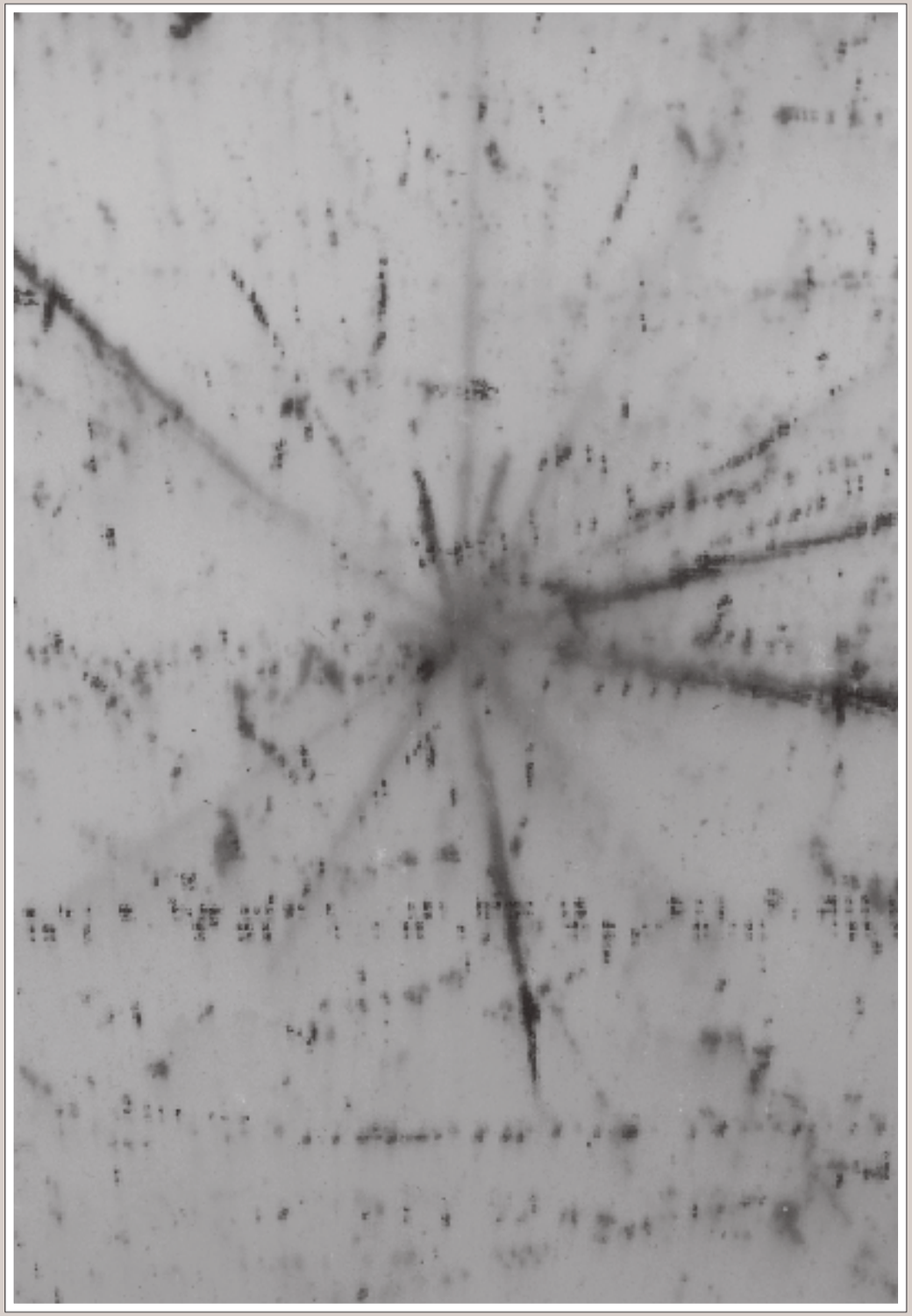
ADAM LOWE
TAKING A COSMIC RAY FOR A WALK
DETAIL
ACETATE AND PERSPEX CUBE
1999

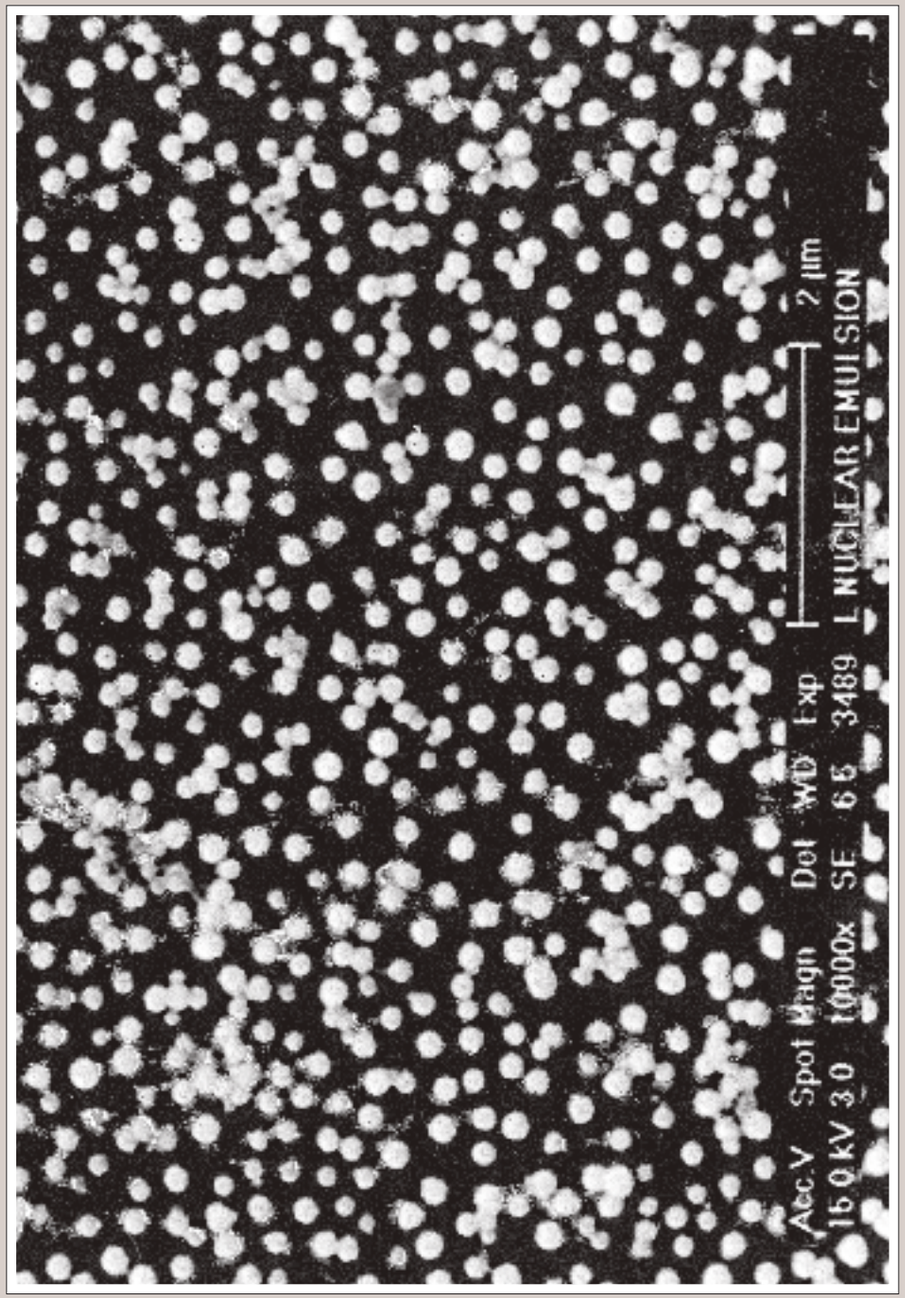
Once Kodak started making a special "nuclear" emulsion, Cecil Powell, an expert well versed in the subtleties of photographic mediation, placed vast stacks of glass plates covered with the new fine-grained emulsion on the Mendip hills near Bristol in order to record cosmic rays. His teams of trained human image scanners then spent hours extracting the tracks of cosmic rays from the background noise in the film. New particles burst onto the scene. These new particles dramatically altered physicists' notions not only about what kind of entities populated the world, but also about the underlying conceptions of the forces that bind matter together.

Some years later Raymond Davis, the son of a photographer, continued the epic task of transforming and recording passive radiation. He demonstrated that he could detect the appearance of a single atom of argon in a tank containing six hundred tons (100,000 gallons) of common industrial dry-cleaning fluid placed 4800 feet underground. Perchloroethylene was chosen because it is rich in chlorine. Upon collision with a neutrino, a chlorine atom transforms into a radioactive isotope of argon, which can then be extracted and counted. Every few weeks, Davis bubbled helium through the tank to collect the argon that had formed, and was able to determine how many neutrinos had been captured.

