which suggested that they were moving away from Earth. If all galaxies are moving away from Earth, the universe must be expanding. This does not imply that Earth is at the center of the expansion; the same phenomenon would be observed from any other point in the universe.

The expansion of the universe suggests that at some point in the past the universe must have had infinite density. The eruption of the universe is often referred to as the *big bang,* which is generally considered to have occurred between about 13 billion and 15 billion years ago. Current models indicate that the big bang involved such great amounts of energy in such a small space that matter could not form clumps or even individual atoms. It took about 380,000 years for the universe to cool from around 10^{32} K to around 3000 K, a temperature cool enough for atoms to begin forming.

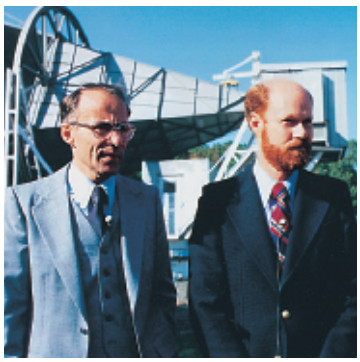

Figure 1
Penzias and Wilson detected microwave background radiation, presumably left over from the big bang, with the horn antenna (in the background) at Bell Telephone Laboratories in New Jersey.

Experimental verification

In the 1960s, a group of scientists at Princeton predicted that the explosion of the big bang was so momentous that a small amount of radiation—the leftover glow from the big bang—should still be found in the universe. Around this time, Arno Penzias and Robert Wilson of Bell Labs noticed a faint background hiss interfering with satellite-communications experiments they were conducting. This signal, which was detected in equal amounts in all directions, remained despite all attempts to remove it. Penzias and Wilson learned of the Princeton group's work and realized that the interference they were experiencing matched the characteristics of the radiation expected from the big bang. Subsequent experiments have confirmed the existence of this radiation, known as *cosmic microwave background radiation.* This background radiation is considered to be the most conclusive evidence for the big bang theory.

Figure 2
This image, called the *Hubble Ultra Deep Field,* is a compilation of images taken by two cameras on the *Hubble Space Telescope* between September 2003 and January 2004. It shows the youngest galaxies ever to be seen. These galaxies may have formed as early as 400 million years after the big bang.

The big bang theory is generally accepted by scientists today. Research now focuses on more detailed issues. However, there are certain phenomena that the standard big bang model cannot account for, such as the uniform distribution of matter on a large scale and the large-scale clustering of galaxies. As a result, some scientists are currently working on modifications and refinements to the standard big bang theory.

In March of 2004, astronomers released a new image from the *Hubble Space Telescope.* This image, called the *Hubble Ultra Deep Field* (HUDF), looks further back in time than any previously-recorded images. The image contains an estimated 10,000 galaxies. Scientists will study the HUDF to search for galaxies that existed from 400 million to 800 million years after the big bang. Because galaxies evolved quickly, many important changes happened within a billion years of the big bang. Scientists hope that studies of the HUDF image will resolve some of the current questions regarding the origin and evolution of the universe.