technical order in the programme, and Webb had less authority to impose his will on them. His determination to maintain a balanced programme and channel NASA funding into socially beneficial schemes was being overtaken by the budget and political crises of the Vietnam war. When he mentioned retirement to President Johnson in 1968, the president hastily called a press conference and practically pushed Webb out of the door. Both men were to attend the launch of Apollo 11 the next summer, but took less joy in the achievement than they might have otherwise.

Bizony tells this familiar story clearly and engagingly. To the existing literature he adds some interviews, primarily with Robert Seamans, deputy administrator of NASA under Webb. He quotes extensively from these sources, occasionally without making clear who is speaking. The result is 'Webb light', a fast-paced, breezy account weak on substance and contextualization. The book climaxes with the Apollo 204 crisis, followed by an impressionistic survey of NASA history since Webb.

The book is reasonably accurate and the undocumented opinions are plausible, but the account is unreliable on the details and silent on the complexity of Webb and the times in which he operated. Similarly, Webb's system of 'management by exception' is not discussed at all. Even so, it is an entertaining introduction to Webb, but it should be supplemented with W. Henry Lambright's *Powering Apollo* (Johns Hopkins University Press, 1995), Arnold Levine's *Managing NASA in the Apollo Era* (NASA, 1982) and Webb's own *Space Age Management* (McGraw-Hill, 1969). These books offer further insight into whether complex scientific and engineering projects on the scale of Apollo, with all their conflicting political, budgetary and technical demands, are manageable in any sense that Webb would have understood. ■

Alex Roland is in the Department of History, Duke University, Durham, North Carolina 27708, USA.

Opposites attract

Measuring the World
by Daniel Kehlmann,
transl. by Carol Brown Janeway
Pantheon: 2006. 259 pp. $23. To be published in the UK by Quercus in April.

John Whitfield

Quite often, it strikes me that being a scientist is an odd way to spend your time. We all ask the same questions. Where do I come from? Where am I going? What does it all mean? Yet few — and only relatively recently — have chosen the scientific method as the means to answer them. And for those who have, many of their answers seem as impenetrable and marginal as avant-garde poetry or 'squeaky gate' music.

Daniel Kehlmann's neat novel *Measuring the World*, a bestseller in Germany last year under the title *Die Vermessung die Welt* and now translated into English, provoked these thoughts once more. The book is set in the late eighteenth and early nineteenth centuries, when the structures of science, and the job of being a scientist, began to take on something like their present form. It weaves together the stories of two of the giants of the time: the mathematician Carl Friedrich Gauss and the explorer, geographer and biologist Alexander von Humboldt.

Kehlmann deploys the two men as archetypal and opposite examples of how to be a scientist. The core of Humboldt's story is his five-year journey to the Americas, which made him famous and had a huge influence on nineteenth-century naturalist travellers including Charles Darwin and Alfred Russel Wallace. But the journey makes no apparent impression on Kehlmann's Humboldt. He is the embodiment of cold rationality, a Gradgrind who, lacking any personality or inner life, builds one out of facts and measurements. He'd rather stare down his sextant than look at a solar eclipse, and rather study a woman's lice than have sex with her. He chases up rivers and mountains, oblivious to hardship, with French botanist Aimé Bonpland as his Sancho Panza.

Gauss, on the other hand, hates going anywhere. But then, he doesn't need to — from childhood, revelation comes to him, in an unbidden stream of mathematical genius. He sees science as "a man alone at a desk, a sheet of paper in front of him". This is also novel writing, so perhaps it is not surprising that Kehlmann makes Gauss the more sympathetic and, despite his freakish abilities, the more human character. He worships his mum, falls in love, visits prostitutes, and has children who disappoint him.

Humboldt is a cipher. This also has the effect of making Gauss's way of doing science seem more noble and authentic than Humboldt's. It isn't, but this is a neat twist, as mathematicians are usually the ones portrayed as weirdos.

