

sciences, which results in far too strong a demarcation of ‘old’ and ‘new’ biology. This is not to deny that important changes have taken place: in the past three decades the relationship between theory and data indeed has changed in biology. Developments as described by Stevens have led to a torrent of data, which in many cases cannot easily be subsumed under a common theoretical framework – a hypothesis-driven science may not be sufficient to do justice to the information contained in the data. It supposedly becomes ever more necessary to let ‘the data speak for themselves’ (this expression, often attributed to R.A. Fisher, is misleading given the heavy statistical processing involved). Although the sheer amount of data might very well be unique to molecular biology from a logistical point of view, on a methodological and epistemological level similar challenges and opportunities also occur in other biological disciplines. For instance, most ecologists would be surprised to read that ‘data-driven’ approaches relying on statistical methods to extract significant patterns from large data sets are characteristic of bioinformatics and can serve as a criterion to distinguish ‘old’ from ‘new’ biology. The author relates how he, during fieldwork in a Harvard lab, was tasked with developing a method to detect patterns in alternative splicing of messenger RNA. He employed what apparently was a statistical resampling technique to assess the significance of the detected patterns, and claims that this experience illustrates that bioinformatics entails new criteria for evaluating knowledge claims. However, in ecology such statistical techniques have been commonly used since the 1980s to detect competition and other complex processes. In addition, the distinction of data production and data ‘consumption’ (i.e. creating new knowledge from the data) and the resulting conflicts remind me of a number of similar struggles in other biological disciplines. There might be less money and prestige at stake, but in ornithology a lot of data is generated by eminently skilled, knowledgeable and experienced amateurs, yet most of the published science is created by academic researchers. ‘Citizen science’ is one attempt to overcome this division.

I tend to give Stevens the benefit of the doubt and assume that statements such as that ‘data only belong to computers; they are part of a set of practices that make sense only with and through computers’ (p. 7) are meant to provoke and should not be taken literally. Data always emerge out of the interpenetration of material aspects and epistemological practices – whether it is a temperature reading from a mercury thermometer or an automated gene-expression microarray. It is an interesting, and as yet unresolved question, whether data quantity on its own leads to new ways of doing science with novel epistemological practices and norms. Stevens appears to promote such a view, but I am not persuaded given the material in his study. Despite these concerns, his book is valuable as an invitation to reflect on these challenges and as a demonstration of how a new, powerful tool can reconfigure work practices, professional standards and hierarchies, as well as fundamental conceptual outlooks.

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KAREN A. RADER and VICTORIA E.M. CAIN, **Life on Display: Revolutionizing U.S. Museums of Science and Natural History in the Twentieth Century**. Chicago and London: The University of Chicago Press, 2014. Pp. xiv + 467. ISBN 978-0-2260-7966-0. \$45.00/£31.50 (hardback). doi:10.1017/S0007087415000928

Visitors to San Francisco’s Exploratorium science centre around 1980 were presented with an unusual spectacle. A grasshopper under a small clear dome with wires inserted into its ventral nerve cord would generate oscilloscope motion and amplified clicks when disturbed. The visitor watched the grasshopper; the grasshopper watched the visitor. Except, as one might expect, because the visitors stopped being as interesting to the grasshopper as vice versa, soon the insect ceased to respond at all. Staff had similar problems with unresponsive fauna or flora in other live physiological displays, such as Brine Shrimp Ballet, which featured ‘sea monkeys’ swimming

towards light, and the mimosa plant, whose leaves recoiled when shaken. When the Exploratorium's heterodox director Frank Oppenheimer (brother of fellow physicist Robert) touched a mimosa leaf with his lit cigarette, he generated a swift and visible response; soon visitors were able to generate the same effect using heat wands.

Oppenheimer's cigarette is just one of many engaging details presented in *Life on Display*. Previous historians of biology and of display have recorded parts of the history of some US museums of natural history and science and technology. But Karen Rader and Victoria Cain have for the first time given us a full twentieth-century history, from the well-documented decades around 1900 to the historiographical *terra incognita* of the 1980s and beyond. Their coast-to-coast geographic span is also impressive. The Exploratorium's story is well known (if not its biology exhibits), as are those of the Smithsonian and the American Museum of Natural History in New York, which also feature prominently. But *Life on Display* also mines the rich histories of museums from Boston to Buffalo, California to Colorado.

The authors support their general observations about the attitude of the museum profession in any given decade with numerous episodes from individual institutions, while at various points connecting them to other cognate sites, including art museums, international expositions and theatres. The great men of American natural history are to be found here – George Brown Goode and Henry Fairfield Osborn – but they rub shoulders with a vast cast. American museum preparator James Clark, we learn, spent a budget Christmas alone in London Zoo in 1909; but returning in 1926 he stayed at the Ritz and dined with the Roosevelts. This was thanks to his hugely increased salary, by now far more than his curatorial colleagues earned – just one example of the authors' keen eye for resources and funding, and what this can tell us about the professional and political emphases of museums.

