



LEFT: RICHARD MASSEY; RIGHT: MARTIN KORNMESSER/ESA/HUBBLE

A two-dimensional map (left) of the Universe's mysterious dark matter can be translated into three dimensions (right) for clarity and impact.

VISUALIZATION

Picturing science

Katy Börner weighs up a lavish, lab-friendly guide to transforming dry data into insightful images.

Images of scientific results matter. They support data exploration and communication, and are particularly valuable in the age of big data. They help to transcend disciplinary, cultural and language barriers. Some are truly beautiful, and are displayed in art museums. Others have gone viral on the Internet. A select few — such as Darwin's tree of life or Watson and Crick's DNA structure — have changed our view of the world forever.

Given the importance of imagery in science, it is surprising that few scholars are properly trained in graphic design or data visualization. *Visual Strategies* aims to redress the balance in a format resembling a lavish 'Design 101' textbook — complete with tabs to ease navigation and a plastic cover suited to the wet lab. Felice Frankel and Angela DePace aim to guide scientists and engineers to create graphics that effectively communicate research results. Their case studies gain much from DePace's systems-biology research and Frankel's decades in science photography and image-making, which are showcased in books such as *Envisioning Science: The Design and Craft of the Science Image* (MIT Press, 2002).

Frankel and DePace have identified three main types of visualization: form and structure, process and time, and compare and contrast. The first part of *Visual Strategies* is structured around these categories, and the

18 before-and-after examples within them are among the book's major assets.

For each example, the answers to five key questions are given — the graphic's intended audience, usage, goal and challenges, as well as suggestions for best approaching its design — along with a list of 'graphical tools' that identifies the approaches used to improve the visualization. The list covers composition, abstraction, colours and layers, as well as refinements used to make the image both insightful, and compelling enough to drive the message home.

A number of case studies and interactive graphics, originally published in leading science journals, are also reproduced, with descriptions and comments by the authors. Interactive graphics that support the book's content can be accessed online, along with the sharing and discussion of graphics (<http://visual-strategies.org>). The book concludes with a 'visual index' that provides references for all of the examples; the appendix



**Visual Strategies:
A Practical Guide
to Graphics for
Scientists and
Engineers**

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Yale University Press:

2012. 160 pp.

£25.00/\$35.00

introduces the online forum.

Frankel and DePace's three visualization types make up just one system in a hugely varied field. IBM's ManyEyes website (www-958.ibm.com), for instance, allows users to generate visualizations to reveal relationships between data, compare data values, track rises and falls over time, see parts of a whole, analyse text and generate maps. By contrast, Nathan Yau's *Visualize This: The Flowing Data Guide to Design, Visualization, and Statistics* (Wiley, 2011) distinguishes five types of visualization — patterns over time, proportions, relationships, differences and spatial relationships — and also looks at identifying the 'story', handling data and selecting tools.

Beyond identifying and explaining different visualization types, writing a practical guide entails deciding the number and content of examples needed to illustrate workflows and key design decisions, and whether they should be concrete or abstract; specific or general; simple or complex; focused or diverse. In *Visual Strategies*, the before-and-after examples cover many areas of science in great detail — such as the 'quantum corralling' of iron atoms, or the loss of neurons in specific parts of the brain in patients with Alzheimer's disease. One is left with a deep admiration for scientist-designers such

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For a review of Frankel's work on the nanoscale, see: go.nature.com/qvaaxl

as Frankel, who within a few weeks or months manage to understand scientific problems and solutions, and ‘translate’ them visually to communicate important structures and dynamics to a large audience. Although the concrete examples are helpful, their complexity and diversity makes it hard to extract general strategies for effective visualization design. A glossary would have helped to define the terminology used.

As admirable as all these guides — including Frankel and DePace’s — are, what is really needed is a general theory for the effective teaching and usage of graphical methods. It might be time for another round of US National Science Foundation workshops or Image and Meaning events (www.imageandmeaning.org), which bring together scientists, writers and visual communicators to develop and share improved methods of communicating scientific results through images and visual representations.

