

**Keys to the Universe**  
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# The Arrow of Time

**Professor Sean Carroll**  
**California Institute of Technology**

**Date:** Monday 23<sup>rd</sup> November 2009  
**Time:** 6:00pm  
**Venue:** Union Hall  
The University of Adelaide



## Synopsis

Why do we remember the past, but not the future? Why don't we meet people who grow younger as they age? Why do things, when left by themselves, tend to become messier and more chaotic? What would Maxwell's Demon say to a Boltzmann Brain? The answers can be traced to the moment of the Big Bang -- or possibly before.

Time pervades our lives -- we keep track of it, lament its loss, put it to good use. The rhythms of our clocks and our bodies let us measure the passage of time, as a ruler lets us measure the distance between two objects. But unlike distances, time has a direction, pointing from past to future. From Eternity to Here examines this arrow of time, which is deeply ingrained in the universe around us. The early universe -- the hot, dense, Big Bang -- was very different from the late universe -- cool, empty, expanding space -- and that difference is felt in all the workings of Nature, from the melting of ice cubes to the evolution of species.

The arrow of time is easy to perceive, much harder to understand. Physicists appeal to the idea of entropy, the disorderliness of a system, which tends to increase according to the celebrated Second Law of Thermodynamics. But why was entropy ever small in the first place? That's a question that has been tackled by thinkers such as Ludwig Boltzmann, Stephen Hawking, Richard Feynman, Roger Penrose, and Alan Guth, all the way back to Lucretius in ancient Rome. But the answer remains elusive.

The only way to understand the origin of entropy is to understand the origin of the universe -- by asking what happened at the Big Bang, and even before.

## Speaker

Sean Carroll is a theoretical physicist at the California Institute of Technology. He received his Ph.D. from Harvard in 1993, and worked at MIT, the Institute for Theoretical Physics at UC Santa Barbara, and the University of Chicago before moving to Caltech. His research involves theoretical physics and astrophysics, focusing on issues in cosmology, field theory, and gravitation. He is the author of *Spacetime and Geometry*, a graduate-level textbook on general relativity; has produced a set of introductory lectures for The Teaching Company entitled *Dark Matter and Dark Energy: The Dark Side of the Universe*; and blogs regularly at *Cosmic Variance*. He lives in Los Angeles with his wife, writer Jennifer Ouellette.

## All Welcome

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