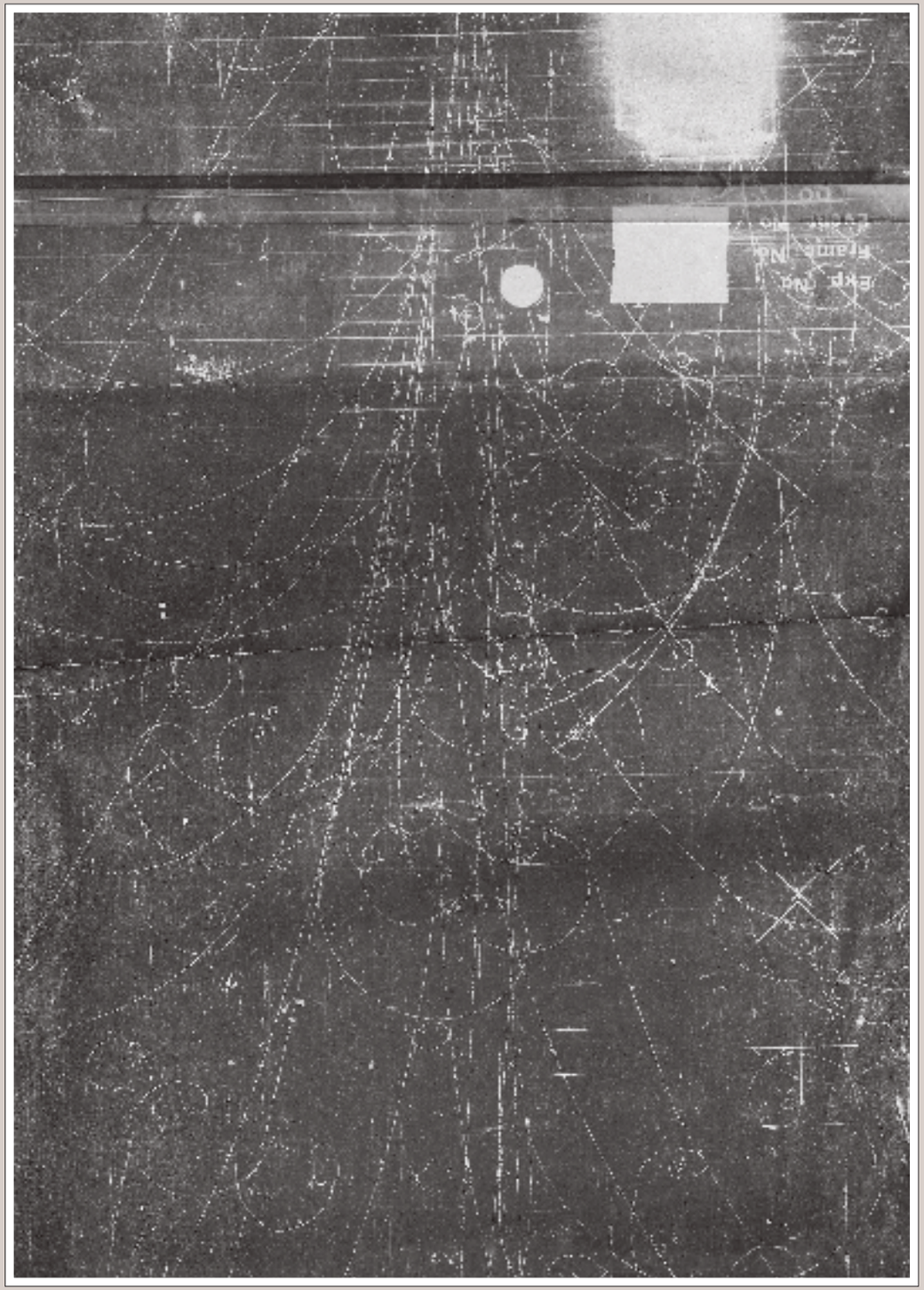
Particle accelerators (the Large Hadron collider) are now favoured over the recording of passive radiation and may yet provide the answer to the Grand Unified Theory.

Photograph by Alicia Guirao del Fresno





A micro-photograph of Ilford's Nuclear Emulsion showing the size of the film grain, far smaller than other film-grains but still large enough to lead many to doubt the results it recorded.



A bubble chamber photograph of a charm event produced by Dr D Tovee, Department of Physics and Astronomy, University College, London.

HORACE DARWIN
AUXANOMETER
ERITH AND CAMBRIDGE
1877

In 1871 the German botany professor Julius Sachs invented a machine that helped plants write. This *auxanometer* was inspired by an earlier machine, a kymograph, designed automatically to record blood and pulse movements in humans and animals. In Sachs' device, a pointer was connected by a thread running from the plant over a pulley to a weight. So the plant became a weight lifter. Movements of the weight could be recorded by the pointer on a turning drum carrying paper covered by lamp-black. The drum turned once an hour; a sheet would be covered in about a day, and let a laboratory botanist read a single plant for days without suffering sleep deprivation. The German professor used devices like this in his conflicts with the eminent Charles Darwin and his enthusiastic son Francis, who came to work in Sachs' lab in person in 1878. Sachs thought the Darwin family were a group of "literary rascals"; and he knew his own experiments depended on the mix of high class botanical machines and ineffably dextrous skill. Sachs certainly loathed Darwin's idea that the direction of plant growth was partly determined by the sensitivity of the root tip, which, according to the great evolutionist, "acts like the brain of one of the lower animals". To show plants had no such brains, Sachs therefore set out to make them record themselves. This was not a new idea: since the early eighteenth century, when the Teddington parson Stephen Hales showed how to fix plant growth with chemical machinery and marks on leaves and stems, experiments had scrutinised how plants changed, grew and moved. Hales' *Vegetable Staticks* stayed famous, and was used as an epigraph in D'Arcy Thompson's *On Growth and Form* two hundred years later. What the auxanometer offered, however, was a way of turning plants into their own witnesses. Francis Darwin was so impressed that he got his own brother Horace to build a machine just like that of Sachs: seemingly random organic growth was disciplined into law-like physical form.

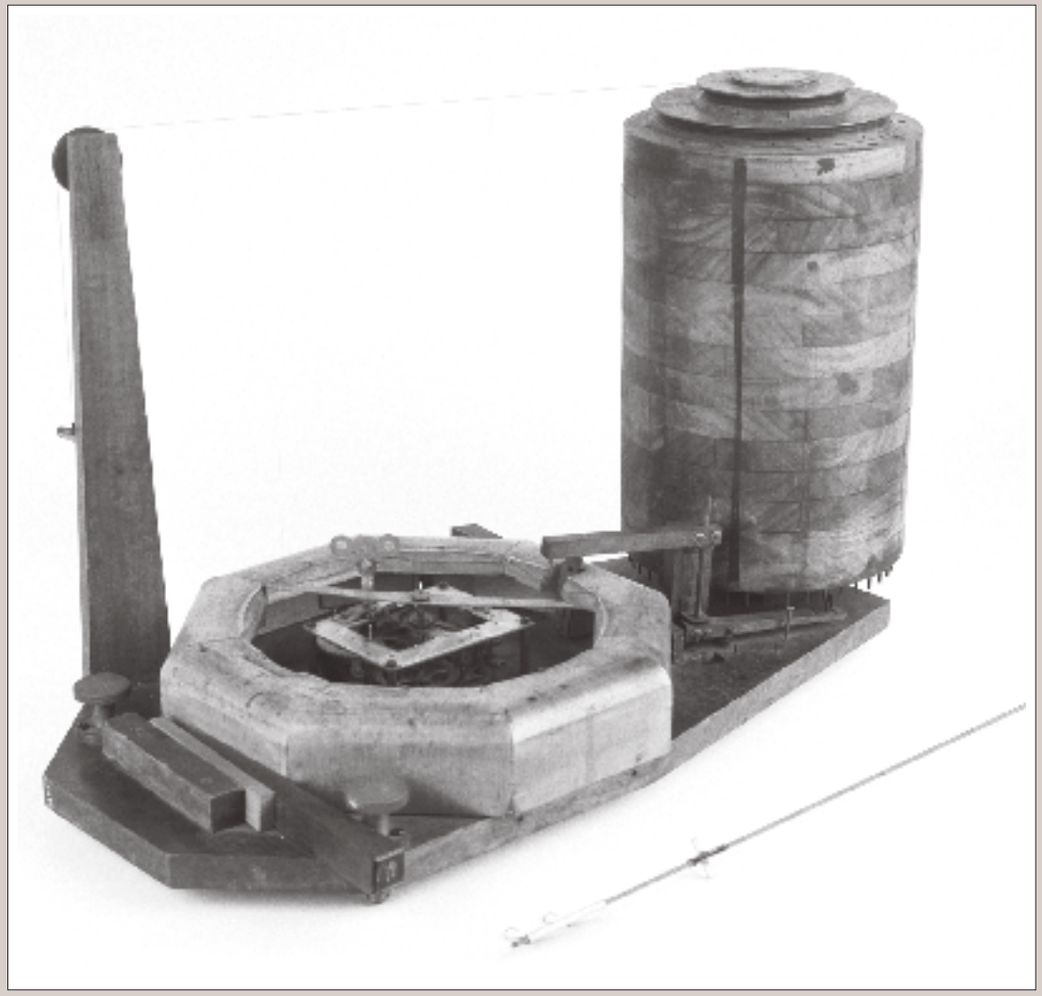
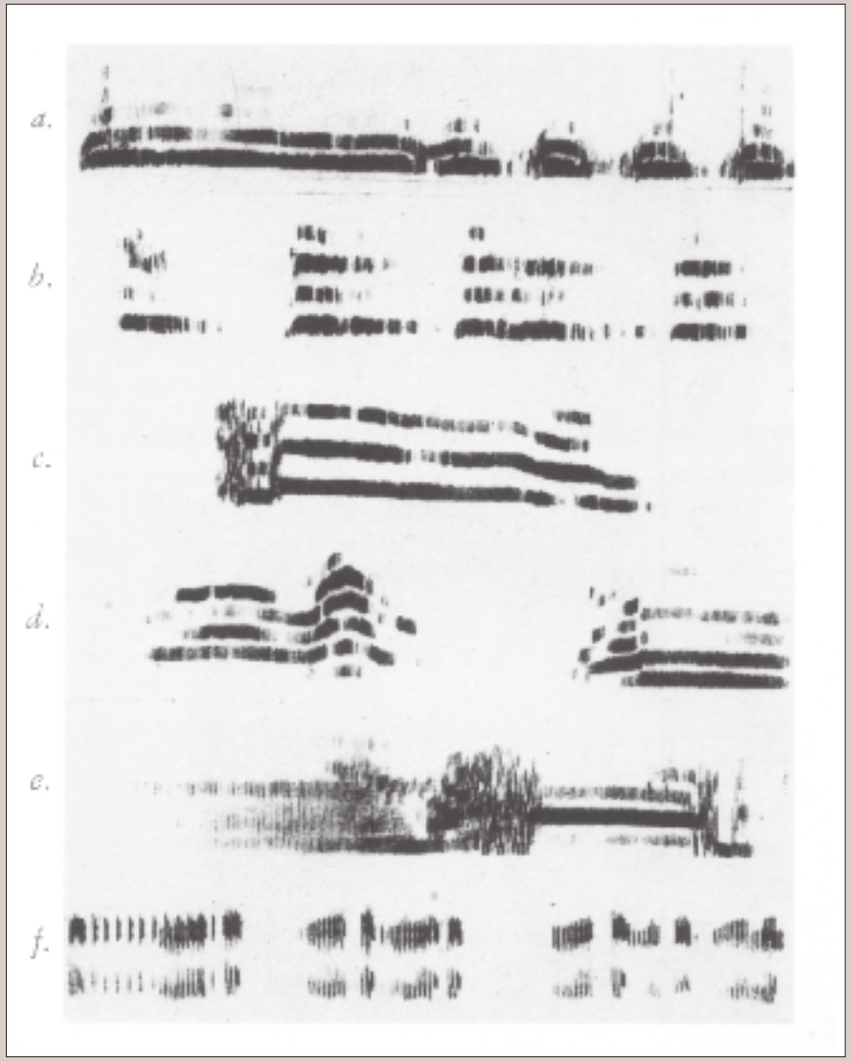


