

who find the style off-putting should persevere, because Angier's gift for metaphor lights up the dustiest corners. Her explanation of how electromagnetic radiation is produced is superbly easy to visualize; she is lucid on evolution, and on intelligent design; and her chapter on molecular biology is an exemplary introduction. Science teachers should find numerous useful resources here. Instead of relying on geeks-and-gimmicks clichés — eccentric geniuses, bitter feuds and zany facts — Angier's word-painting allows the scientific material to speak for itself in some depth. Consequently, we get a real sense of science as an immense collective endeavour, comprising both established knowledge and works-in-progress, done but not entirely dominated by personalities.

This is not a cutting-edge specialist text, so its contents are likely to be familiar to *Nature* readers. Much is necessarily omitted; the chapter on astronomy in particular feels disappointingly slight. Nevertheless, as an introductory guide, *The Canon* sets the standard for science writing and deserves at least to be shortlisted for the Royal Society Prize for Science Books. Its style may seem densely, even formidably, allusive at times, but Angier's gift for accessible explanation is outstanding. If any book can help the public learn to love science, this is it. ■

Kathleen Taylor is in the Department of Physiology, Anatomy and Genetics, Oxford University, Parks Road, Oxford OX1 3PT, UK.

The dark heart of the bomb

Plutonium: A History of the World's Most Dangerous Element
by Jeremy Bernstein
Joseph Henry Press: 2007. 258 pp. £16.99, $27.95

John S. Rigden

Plutonium has either a celebrated or a tragic history, depending on your point of view. It was the core of the weapon that destroyed much of Nagasaki on 9 August 1945, and has only military uses. For those who find security standing behind a stockpile of plutonium bombs, the element is a reason to celebrate. By contrast, for those who regard the bombing of Nagasaki as a needless repetition of the Hiroshima catastrophe, plutonium is a symbol of the US–Soviet arms race that dominated the second half of the twentieth century. It now signifies the rank and status of a nation's military prowess.

In his book *Plutonium*, Jeremy Bernstein acknowledges that everything connected with the element is complicated, and that includes plutonium itself and its history. Its discovery in 1941 by Glenn Seaborg and Arthur Wahl is part of a much bigger story in which each part becomes a story in itself.

Plutonium does not occur in earthen deposits, for example; it is produced instead by the radioactive decay of uranium by way of neptunium, and it is with uranium that the book begins. Then there is the story of the periodic table and the problems associated with fitting the elements into their proper places — especially the lanthanides (the elements of atomic number 58 to 71 that follow lanthanum in the periodic table) and the actinides (elements 90 to 103 following actinium).There is the story of radioactivity (and the connected story of the discovery of X-rays) and of Enrico Fermi bombarding uranium nuclei with slow neutrons. Add to these the story of fission, with various elements and isotopes complicating the plot. Los Alamos and the development of atomic bombs are also a central part of the plutonium story. Finally, there are the complications arising from the element plutonium itself that must be understood and the associated problems solved. Melding these many parts into a short book represents a daunting challenge, which Bernstein confronts head on.

One of the benefits of this multifaceted approach is the opportunity it gives the author to educate readers by means of historical information and thumbnail sketches of interesting people. In his 1903 Nobel address, for example, Henri Becquerel, who discovered radioactivity, suggested that the energy associated with radioactivity may involve the modification of atoms in the radioactive material. Two years later, Einstein showed that there was a loss of mass, which becomes energy according to his famous equation $E=mc^2$. In 1934, Ida Noddack correctly criticized Fermi, suggesting that in his neutron-bombardment experiments he had actually discovered nuclear fission. Fermi's Nobel speech in 1938 was wrong on this point because he assumed he had discovered transuranic elements. When the Nobel Prize was awarded for the discovery of fission, the Nobel committee made so many erroneous assumptions about who did what, and when, that Lise Meitner was wrongly denied a share of the prize.

The tale of Fritz Houtermans is particularly interesting and not well known. Houtermans wrote a report in 1941 in which he considered the absorption of a neutron by uranium-238 and concluded that it would lead to plutonium via neptunium. He further concluded that plutonium would be fissionable. Perhaps generalizing from his own insights, he twice sent messages (from his native Germany) to the Allies that Germany was "on the track" to making plutonium. It would be interesting to know why he did this, but Bernstein says only that he wanted to "warn the Allies". In any event, Houtermans was wrong: the Germans were not close to making plutonium.