It would be just as silly to complain that Gauss and Humboldt probably weren't much like this as it would be to object to Peter Shaffer's play *Amadeus* on the grounds that Salieri probably didn't aim to bump off Mozart. I will, however, make one point in Humboldt's defence. Kehlmann is truthful to the facts of his biography, and Humboldt was an enigmatic man, who tried to destroy documents pertaining to his early life, and who might have substituted work for emotional fulfilment. (There has been speculation, to which Kehlmann briefly alludes, that this is because Humboldt was homosexual.) But he knew how to do the right thing. Bonpland returned south to America but was caught in disputed border territory and imprisoned. Kehlmann's Humboldt wrings his hands; the real Humboldt, in contrast, sold his world-class collection of plant specimens to provide his friend with financial support.

Kehlmann skilfully stops *Measuring the World* becoming a highbrow tale of nutty professors. For a start, his professors are more melancholic than nutty. Gauss's prodigious abilities — and his decision to be true to them, even at the cost of his own and others' happiness — cut him off from people, and everyone else's stupidity depresses him. Humboldt's political, administrative and official duties gradually overwhelm his opportunities to take measurements, and in old age he reprises his American journey in Russia, as farce. Each learns that no degree of cleverness or immersion in science grants immunity from, or even helps much with, the messy business of life and death.

Kehlmann also avoids naffness by telling

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Carl Friedrich Gauss (left) and Alexander von Humboldt had very different views of how science should be done.

his story in a relentless deadpan, which is at first alienating but then gets under the skin. As the story develops, your sympathy for the two men grows, as their own does for each other. One of the things they agree on, for example, is the deplorability of "novels that wandered off into lying fables because the author tied his fake inventions to the names of real historical personages".

Kehlmann, then, does a good job of capturing the strangeness and comedy of science, as well as the powerful sense of futility that can afflict researchers from time to time. But he doesn't get near to explaining why, despite its oddness, science provides such powerful and beautiful answers to our questions, or why mathematics has such an uncanny power to provide these answers. Nor do we get any idea why a few people, such as Gauss, have mathematical abilities that seem supernatural to the rest of us, or why others, such as Humboldt, are willing to give up their fortunes, comforts and sometimes lives to see, and measure, what's over the horizon. Quite right too, I'm tempted to think — where would the fun be in knowing that? ■

John Whitfield lives in London and is the author of *In the Beat of a Heart: Life, Energy, and the Unity of Nature* (Joseph Henry Press).
www.inthebeatofaheart.com

SCIENCE IN CULTURE

The molecular landscape

Lucia Covi uses modern microscopy to highlight the world at the nanoscale.

Martin Kemp

"We are 'connoisseurs of chaos', patterners. So we look for resemblances to things in our experience... The gold tip is a digital Tower of Babel, or a wedding cake. And a fractal set, and the electron microscope image I once saw of a small worm's mouth."