Image courtesy of the Whipple Museum of the History of Science, Cambridge

BELL LABORATORIES
VISIBLE SPEECH
THE BELL TELEPHONE LABORATORIES SERIES
NEW YORK
1947

Just as plants can write, so sounds can inscribe themselves. Early systematic experiments on visible acoustic patterns were performed by Georg Lichtenberg's disciple Ernst Chladni, an impoverished science teacher and one of the early advocates of the interplanetary origin of meteorites. In 1798 he showed that sand grains scattered on a metal plate formed regular patterns when the plate's side was stroked with a violin bow, using these data to design a cheap and best-selling glass harmonica. Sound visualisation became ever more sophisticated, often alongside efforts to make speaking machines and study animal voices. Scientific aesthetes suggested such patterns were nature's innermost form of writing. By the twentieth century, cathode ray displays were used to image insect noises, but failed to display more complex sounds. During the Second World War Bell Labs' technicians, concerned to improve telephony, teach the deaf to speak, and track submarines, designed an electronic Vibralyser, a machine built from modulators, amplifiers and a recording magnetic disc to display visible speech as spectrograms. While these techniques initially proved almost useless for human voices, they worked well for birdsong, revealing surprising patterns of learning and imitation in the living world. Such resonant patterns had already interested the early twentieth century geneticist William Bateson, striking a chord with his refined tastes.

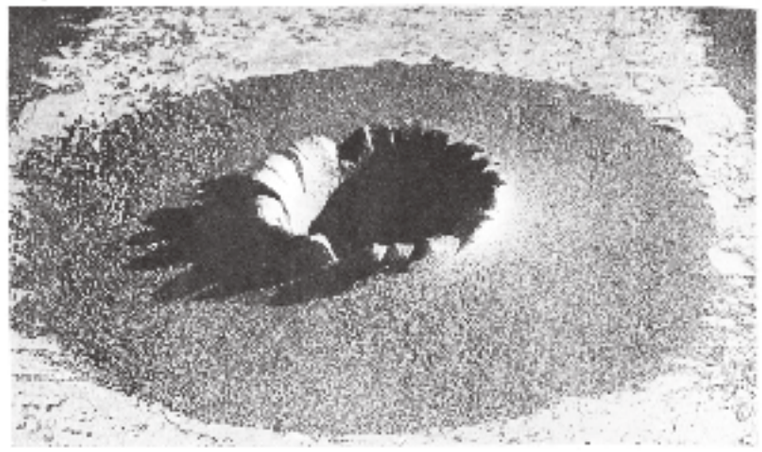
Holidays on the Norfolk coast gave him key ideas for how all seemingly random patterns in living nature could emerge from vibrational symmetries: "I had a good look at ripples. Both water- and wind-formed." Copenhagen shopping also helped. "I noticed bunches of cat skins in a leather shop. I took the opportunity of buying two, illustrating the octave idea of striping." The model that Bateson judged best showed the origin of harmonic form was "a pretty stiff viscous fluid pouring in a thin layer down a plate". Margaret Watts Hughes' Eidophone is an example of this phenomenon. This is also rather how the *Identity Engine* images the emergence of seemingly living form.



Animal Sounds made visible by Bell's translator
a. newfoundland dog, b. small dog, c. wolf, d. cow, e. and f. frog

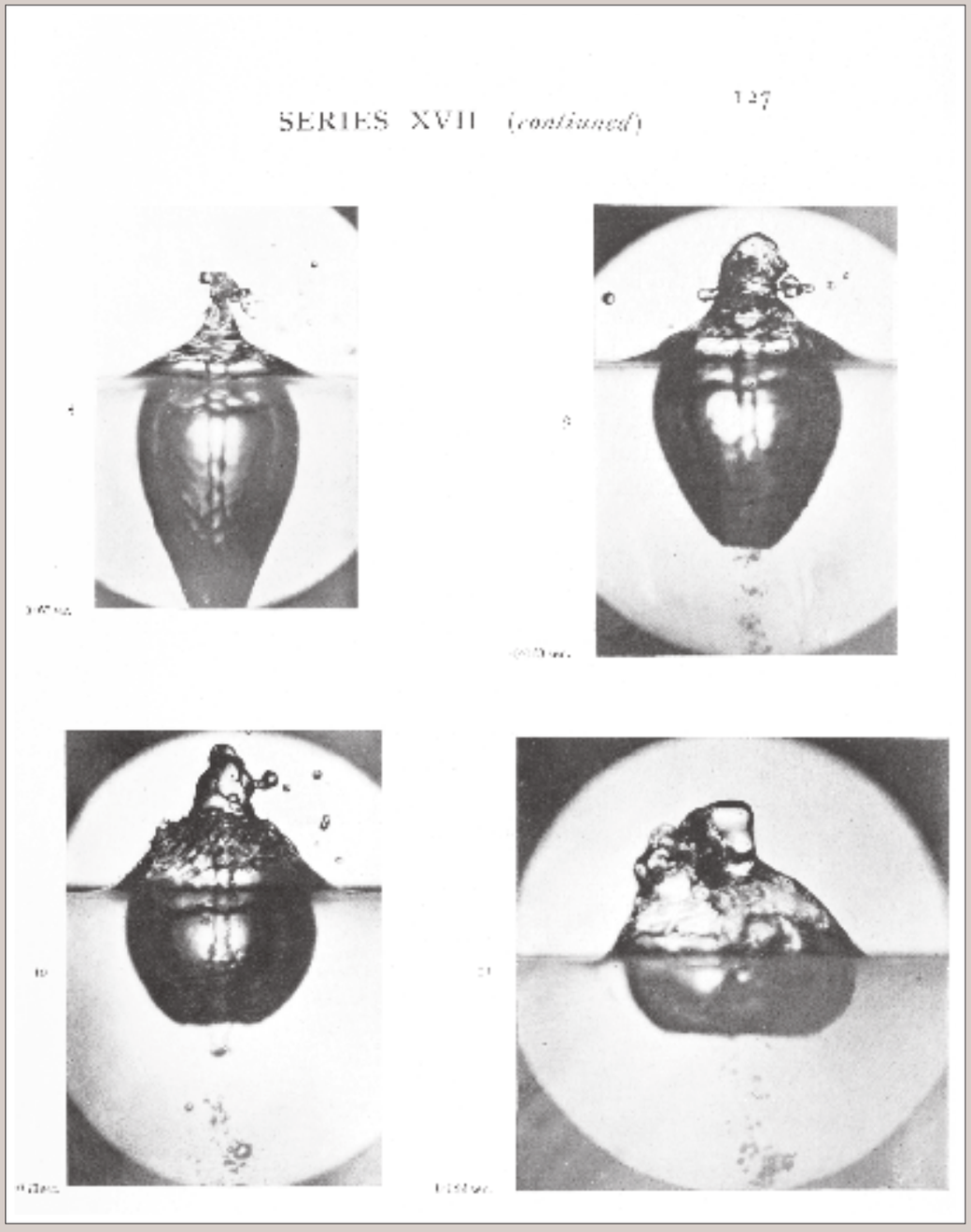
ARTHUR WORTHINGTON
A STUDY OF SPLASHES
LONDON
1908

Arthur Worthington, an ingenious physics teacher for the Royal Navy, became passionately interested in bubbles and splashes when a schoolboy at Rugby School in 1875 – he and a classmate tried dropping ink onto sooty glass dishes, then attempted the same trick with mercury. By the 1890s, after exciting chats with many of the leading physicists in Britain, he helped out at science lectures by drawing bubble shapes on huge rubber sheets for public edification and took over Brighton Aquarium to explore the strangeness of surface and underwater forms. Newfangled lights and sparks aided his passion. He dropped liquids onto glass sheets in a dark room lit only by flashes automatically let off when the liquid hit the sheet. "The mind of the observer is filled with an ideal splash, the autosplash, whose perfection may never be realised". Eventually, to show the amazing beauty and regularity of these liquid explosions, he helped himself to state of the art cinema photography, superimposing pictures of splashes in a masterpiece of scientific imaging, *A Study of Splashes* (1908). In the epoch of dreadnoughts and high-powered guns, the naval scientist's work wasn't entirely innocent. The frontispiece of his book showed what happened when shells pierced the armour of a battleship.

