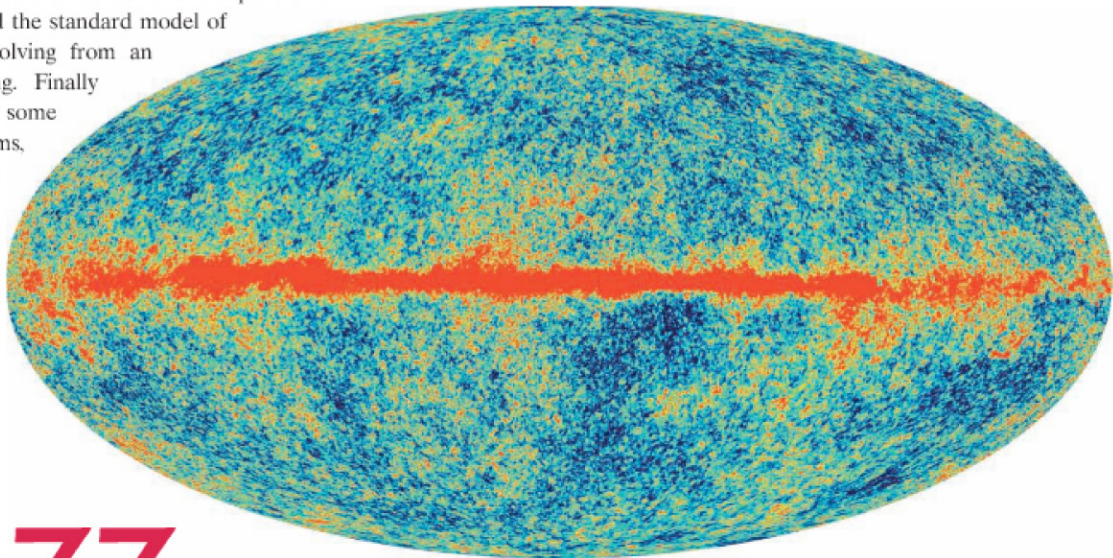This map of the entire sky (WMAP) is color-coded to represent slight temperature variations in the almost perfectly uniform 2.7-kelvin microwave background radiation that reaches us from all directions in the sky. Produced in 2003, it is providing detailed information on the origins of our universe and its structures. The red stripe across the middle is our own Galaxy, the Milky Way, showing up in the foreground. (It has been chosen as the "equator" for this projection of the full sky.)

To discuss the nature of the universe as we understand it today, we examine the latest theories on how stars and galaxies form and evolve, including the role of nucleosynthesis. We briefly discuss Einstein's general theory of relativity, which deals with gravity and curvature of space. We take a thorough look at the evidence for the expansion of the universe, and the standard model of the universe evolving from an initial Big Bang. Finally we point out some unsolved problems, including the nature of dark matter and dark energy that make up most of our universe.

Astrophysics and Cosmology

I n the previous Chapter, we studied the tiniest objects in the universe—the elementary particles. Now we leap to the largest—stars and galaxies. These two extreme realms, elementary particles and the cosmos, are among the most intriguing and exciting subjects in science. And, surprisingly, these two extreme realms are related in a fundamental way, as already hinted in Chapter 32.

Use of the techniques and ideas of physics to study the heavens is often referred to as **astrophysics**. Central to our present theoretical understanding of the universe (or cosmos) is Einstein's *general theory of relativity* and the modern theory of gravitation. Many other aspects of physics are involved, from electromagnetism and thermodynamics to atomic and nuclear physics as well as elementary particles. General Relativity serves also as the foundation for modern **cosmology**, which is the study of the universe as a whole. Cosmology deals especially with the search for a theoretical framework to understand the observed universe, its origin, and its future. The questions posed by cosmology are profound and difficult; the possible answers are often unimaginable. They are questions like "Has the universe always existed, or did it have a beginning in