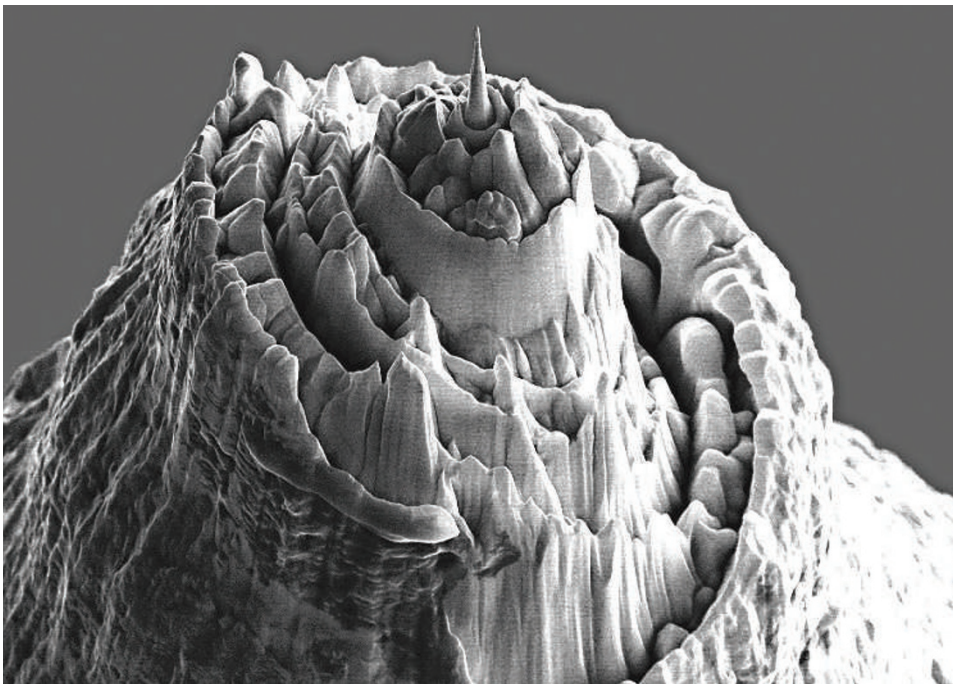
So says Roald Hoffmann, winner of the 1981 Nobel Prize in Chemistry, in his introduction to Lucia Covi's book *Blow Up: Images from the Nanoworld* (Damiani Editore, €26; www.damianieditore.it). Hoffmann's brief essay should be compulsory reading for anyone involved with machine-generated images in either science or art.

Covi is a Milanese photographer who has worked with Elisa Molinari and her colleagues at the Italian National Research Center on nanoStructures and bioSystems at Surfaces in Modena. Together they have made extraordinary structures visible at the scale of millionths of millimetres. Covi's book was published to mark an exhibition previewed at the 2006 Genoa Science Festival and now on show in Modena (www.s3.infm.it/blowup). It also stands on its own as a visually and intellectually stimulating panorama of images from the strange yet somehow familiar nano-landscapes of modern microscopy.

Covi has turned scientific data into 'photographs' to magnify their visual impact. This often involves limiting the propensity of scientists to render their computer images in garish colours, a cacophony of metallic hues and tones. To make the images appear convincing and highlight their beauty, all the visual effects need to be internally consistent. As Hoffmann declares: "Differences in surface texture, in smoothness and roughness matter. They are compared in our brain with memories of tangible objects." Internal visual consistency is an incredibly subtle matter.

The image of the gold tip (shown here), specifically mentioned by Hoffmann and used on the cover of the book, was captured by a scanning electron microscope focused on the tip of a probe used in scanning near-field optical microscopy — one microscope in effect scrutinizing another.

Just like Robert Hooke, when he described the wondrous little 'engines' and landscapes he witnessed when compiling his *Micrographia* in 1665, we automatically draw perceptual parallels with familiar objects when we see new structures.



Making a point: a gold tip used in microscopy resembles Brueghel's Tower of Babel.

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Now, in this age of fractal landscapes in science fiction and animated films, my first thought when seeing the gold tip is of a fantasy castle constructed on a conical mountain-top. Or, to pick up Hoffmann's more erudite, historical parallel, the Tower of Babel as characterized in Pieter Brueghel's amazing sixteenth-century painting.

The gold tip is an artefact of the nano-sculptor's craft. It was sculpted by milling with a focused ion beam, a top-down process. Other images in the book show structures that have self-assembled spontaneously, in a bottom-up manner.

At this scale — as perhaps at every level of the structural organization of the material world — the basic building blocks aggregate and form into morphologies that are recognizably regular yet irreducibly individual and unpredictable.

My one quarrel with Hoffmann is when he declares: "No one is born with a feeling for harmonious arrangement." My conviction is that our systems of perception and cognition are profoundly endowed with an innate propensity for discerning levels of order and disorder, which I have termed 'structural intuition'. The images in Covi's book present a veritable field day for the exercising of this propensity — whether we think it is taught or innate, or a compound of both.

Martin Kemp is professor of the history of art at the University of Oxford, Oxford OX1 1PT, UK. His new book, *Seen | Unseen*, is published by Oxford University Press.