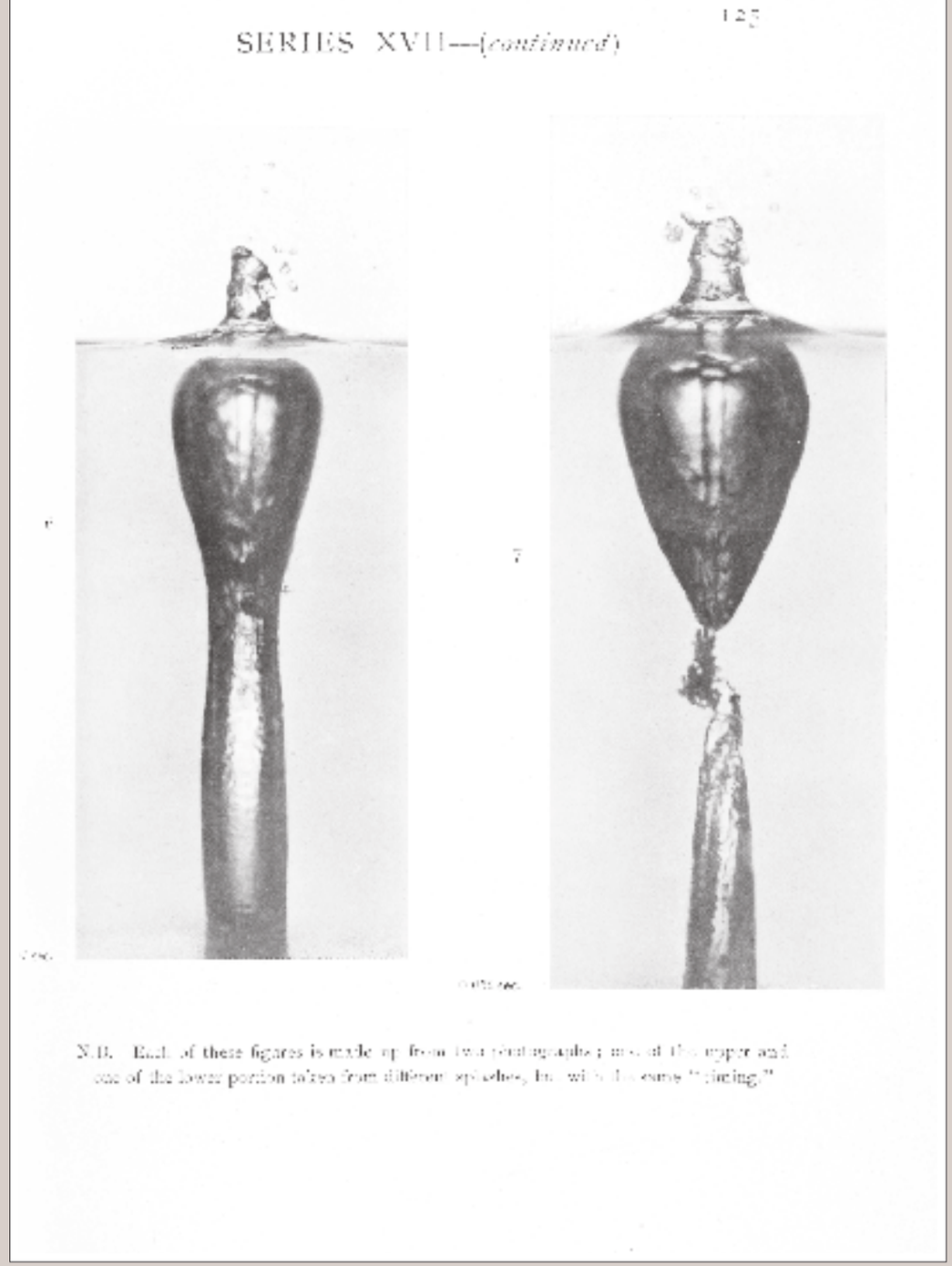


Permanent Splashes
left where a Projectile has entered an Armour-plate.

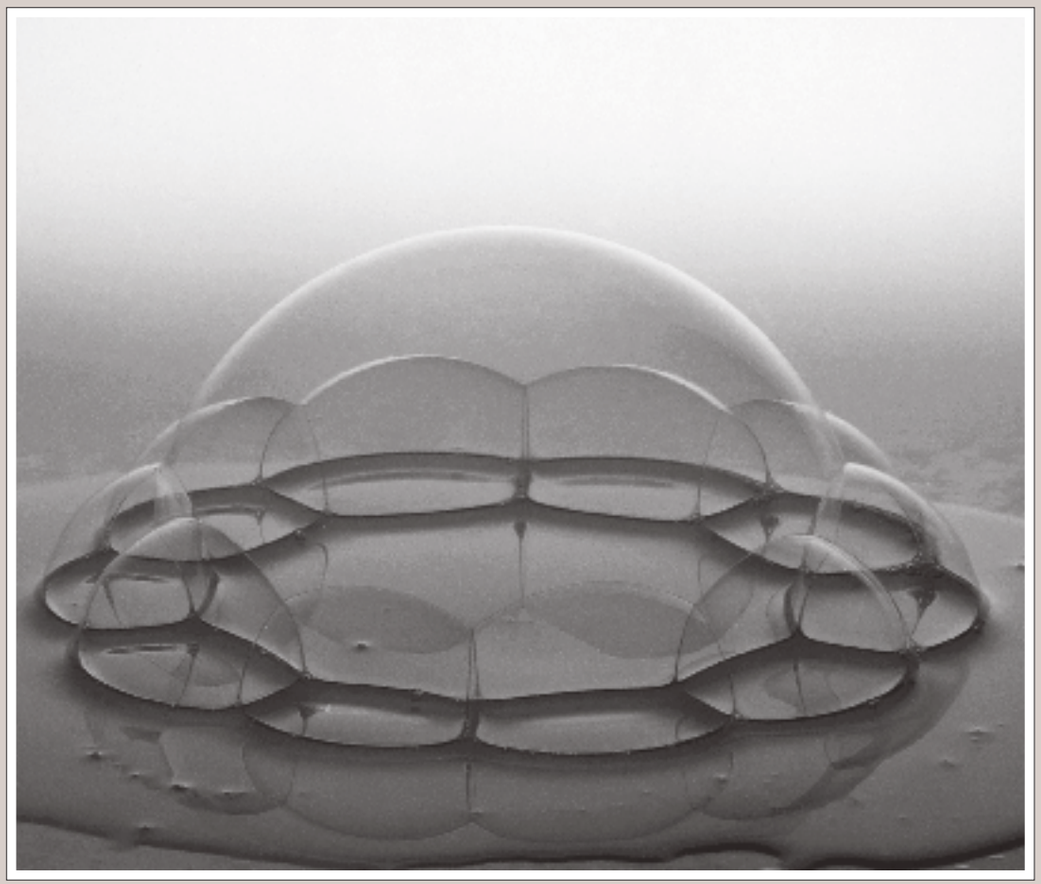
(See page 147.



A. M. Worthington, *A Study of Splashes*, London, 1908
A rough sphere falling 140 cms into water



IL18, FORMING BUBBLES
A HEMISPHERICAL BUBBLE SURROUNDED BY A RING OF TEN BUBBLES
ARRANGED ON THE FREE BOUNDARY OF A WETTED PLATE
INSTITUTE FOR LIGHTWEIGHT STRUCTURES
STUTTGART
1985



Bubbles are balloons, lenses and toys with fascinating life stories. Because they come into being and pass away, their lightness had long been a symbol of childish innocence and their transience a symbol of vanity and inevitable death. Bubble physics properly began with the nineteenth-century Belgian experimenter Joseph Plateau, a scientist who cared how things looked. He lost his sight through trials on the persistence of vision; but even when blind he made amazingly long-lived bubbles from glycerine and soap, showing that they naturally stabilised as perfect spheres, and that in films three surfaces would always meet along a curved edge at angles of 120 degrees. His friend Michael Faraday joined in the bubble quest: "what a beautiful and wonderful thing a soap bubble is." Lectures on bubble physics, equipped with high class soap, gas canisters, and flashing lights, entertained the crowds, who were sometimes inundated with bursting sheets and films. "Even though everything seems to be at random," Plateau argued, "such foam must obey the same laws."

