palaeontological resentment about the impact theory of end-Cretaceous extinction is ascribed to an irrational fear of apocalypse, or when parents applauding their baby's first steps subconsciously celebrate the rise of bipedal primates. Given the generosity of the text in general, Fortey's portrayal of research conferences strikes a sour and dissonant note.

Perhaps the greatest pleasure of reading Fortey's book is provided by the prose itself. His style is conversational, literate, and relaxed — Darwin as told to Calvin Trillin. A page that begins with the biology of sponges might proceed to a rumination on the use of animal names as insults (see "snakes" above) and end with an attempt to rehabilitate the epithet "slime". Patience is rewarded — as often as not Fortey's digressions fold back on the main narrative to reveal it from a new perspective.

In making the case for the history of life as science's creation narrative, and palaeontology as a way of understanding how we got here, Fortey effectively counters Whitman's accusation that scientists rob nature of joy and wonder. But then, even Whitman was capable of proclaiming: "Of physiology from top to toe I sing.… Of life immense in passion, pulse, and power". Richard Fortey could hardly disagree. □

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Fabric of the Universe

Shadow of a Star: The Neutrino Story of Supernova 1987A
by Alfred K. Mann
W. H. Freeman: 1997. Pp. 210. $22.95, £16.95

Cosmic Clouds: Birth, Death, and Recycling in the Galaxy
by James B. Kaler
W. H. Freeman/Scientific American Library: 1997. Pp. 252. $32.95, £22.95

F. D. Kahn

Supernova 1987A is the most famous supernova of them all. There are two main reasons: it was the first supernova visible to the naked eye for some four centuries and it was the first ever to be detected by its neutrino flux. In fact the neutrinos were registered around three hours ahead of the first optical detection — not surprising really, because the neutrinos are produced deep down within the star that became a supernova and travel straight out from there. The light from the event, however, is not emitted until the shock wave reaches the surface of the precursor star; the passage from the deep interior took three hours in the case of 1987A. In all, 20 neutrinos were collected at the Kamioka and the Lake Erie installations, carrying between them about 10^{-10} joules, or roughly one part in 10^{56} of the energy released in the collapse of the precursor to a neutron star.

What a fantastic success; and the experiment had not even been planned that way. As Alfred K. Mann explains in his delightful book, the apparatus was designed to detect neutrinos emitted during the putative decay of protons. One tends to think of the proton as a stable constituent of the Universe, but theory has it that even protons do not last forever, with a lifetime possibly as short as 10^{30} years. In the event, this turned out to be an underestimate, and so the apparatus was left with nothing to look at. Mann tells the story of how he and his colleagues modified their experiment, what incredible care had to be taken with their procedures and how they made their great coup just months after the final adjustments. Those 20 neutrinos are probably the most important particles in the history of astrophysics, and will continue to be so until someone actually catches a magnetic monopole. But the biggest surprise of all is that nobody on the Kamiokande team has yet been awarded a Nobel prize. If ever recognition was overdue, here is a prime example.

Mann's book is compact, and focused on one essential aspect of astrophysics. By contrast, James B. Kaler's book is large and wide-ranging, although a little small for a coffee table. It is concerned with great theories, and all astrophysical life is there. The illustrations vie with each other in magnificence. Inevitably, the most striking of them are pictures of diffuse objects such as the Eagle Nebula, a region of active star formation in interstellar space, and of the Helix Nebula, a planetary nebula. Both photographs were taken with the Hubble Space Telescope — where would we be without it?

Kaler has organized his text around the pictures to trace the sequence of events whereby material in space takes its various known forms: how we can observe it and what we need to do to understand its physical and dynamical evolution. It is a bold scheme, but perhaps the author asks too much of his audience. It is hard to expect readers to spend great lengths of time ploughing through, say, the ins and outs of molecular spectroscopy when they could be feasting their eyes on all the gorgeous colour pictures. And quite right, too: as the Bard says, in *Love's Labour's Lost*: "Small have continual plodders ever won save base authority from others' books."

Both Kaler's and Mann's books illustrate one great eternal truth. If an author knows what he wants to say then his text is easy to read. When Kaler deals with the subject of planetary nebulae or when Mann describes his experiences with Kamiokande, then the reader is carried along willy-nilly, like a yacht with a following wind. But the going gets much rougher when they write about sub-

Watching the neutrinos

Supernova 1987A appears in the photograph on the right, taken a few days after the explosion, as a bright spot in the upper right where before there was none. The pictures are reproduced in *A Short History of the Universe* by Joseph Silk, which is now out in paperback. When first published in 1994, it was described by Michael Rowan-Robinson in these pages as "the best introduction to cosmology for the general reader currently available". The new edition comments on improved images from the Hubble Space Telescope and recent searches for dark matter. W. H. Freeman/Scientific American Library, $19.95, £14.95.

jects outside their ken, as witness Kaler's strange views on barred galaxies or on synchroton radiation. And Mann, for all his wisdom, delivers himself of the following insight: "the supernova phenomenon... is an event with far more violence than humans can produce, but unlike much of our violence it is not mindless". Something inside one boggles. A learned rabbi once told me that no human construct should ever be expected to be perfect, and that only the Almighty can achieve perfection. He was probably right. □

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Tomato-watching in a dark corner

Readings on Color: Volume 1 — The Philosophy of Color; Volume 2 — The Science of Color
edited by Alex Byrne and David R. Hilbert
MIT Press: 1997. Pp. 317/465. $50, £42.50 (hbk), $30, £25.50 (pbk) each

Michael Morgan

Are tomatoes red in the dark? If your interest in this question was extinguished by late-night discussions with your undergraduate friends, read this review no further. Otherwise, open Volume 1 of this book and meet "Mary the super-scientist" who doesn't know what it's like to see red; the "Invert" who sees tomatoes as blue; and — for all I know, since I skipped a few pages — Superman, with his useful ability to see colours under short-wavelength illumination.

