in New Mexico, that "there was never a forest in the canyon" and that analysis of plant remains in ancient pack-rat middens there "reveal a climate and ecology almost exactly like that which exists today". Yet the opposite is true: radiocarbon dating of middens revealed a former pinyon-juniper woodland that is now absent from the canyon.

The book promotes an absurd rewriting of the Spanish conquest of the Inca Empire: "Spain was a mess, whereas Inca Peru was a model of good government … in effect, the conquistadors were adopted by their native Andean allies." It argues that overpopulation did not contribute to the 1994 genocide in Rwanda, relating it instead to local views of sacred kings. But a surviving Rwandan schoolteacher whose wife and four children were killed in the genocide gave a blunter explanation when he was interviewed: "The people whose children had to walk barefoot to school killed the people who could buy shoes for theirs." Another essay describes a New Guinean man named Yali, giving a lengthy reinterpretation of his views about the European colonization of New Guinea in the light of the experiences of another man with the same name — not realizing that the two Yalis were different people, 40 years apart in age and with dissimilar life stories and opinions.

Although the authors of *Questioning Collapse* may wish it were otherwise, students and laypersons alike know that Europeans did conquer the world. They will not be satisfied by being told that Andean peoples merely adopted Spanish conquistadors. The depopulations of the southern Maya lowlands and Chaco Canyon also cry out for explanation, even if one relabels them as something other than a collapse. Most readers of Shelmerdine's book will conclude that the end of the Aegean Bronze Age rates as a collapse.

It makes no sense to me to redefine as heart-warmingly resilient a society in which everyone ends up dead, or in which most of the population vanishes, or that loses writing, state government and great art for centuries. As *Questioning Collapse* shows, that naively optimistic redefinition inevitably forces one to distort history and to avoid trying to explain what really happened. Even when many people do survive and eventually reestablish a populous complex society, the initial decline is sufficiently important to warrant being honestly called a collapse and studied further. We today, who face similar problems and could face similar fates, will not be consoled by the thought that our grandchildren might exhibit resilience.

Modern peoples often fail spectacularly to respond to circumstances as well as they could, and the past offers abundant examples. Although *Questioning Collapse* aims "to shed light on the way forward", readers seeking illumination should instead turn to Shelmerdine's volume and the many other books that are available on the fates of past societies. ■

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The unfolding of time

From Eternity to Here: The Quest for the Ultimate Theory of Time
by Sean Carroll
Dutton: 2010. 448 pp. $26.95

Why does time run forwards, not backwards? In his much-anticipated book, theoretical physicist Sean Carroll offers an explanation that unifies thermodynamics and cosmology.

Carroll is a good citizen of the scientific blogosphere. A regular Internet pundit — writing first on his own blog, The Preposterous Universe, but more recently on Cosmic Variance, a collective blog hosted by Discover magazine — he opines on topics from physics and philosophy to religion, poker, baseball and coffee. Carroll's easy and engaging style has attracted a mass of followers, and opened up a lively forum for debate about science.

Carroll's research focuses on the arrow of time. The Austrian physicist Ludwig Boltzmann supplied the standard explanation that time's advance is due to the second law of thermodynamics and the growth of disorder, or entropy. As Carroll points out, this merely shifts the problem. The question becomes: why did the entropy of the Universe begin so low? The answer to that involves gravity, spacetime and multiverses, and Carroll brings these jigsaw pieces together to explain it.

> "Carroll suggests that universes such as ours continually pop into existence within the multiverse."

The narrative is colloquial and jolly, but *From Eternity to Here* reads more like an extended essay than a popular physics book. It is largely devoid of anecdotes and potted biographies of famous scientists, and the pages convey the high density of material that you would find in a *Scientific American* article. Carroll has a point to make, and must cover a lot of concepts to make it. The book is a modern incarnation of the sort of works that twentieth-century physicists such as Arthur Eddington, Erwin Schrödinger and Werner Heisenberg wrote late in their lives — venerable, erudite accounts with a new, possibly esoteric idea to put across.

Time is a clever unifying theme. Using its role in relativity, quantum mechanics, philosophy and thermodynamics to pull together many developments of modern physics, Carroll brings the reader back to focus on his big question. This trick gives the book a sense of purpose and prevents the prose from becoming too glutinous. Carroll's excellent description of Boltzmann's towering achievements and the limitations of his proof is sharp. The explanation of attempts to study time travel in general relativity is on a par with Kip Thorne's masterful *Black Holes and Time Warps* (W. W. Norton, 1994).

Carroll's solution for the arrow of time invokes the multiverse, a controversial concept that is a current battleground in theoretical physics. Arguably a prediction from cosmology and string theory, and to some extent quantum mechanics, the multiverse idea supposes that the Universe that we perceive is but one of a countless collection, each of which can be in a different physical state. A case can be made that our Universe looks the way it does because it is the only one of the many possible universes that can harbour us. For example, in another universe in which the constants of physics were slightly different from those in ours, life would not be possible.

Going further, Carroll adapts the multiverse idea to explain the directionality of time. Universes such as ours, he suggests, continually pop into existence within the multiverse, which is itself in thermal stasis, with no sense of time. We just happen to live in one of these baby universes, which started off in a low-entropy state and has an entropic arrow of time.

Carroll rightly relegates his speculative proposal to the final few pages. It remains to be seen how his provocative conclusion will be received within the physics community, but multiverse explanations are fashionable so it will garner interest. As a device to end the book's digression from relativity to the quantum, it works. *From Eternity to Here* is an engrossing, well-crafted introduction to the Universe and the foundations of modern physics. ■

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