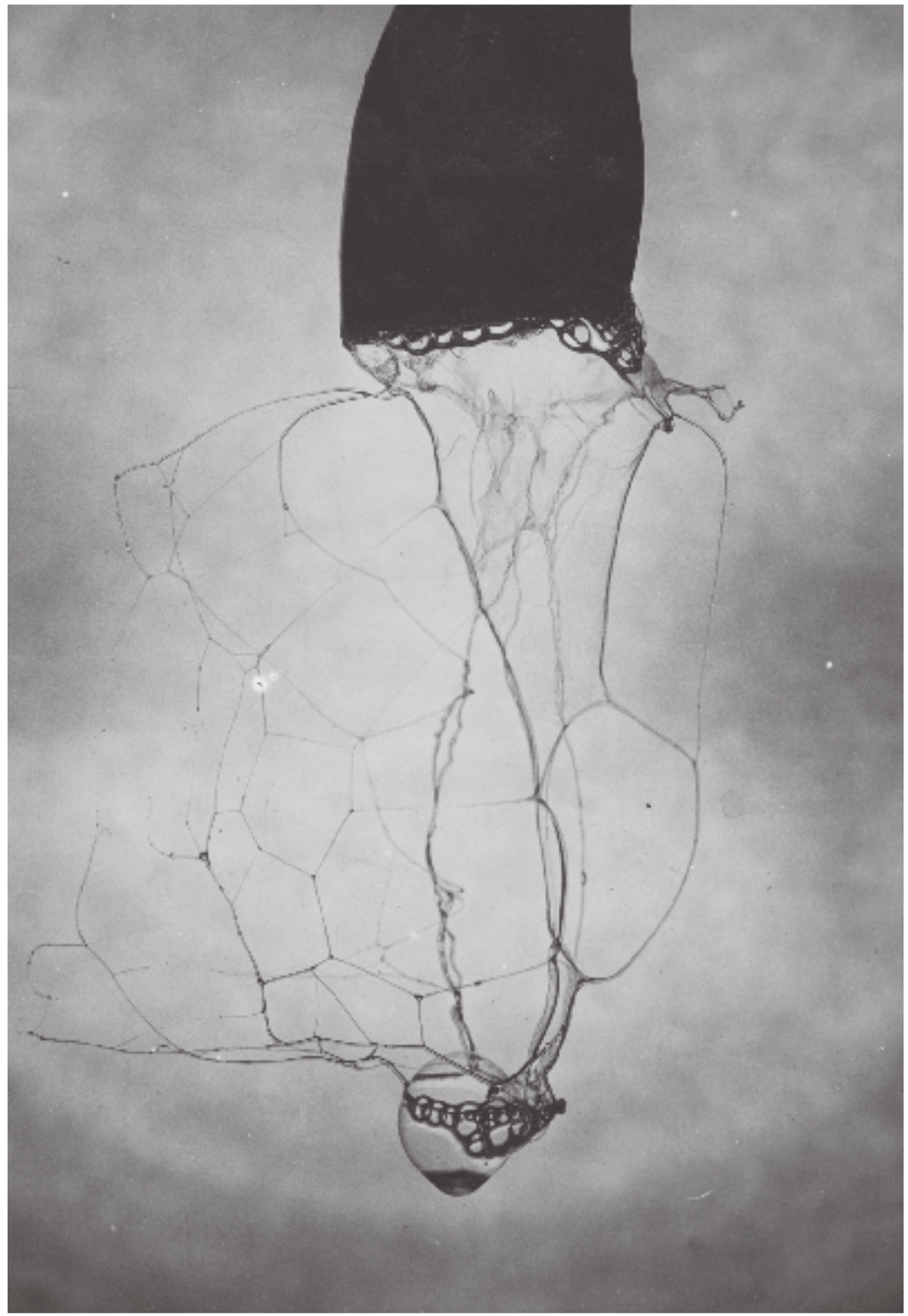
The great Scottish physicist Lord Kelvin, who used hot baths to experiment on the laws of bubbles, even managed to work out how a bubbly foam could fill all space with minimum surface area for each bubble: Kelvin's bedspring, as it came to be known, would be a *tetrakaidekahedron*, with six square and eight hexagonal faces. (In 1994 a group of Dublin physicists used a topological computer program to derive an even better solution than the Bedspring which incorporated a fourteen-sided structure of twelve curved pentagons and two hexagons.) "The questions involved in the seemingly simple operation of blowing bubbles were amongst nature's greatest enigmas," wrote Kelvin's niece Agnes. His admirer D'Arcy Thompson soon picked up these soapy calculations to show how embryos and cells must be packed according to the very same physical laws as bubbles and foams.

Courtesy of ILEK, Institut für Leichtbau Entwerfen und Konstruieren, Universtät Stuttgart, Germany

HAROLD EDGERTON
SOAP BUBBLE BURST, 1935
SILVER GELATIN PRINT
TIME-LAPSE PHOTOGRAPH – THE FINAL IMAGE OF A SERIES OF 3
PUBLISHED IN EDGERTON'S BOOK *FLASH*, 1939

The physics of bursting made bubbles one of the most important interests of newfangled scientific and artistic image machinery. MIT engineer Harold Edgerton's strobe photos of bursts, splashes, bubbles, balloons and bullets pushed the boundaries of this obsession with fixing the transient in film. From the early days of photography fixing moving things presented specific challenges. Etienne-Jules Marey developed a photographic gun to capture motion and along with Eadweard Muybridge pioneered the subject of chronophotography which can be divided into two approaches - Motography (continuous exposure) and Strobophotography (intermittent exposure). Harold Edgerton was the master of Strobophotography. Working in his Lab at MIT he developed strobe lights that could flash up to a million times a second enabling him to freeze motion. The processes he perfected resulted in more detailed photographs than Arthur Worthington had been able to achieve with his relatively simple timing systems. In the first edition of D'Arcy Wentworth Thompson's *On Growth and Form* Worthington's photographs were used in the discussion of the forms of cells. In the second edition Edgerton's images are also used.

With his process of high speed capture Edgerton was able to reveal exactly how a soap bubble burst, how the bullet enters and exits the bubble and how the film of the soap bubble peels back causing secondary holes to appear until only the connecting strands exist for a brief moment.



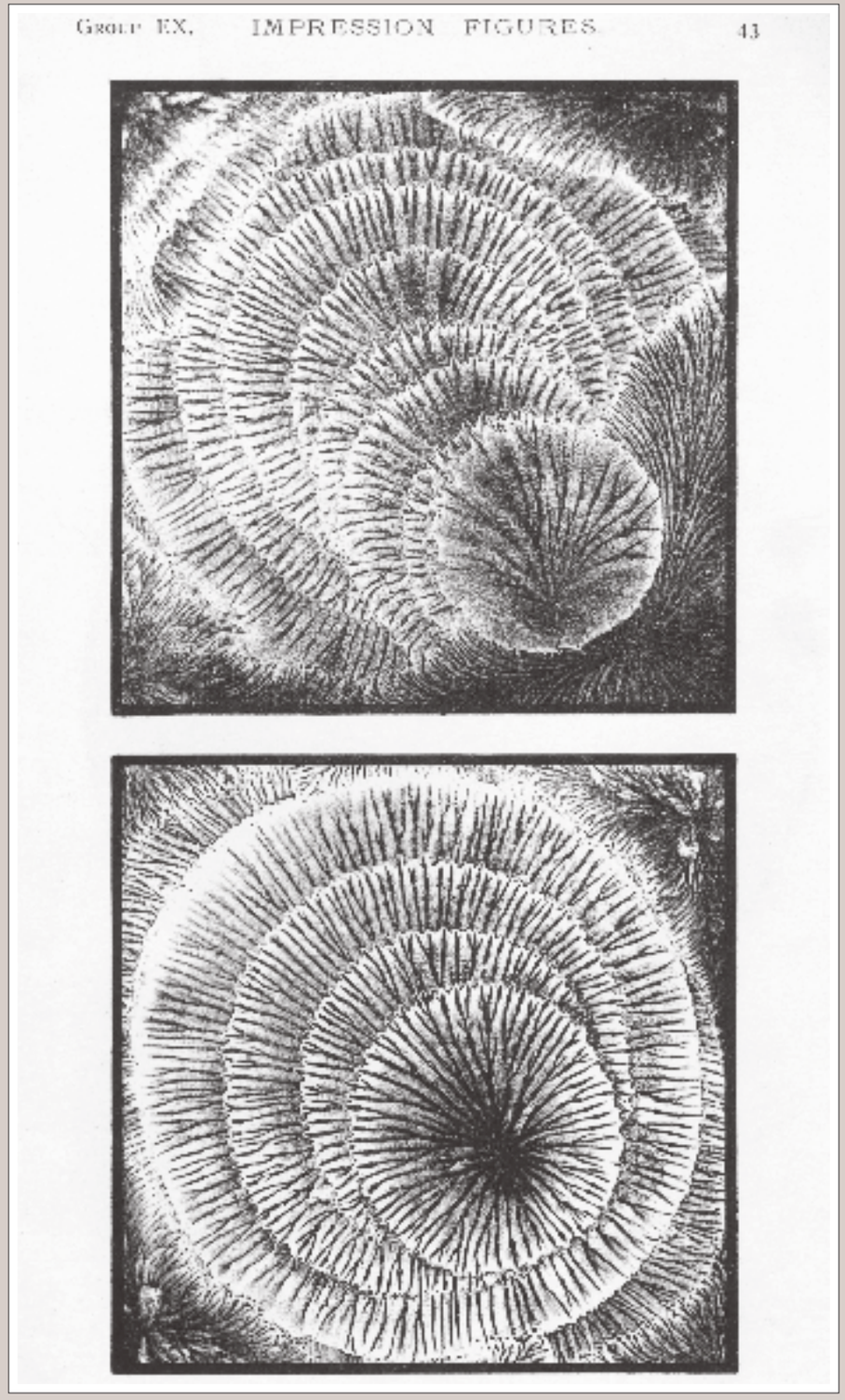
DAVID MEDALLA
CLOUD CANYONS
SOAP AND AIRPUMP IN BOX
1964

While bursting bubbles and fixing the moment on film was the preoccupation of Harold Edgerton in the late 1930's, others were to focus on their generation. In David Medalla's *Cloud Canyons* a wooden box slowly but surely pumped out a stream of bubbles. As they emerged from the hole in the box they took on a homogenised string-like form; convoluted, intricate and continually mutating. The gentle sounds of the tiny bubbles bursting, mixed with the occasional plop as they fell from the table to the floor, added a sonic dimension to the ephemeral event.