Both volumes are aimed, it seems, primarily at philosophers. The editors are philosophers at the Massachusetts Institute of Technology and the University of Illinois.

I learned from a recent radio broadcast by the UK geneticist Steve Jones that London's Albert Hall, home of the Promenade Concerts, was originally intended as part of the 'Albertopolis project' that would unite the sciences and the arts, following the successful Exhibition of 1851. Alas, all that resulted from Prince Albert's grand scheme was an exhibition of Bulgarian wine in the Albert Hall.

When asked by Jones to account for the failure of the Prince Consort's project to unite the sciences and the arts, the present secretary to the commissioners for the 1851 Exhibition, Patrick Middleton, observed, interestingly, that he blamed the philosophers. Philosophers, he said, are supposed to keep knowledge from fragmenting. Instead, they have retreated into a dark little corner of their own, in which philosophers are experts on philosophy. No more contemplation of the starry heavens above and the moral law within, thank you very much.

Alex Byrne and David R. Hilbert deserve credit for joining the 'neurophilosophers' who are trying to bring philosophers back to science. They clearly believe that philosophers who want to study colour should know some colour science.

Volume 1 shows how desperately this reform is needed. Let us join the philosophers in considering the unilluminated tomato. Is the tomato a fruit or a vegetable? No, sorry, that's a different problem — I mean is it red in the dark? I take it that no colour scientist would disagree with the following.

Of course, we do not see the tomato as red in the dark, and will not do so until transgenics offers us a combination of the tomato and the deep-sea fish. But the tomato in the dark has a surface reflectance spectrum that causes it, in daylight, to look red to us. The light that reaches our eye is a mathematical product of the surface reflectance spectrum of the tomato and the spectrum of the illuminant — say, northern daylight. The tomato continues to look red when illuminated by sunlight bouncing off green leaves. But this colour constancy has its limits. The tomato does not look red under sodium streetlights, and it most emphatically does not look red in the dark.

Whether one says tomatoes are red in themselves or not would seem to most scientists to be a fairly uninteresting question for the attention of lexicographers. But if you are a certain kind of philosopher, you take sides on the question and fight your corner.

You claim, like J. J. C. Smart, that colours are properties of objects, and you are a physicalist; or you say they are properties of objects that cause colours to be seen, and you are a dispositionalist; or you adhere to eliminativism and say that colours are illusions. Or, if you are a sensible sort of chap — and they nearly all are chaps — you say there is merit in all these positions. The economic advantages of a system in which everyone is paid to take in everybody else's washing are thereby convincingly demonstrated.

Most of the articles reprinted in *The Philosophy of Color* rehash the physicalist versus dispositionalist versus eliminativist positions until one groans with boredom. Having once put the book down, I had great difficulty in picking it up again. Why do so many philosophers prefer thought-experiments to real ones?

For example, we read in one chapter: "Surely, people can see things as red without even having the concept of a tomato or a [British] phone booth". But could one in fact see red without any concept of red objects: if one had never associated warmth with the red Sun seen through closed eyelids? Probably, but I see no "surely" about it.

To be fair, some chapters, and particularly the one by the editors themselves, do deal with recent discoveries about the properties of naturally occurring surface reflectance spectra. And Justin Broakes contributes an interesting chapter, describing the colours that emerge from flickering achromatic stimuli in Benham's top, and the doomed Butterworth encoder which tried to use this as a basis for colour television.

But elsewhere it is all Mary the super-scientist and her relatives. Why don't Mary's friends consider instead the far more interesting cases of real people with defective colour vision in one eye, who are described nicely in Volume 2?

Also, to be fair, scientists play some part in causing confusion. Newton's statement that the "Rays are not coloured" is well known. Galileo is quoted on page 81: "Hence I think that these tastes, odours, colours etc. are nothing else but mere names." I recall a public lecture by an eminent colour scientist entitled "Colour: The Great Illusion". If colour is an illusion, then so too is the movement seen in the cinema or television. But it is pointless to argue about an issue that is merely terminological.

Let us return to the science. The chapters in Volume 2 are mostly reprinted from scientific journals. We learn from the introduction that the selections were chosen "with an eye to their philosophical relevance". This rang alarm bells for me. All advances in colour science are of philosophical relevance if philosophy is to be understood in the generous spirit of the chairman of the commissioners for the 1851 Exhibition. It is a cop-out to suggest to philosophers that they can pick the plums out of the literature without being troubled by the details.

Many solid scientific papers are here, to be sure, but it is scarcely believable that the most recent paper on the neural coding of colour is from 1977! The term "cardinal axis" figures neither in the helpful glossary nor in the index. The key question of how the achromatic and chromatic signals are disentangled from the univariant parvocellular pathway is nowhere to be found: the reader has to make do with a paper from1982.

To call this collection heteroclitic would be to exaggerate its cohesiveness. The editors do not seem to have made up their minds whether to present a volume of classic papers or one of recent advances. Physiology, as I have indicated, is particularly badly served. On the other hand, molecular genetics is well represented by a *Scientific American* article by Jeremy Nathans, and there is welcome attention paid to the ecology and evolution of colour vision. The chapters on the physics and chemistry of surfaces will be useful to many colour scientists.

Interestingly, what is completely lacking is anything serious on the aesthetics of colour. Could not painters claim to be the true experts on colour science? The Albert Hall lies only a few minutes' walk from London's Imperial College of Science, Technology and Medicine,