Such a theory would build on a range of sources, such as William Playfair’s 1786 publication *The Commercial and Political Atlas*, Jacques Bertin’s 1967 *Semiology of Graphics: Diagrams, Networks, Maps*, John Turkey’s practical epistemology, Bill Cleveland’s combination of statistical and experimental evidence, Edward Tufte’s many examples of “beautiful evidence”, and Leland Wilkinson’s *The Grammar of Graphics* (Springer, 2000). It would draw from psychology, cartography, statistics and other sciences that use data analysis, visualization, graphic design and illustration.

That theory might in turn become the basis for a ‘visualization design cookbook’. Taking the reader’s information needs as input, this would output a ‘shopping list’ of relevant data sets, tools and workflows; detail and exemplify each data analysis and visualization step; show pictures of the anticipated end result; point out major challenges; and provide suggestions on how best to meet them. Then, all you would have to do is find the best ‘recipe’, follow the instructions, make and interpret the visualizations — and the power would be with you. ■

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RENAISSANCE ART

Puzzles beneath Dürer’s paint

Alison Abbott assesses an infrared analysis that could point to the artist’s real ambitions.

Albrecht Dürer (1471–1528) — painter, print-maker and author of books on mathematics, perspective and other aspects of applied science — has been a magnet for art historians since his youth. Nearly 11,000 books and articles have been written about him and his works. Is there anything left to say?

Yes, thanks to a three-year grant from the German government, which has funded an unusual collaboration between art historians and scientists at the German National Museum in the artist’s hometown, Nuremberg. The scientists used infrared reflectography systematically to look beneath the surface of Dürer’s paintings around the world, and revealed that the levels of detail in the underdrawings vary, both within and between paintings. Their insights now inform the museum’s latest blockbuster exhibition, *The Early Dürer*. The art historians involved speculate that the Renaissance man’s main ambition was to be an art theorist.

The son of an immigrant goldsmith, Dürer quickly emerged as a force to rival his contemporary, Leonardo da Vinci. Venetian painter Giovanni Bellini is said — perhaps apocryphally — to have asked Dürer for the brush with which he crafted his startlingly realistic beards, with their individual hairs. Dürer gave him an ordinary brush; it was his skill that was extraordinary.

But geographically distanced from the major centres of European art in Italy and the Netherlands, how did Dürer develop his painterly skills? Was he primarily a businessman generating brilliant prints for cash, or a selfless genius in the service of art? Was this prolific self-portraitist, who signed his works with a curious monogram, really an egomaniac? The research project provided no conclusive answers to the many open questions, but did generate a horde of facts for art historians to chew over.

In 2009, the scientists packed up their mobile infrared-reflectography machine for a tour of Dürer’s early paintings in 20 museums and private collections in Europe and the United States.

Until then, art historians had made much of the scraps of underdrawing

The Early Dürer
Germanic National
Museum, Nuremberg.
Until 2 September
2012.



Albrecht Dürer’s *Self-Portrait* (1500) was a private attempt to stretch the limits of technique.

revealed by thinning patches of paint or partial infrared analysis. But this systematic analysis of 45 paintings shows that the underdrawings don’t actually reveal much about Dürer’s artistic development.

What they do reveal is the extreme effort that Dürer put into the works he did not intend to sell — such as his self-portraits — in comparison with the works that he did under commercial contract. The detailed underdrawings of his self-portraits indicate his attempts to push the boundaries of artistic technique. The curators speculate that the self-portraits — the last completed when he was just 28 — represent his early, innovative striving for perfection. He may, they posit, have generated his large body of commercial artworks, with their varying levels of workmanship, to gain economic freedom to carry through his great ambitions in art theory. Dürer had planned a series of ten volumes on art theory, but died before he could finish the task. ■

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