Photograph by Clay Perry, England & Co. Gallery, London

MARGARET WATTS HUGHES
VOICE FIGURES
LONDON
1891

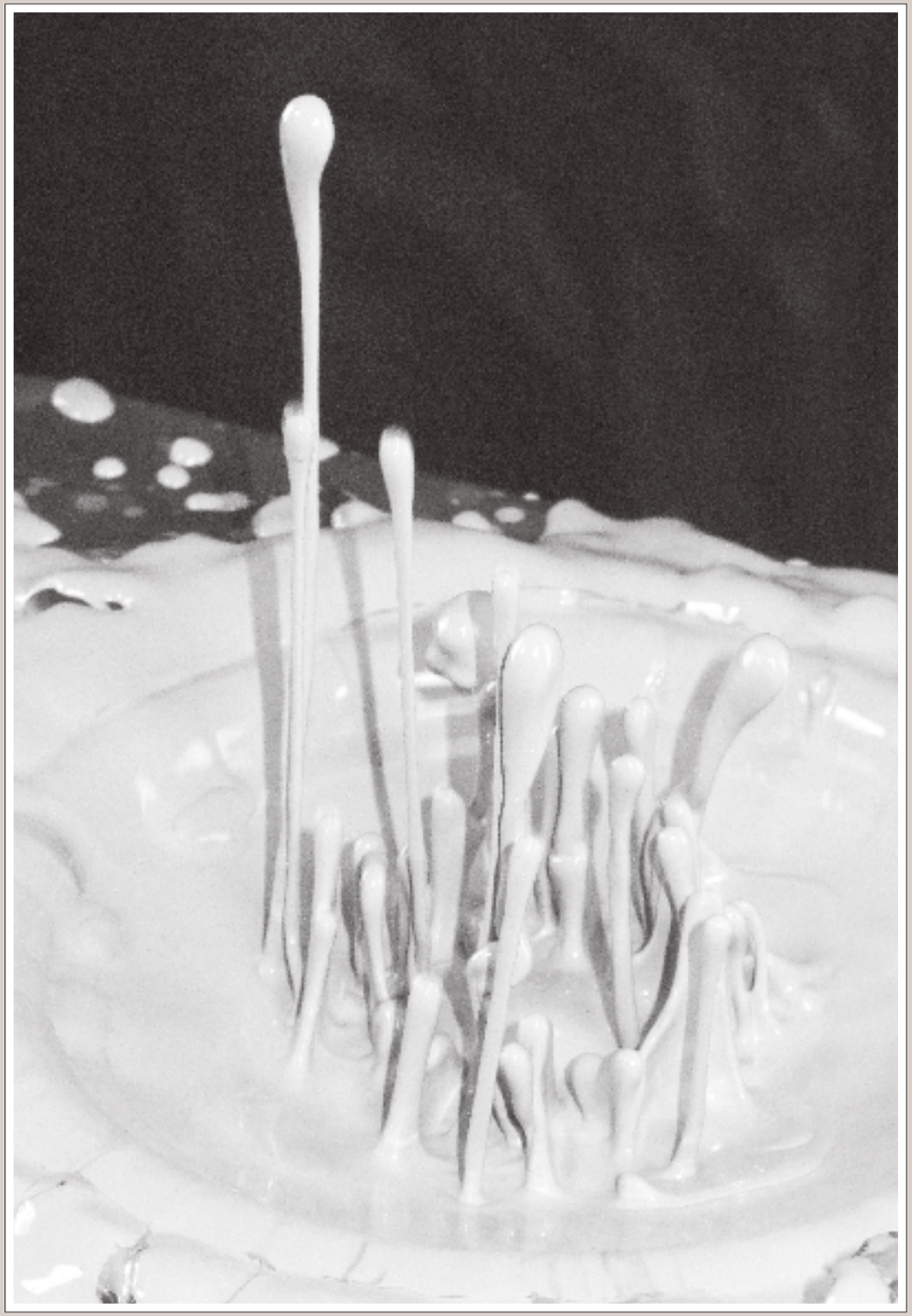
Surface tension and membranes are the key elements in Margaret Watts Hughes' two main publications, *Voice Figures,* 1891, and *Eidophone Voice Figures,* 1904. The images made by Margaret Watts Hughes depend on the interference and adhesion patterns caused when a vibrating elastic membrane is separated from a glass plate covered with watercolour paint. The viscosity of the paint constrains the appearance of the patterns, producing a variety of marks either geometric and regular or unpredictable and organic, resembling plants. The images she produced are expressed, not plotted – she described her feelings of great release from resistance at the point where the aparatus suddenly began to respond to the sound with patterns. Her images prefigure the decalcomania works by Max Ernst and Oscar Dominguez. But whereas they were seeking to exploit chance, Mrs Hughes was preoccupied with visualising sound with all its subtle nuances of sensory information. Under the influence of Walter and Annie Besant she went further than this and attempted to use the sonic images to record the presence of spirits and ghosts.



NATHANIEL MANN
3 DIMENSIONAL SOUND
CORNFLOUR AND HEAVY LIQUID WITH SUB WOOFER
2009

By mixing cornflour with a heavy liquid it is possible to create three-dimensional manifestations like those Margaret Watts Hughes generated with her Eidophone. The frequency of the sound initially forms Chladni patterns in the thick mixture, but as the volume is increased these rise into finger-like protrusions that act like the Hydra, generating new fingers as they collapse.

Photograph by Alicia Guirao del Fresno



CRACKED SURFACE
TEST FOR ANISH KAPOOR MADE BY FACTUM ARTE
GESSO OVER PLASTER
2007

The word *genetics* was invented by the Cambridge scientist William Bateson in 1906. He knew all about the science and art of breeding and variation: his father had been head of his Cambridge college; his feminist sister was a distinguished historian; his son would help invent cybernetics. As the University's first genetics professor, Bateson taught how different characters in offspring must suddenly emerge from regular patterns within factors inherited from parents. Cell biologists could see dark-staining strands inside cell nuclei that they called *chromosomes* that must be home to these factors. Some American biologists identified hereditary material with the stuff inside these chromosomes and invented the word *gene*. They argued that genes must be arranged in very long lines inside each chromosome. But the aesthetic and judicious Bateson detested this attempt to explain the sudden emergence of offspring's character by matter alone. "The appearance of chromosomes is not suggestive of strings of beads of extreme heterogeneity, but rather with that seen for example in drying mud."

A dried mud look-alike was not a plausible nor appropriate basis for life. Bateson moved down to a London suburb to run the high-powered John Innes Institute for plant breeding. Instead of muddy chromosomes and their unobservable gene strings, he compared the activity inside cell nuclei with transient eddies, spinning whirlpools and the gorgeous patterns of sound in sand. "The relation and likeness between two brothers is an expression of the same phenomenon as the relation and likeness between two leaves on the same tree - the resemblance which we call heredity may be a special case of the phenomena of symmetry."

Photograph by Alicia Guirao del Fresno

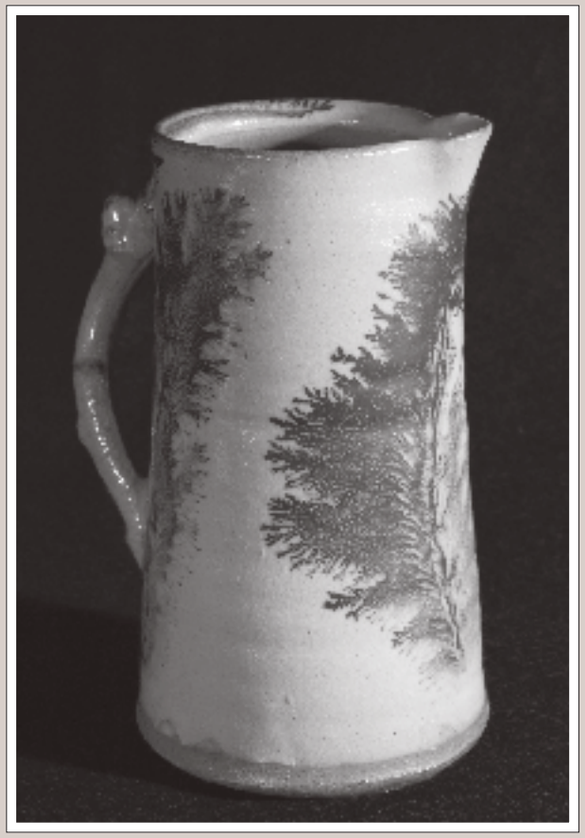
LEAD FORM
SPRING, 2007

The sense of mystery consists in the continuous ambiguity, in the double and triple aspects, hints of aspects (images within images), forms that are about to come into being or will take their being from the onlooker's state of mind. All things are more than suggestive, since they actually appear.

Odilon Redon, *Soi-même* journal 1867-1915

The example of entropy offered by Roger Caillois is simple: hot and cold water mixing together to settle into a uniformly tepid blandness. If molten lead is poured into water an entropic reaction takes place that results in physical evidence. In Austria this is done on New Year's Eve and is used as an augury to predict events for the coming year. Like reading tea-leaves or coffee grounds, the variability and complexity of the resulting deposits are suggestive of states of being and mind. Salzburg has a similar tradition where branches are left in the salt mines to form crystal growths of unpredictable size and form.