Rader and Cain use these and many other micro-histories to show that American museums were subject to multiple revolutions and uneven change throughout the twentieth century. Ecological collecting and life group displays had dominated before the First World War, while after it the introduction and impact of dioramas revived many natural-history museums, where live displays were already delighting visitors. (Oppenheimer would later ban the former in his commitment to the latter.) Elsewhere, dedicated museums of science and technology established themselves in the educational and heritage landscape with new approaches to display centred around human biology drawn from Europe, including the iconic transparent man and woman. With them came the push buttons that would come to characterize the science museum experience.

We learn that curators contributed to the Second World War effort by providing instruction and information to the troops (in 1941 Smithsonian staff supplied the migration patterns of Pacific shrimp to cloak naval movement, and details of Eskimo clothing for designing cold-weather combat gear). Museums also played their role in the Cold War, inspiring budding young American scientists in response to sputnik. This was followed by a massive growth in the size and number of museums in the 1970s, sustained by edutainment in 1980s and 1990s, during which museums sailed the choppy waters of the creationism debates and staged the blockbuster exhibitions of mummies or dinosaurs that we know so well today.

Balancing such change-upon-change, Rader and Cain argue, was the inherent conservatism of many curators, which, combined with a constant struggle for resources, ensured that earlier forms of display and practice endured, and emphases shifted from research to education to exhibitions and back again. National Museum of American History director Remington Kellogg's contribution in the 1950s, for example, was to privilege research over display to the extent that staff referred to him as 'the abominable no-man' (p. 171). Later arguments between curators and designers around the planned installation of a bespoke giant grasshopper in the Smithsonian were so disruptive that the expensive fourteen-foot insect was not in the end installed, but rather sold to the Boston Museum of Science. Debates waxed and waned across the century as

to what sort of research, education and exhibitions were appropriate and effective: systematics or ethology, immersive or interactive.

With this exhaustively researched and seamlessly co-authored book Rader and Cain have given us a much-needed history of debates about the function of museums and about their internal and external political context, and a structure within which to explore the history of twentieth-century life-science collections. For *Life on Display* is a history of writing about museums, of advocacy and arguments, ‘chronicling the social history of their exhibits to explain how science and natural history museums have conceived and reconceived their institutional roles in relation to one another, as well as in relation to life science and society in the twentieth-century United States’ (p. 280). The challenge is now for others to propose complementary histories of the collections and objects themselves, of the visuality of exhibits and the practices (rather than the proclamations) of curators, conservators and visitors. We also sorely need a transatlantic equivalent to this worthy tome, which for anyone interested in American museums during the last century will remain essential reference deep into this one.

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FRANCIS GRAHAM-SMITH, *Unseen Cosmos: The Universe in Radio*. Oxford: Oxford University Press, 2013. Pp. vii + 256. ISBN 978-0-19-966058-2. £20.00 (hardback). doi:10.1017/S000708741500093X

In this book Sir Francis Graham-Smith, former Astronomer Royal and vice-president of the Royal Society, speaks from over seven decades of personal involvement to describe the rise of radio astronomy ‘from the first discovery of cosmic radio waves to its present role as a major part of modern astronomy’ (p. vi). The expansive subject matter is organized by chapters centred on objects, from natural objects such as pulsars or black holes to the technical objects – dishes, arrays and so forth – associated with their discovery. This is a technique familiar in popular physics books, from Stephen Hawking’s *A Brief History of Time* (1988) to Michio Kaku’s *Hyperspace* (1994). At its best this structure allows neat linkage between some key ingredients of popular science writing: specific details of objects become part of engaging discovery narratives, and then are connected to the rest of the universe through broader physical theories. However, in this work all the experimental narratives, technological developments, biographies, astrophysical crash courses and often over-specific details arrive and supersede one another at an alarming rate. The cumulative effect energetically conveys the breadth and activity of radio astronomy, but does little to aid understanding.

The problem seems to stem from a lack of clarity over audience. This is most notable in the inconsistent levels of basic familiarity expected of readers. The basics of the electromagnetic spectrum are given as much space as spherical harmonics and Fourier analysis; familiar descriptions of Newtonian and Einsteinian gravity rub shoulders with graphs and figures lifted, with little elaboration, from more technical spheres; and terms like ‘azimuth’ and ‘arcsecond’, the bread and butter of the field, are brought in without definition. But this scattergun approach is perhaps more problematic in the level of detail readers are expected to engage with. An extremely large number of astronomical objects, technologies, techniques, characters and developments are introduced throughout the book. Some are introduced in great detail, arguably too much detail – a whole page on the emission spectrum of carbon monoxide, for instance (pp. 76–78). Others are passed over with frustrating scantiness; in particular, Graham-Smith has a habit of omitting dates from many of his historical accounts. Of all these details, some disappear quickly while others reappear unexpectedly in the midst of fresh new information; to give just one example, the story of Karl Jansky’s radio emitters features in a discussion of telescopes (p. 15), but is then brought back in a discussion of synchrotron radiation (p. 71). Such connections between