In early 1943, the Los Alamos laboratory — the home of the Manhattan Project — began to take shape. By the summer of 1944, plutonium started arriving there. The element's idiosyncrasies and complexities soon became apparent. William Zachariasen discovered that plutonium had six different crystal structures, or allotropes, which he labelled α, β, γ, δ, δ' and ε. One of these allotropes had to be formed into a metal suitable for a bomb, which meant being stable and free of isotopes that would interfere with a chain reaction. The metallurgist Cyril Stanley Smith had the good fortune and acute intuition (there were no data) to select gallium to form an alloy with the δ allotrope of plutonium to produce the needed stability. It was still unclear whether the δ allotrope would revert to the α allotrope before explosion. And a way of bringing the two subcritical pieces of plutonium together to form the critical mass — and initiate the chain reaction that would lead to a nuclear explosion — had to be developed from scratch, as the gun trigger used for the uranium bomb that was dropped on Hiroshima was not suitable. Plutonium, then, presented challenges at every turn. As Bernstein suggests, it may have been only the fear of what the Germans were doing that kept the physicists working long into the night.

This book will make demands of readers. There are many things to hold in the mind as Bernstein repeatedly moves away from the main thrust of the book to develop one of these side stories, which enrich the story of plutonium but are also sometimes a distraction. But Bernstein's writing ability smoothes the way and makes this a successful book. ■

John S. Rigden is in the Department of Physics, Washington University, St Louis, Missouri 63130, USA.

Trouble in paradise

Coral: A Pessimist in Paradise
by Steve Jones
Little, Brown: 2007. 256 pp. £15.99