Photograph by Michael Perry



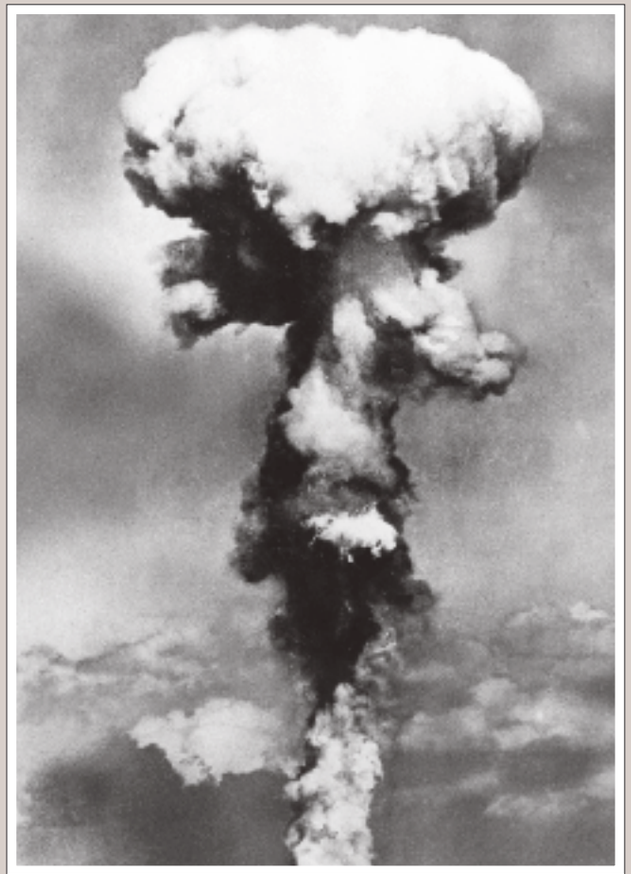
MOCHAWARE JUG
JANICE TCHALENKO
2003

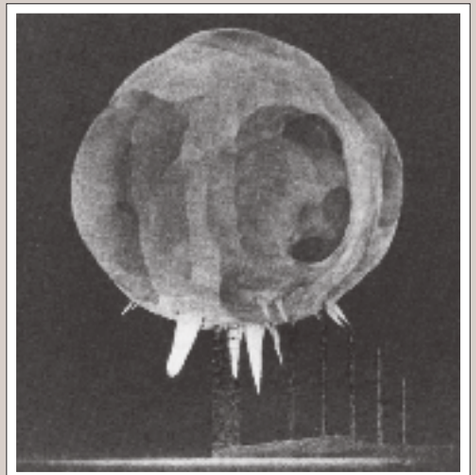
Mochaware (Mocha diffusion) is a glazing technique invented in Staffordshire, that gives rise to complex dendritic patterns on pottery. The recipe involves a "tea" made by boiling tobacco, which is then colored with a metal oxide. The piece is first coated with a wet "slip" and the tobacco mixture is dropped onto the wet surface. The acidic tobacco mixture reacts with the alkaline slip and the dendrites grow quickly from the point of contact.

The dendritic pattern is clearly the result of a dynamic process in which the contact line between the two liquids becomes unstable. The surface tension of the "tea" is less than that of the slip. The instability is probably driven by a combination of capillary and Marangoni (surface tension gradient) stresses, coupled to the acid/base chemical reaction.

Photograph by Alicia Guirao del Fresno

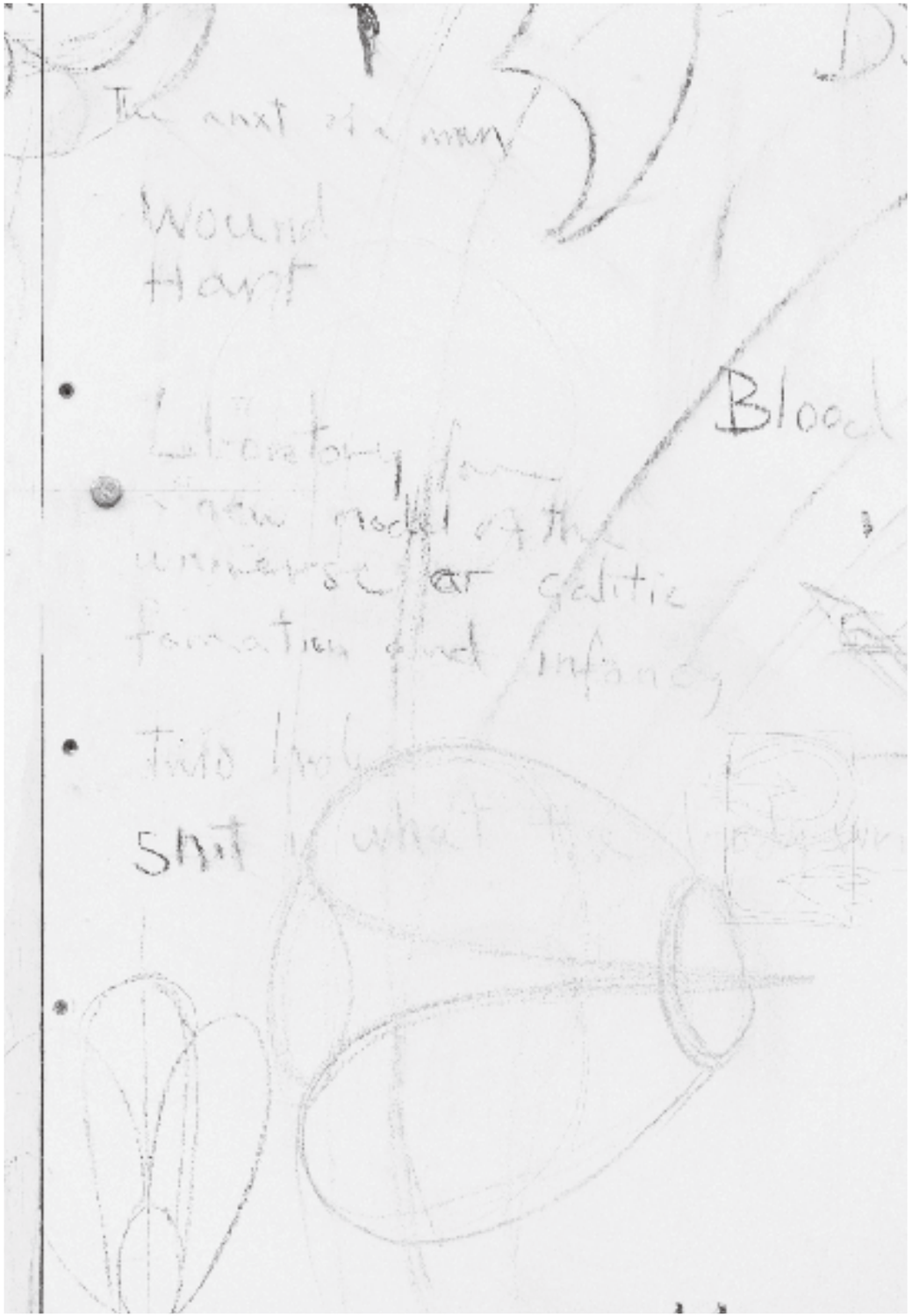
MUSHROOM CLOUD
OVER NAGASAKI
1945
The Fatman Mushroom Cloud rose 18 KM into the air above Nagasaki from the epicentre of the explosion in the centre of the city. The bomb, dropped on 9th August 1945, killed an estimated 80,000 people.