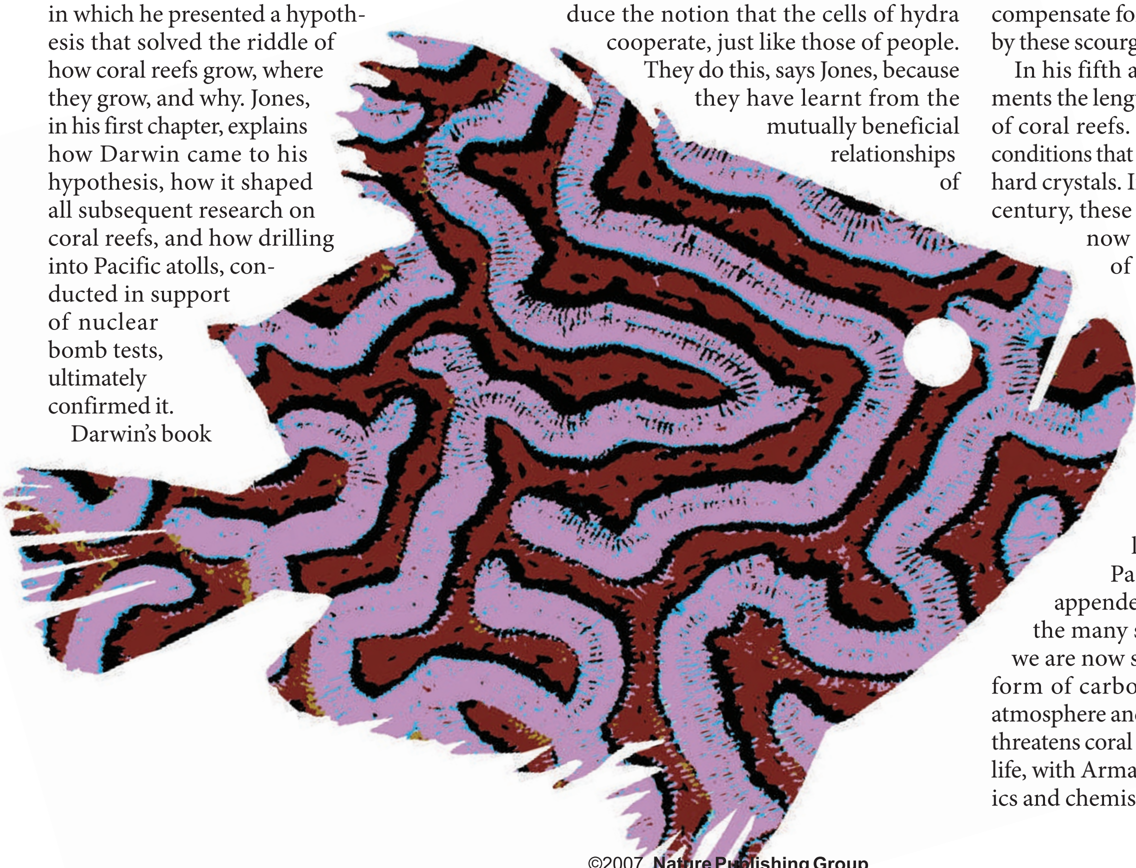
Daniel Pauly

If I had first seen *Coral* by Steve Jones in a bookshop, rather than receiving a review copy, I would have bought it. I would have been attracted by its superb cover, whose eerie blue serves as a glorious background for a swimming red snapper. And attempting to casually browse through the text, I would have been slowly ensnared by the loops of its fascinating literary, historic and scientific digressions.

Any book with the word 'pessimist' in its title must have a sound basis. Here it rests on Charles Darwin's solid shoulders — or more precisely, on his first scientific book, from 1842, *The Structure and Distribution of Coral Reefs*, in which he presented a hypothesis that solved the riddle of how coral reefs grow, where they grow, and why. Jones, in his first chapter, explains how Darwin came to his hypothesis, how it shaped all subsequent research on coral reefs, and how drilling into Pacific atolls, conducted in support of nuclear bomb tests, ultimately confirmed it.

Darwin's book relied on the simple but profound idea that 'lowly' organisms, here coral polyps, pursuing their own tiny goals, through their sheer numbers and over the immensity of time, could play major roles on the geological stage. This is also a theme in his 1859 book *The Origin of Species*, whose detractors could not fathom the transformative power of small, between-generation changes occurring over eons. This simple idea was again the theme of his 1881 book on the slow, subterranean work of earthworms, *The Formation of Vegetable Mould Through the Action of Worms*, to which he devoted his final years.

Genomics has given us a powerful tool to study the phylogenetic history and affinities of these tiny agents of change. In his second chapter, Jones uses genomics and the hydra (a non-colonial polyp related to corals) to introduce the notion that the cells of hydra cooperate, just like those of people. They do this, says Jones, because they have learnt from the mutually beneficial relationships of their organelles, many of which are descendants of formerly independent bacteria-like organisms.



He explores this idea further in the third chapter, which is devoted to what appears, in coral reefs and other ecosystems elsewhere, to be disinterested cooperation between species. But it isn't, notwithstanding the benevolent anarchist Prince Kropotkin, who gets a loop of several pages. Rather, barely masked warfare prevails, interrupted by tenuous and short truces, revoked when conditions change. Altruism seems to be limited to humans, and one of the biggest tasks we face is to expand our altruistic acts from our circle of relatives, friends and compatriots to the whole of humanity.

Jones then disposes, in his fourth chapter, of the tenacious Western myth of South Pacific coral islands as 'paradise'. Life was too precarious for that, particularly after the first contact with Europeans, who brought previously unknown diseases, some sexually transmitted. The abolition of cannibalism did not compensate for the population losses caused by these scourges.

In his fifth and final chapter, Jones documents the lengthy and rapacious exploitation of coral reefs. He starts with the geological conditions that cause carbon to form extremely hard crystals. In the middle of the nineteenth century, these conditions in parts of what is now India enabled the Maharajah of Hyderabad and his court to trade diamonds, via the East India Company, for jewellery carved from calcium carbonate from Mediterranean corals. Now the East India Company is no more, and these precious corals are mostly gone too.

Jones calls the book's epilogue, entitled 'A Pessimist in Paradise', an 'envoi', as if it were appended to a poem. He uses it to pull the many strands of this book into one: we are now stuck with trash carbon in the form of carbon dioxide that gums up our atmosphere and, as carbonic acid in sea water, threatens coral reefs, and indeed much marine life, with Armageddon. He explains the physics and chemistry involved with much verve,