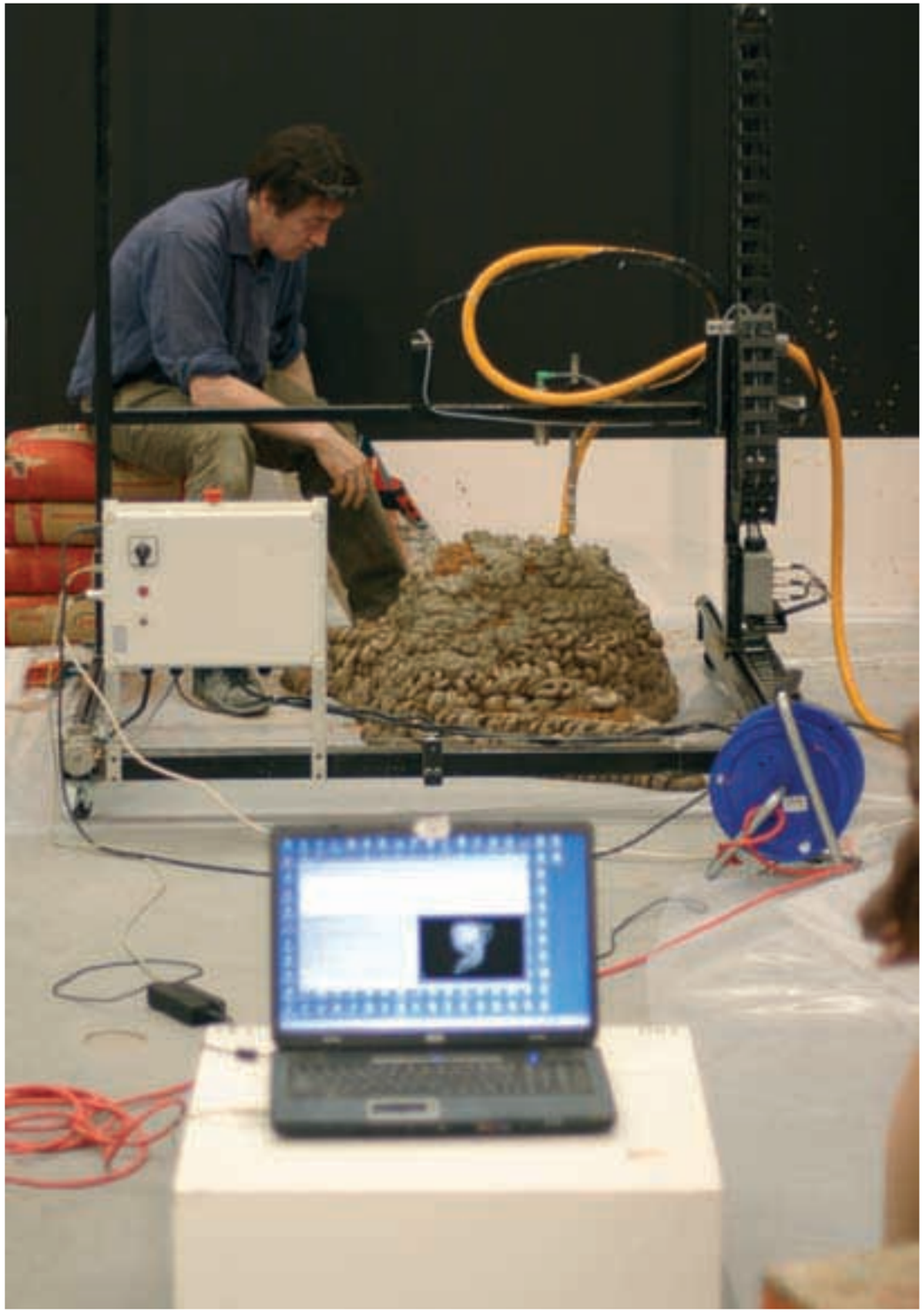


OPERATION TUMBLER-SNAPPER
NEVADA PROVING GROUND
1952
An image from one of the Snapper tower shots taken about one millisecond after the detonation. The spikes coming from the bottom of the fireball are the cables that stretch from the top of the tower to the ground. The mottled pattern in the photograph is a by-product of the effects of the explosion.

RIGHT: ALFRED OTTO WOLFGANG
SCHULZE, CALLED WOLS
1913 – 1951
Untitled. Silver Gelatin Print. Undated



Anish Kapoor



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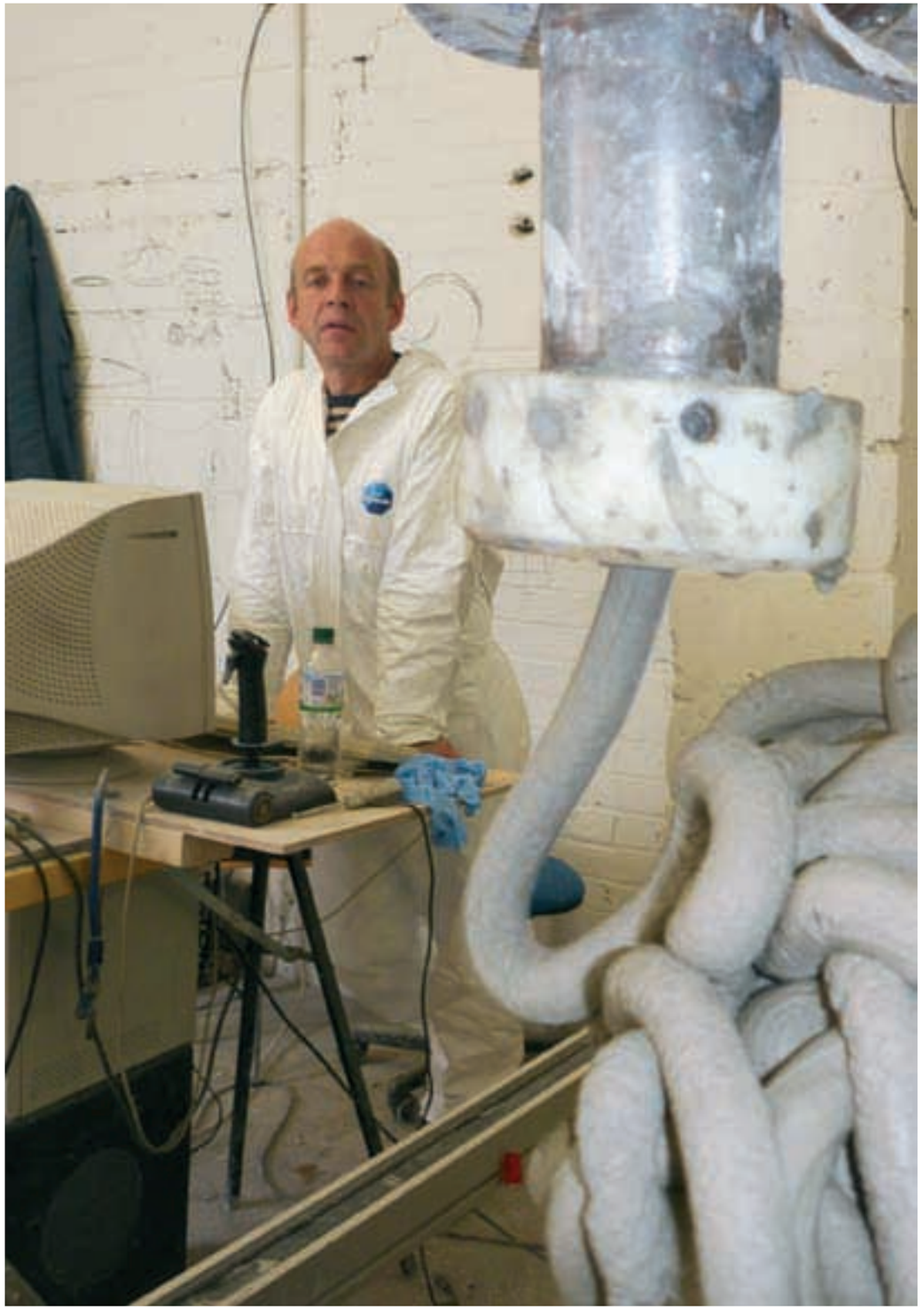
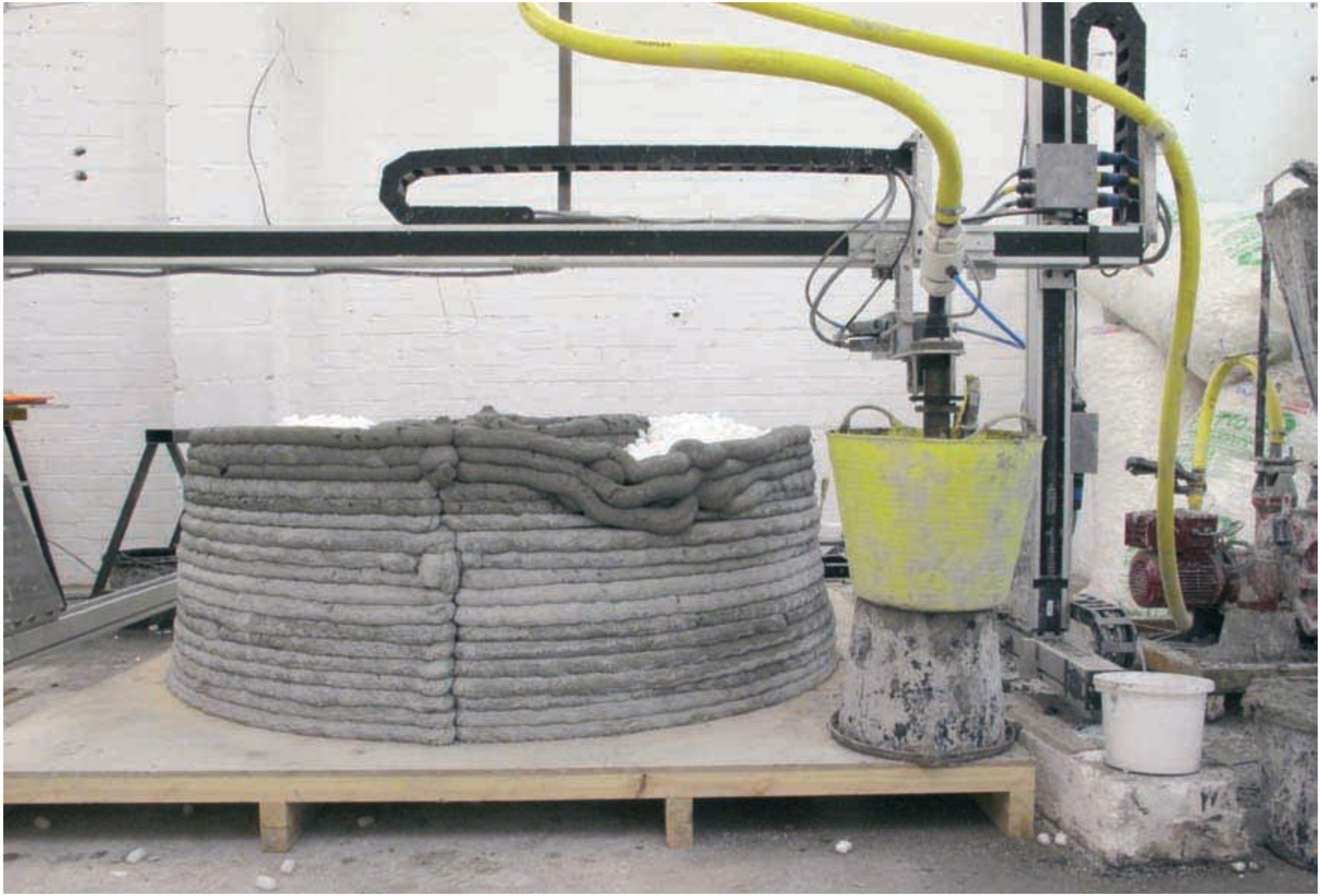
Dwight Perry and Piers Wardle



Michael Perry

Seth Pimlott and Michael Ward.

Zac Russell



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