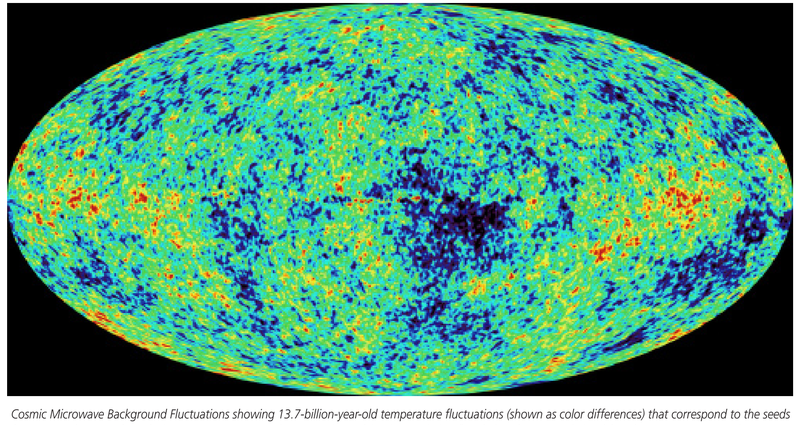
THE UNIVERSE LETS ITS LIGHT SHINE — THE FIRST BILLION YEARS

The BIG BANG Continues . . .

The Era of Nuclei — From 3 minutes to 380,000 years

The Universe settles down to a much lengthier period of cooling and expansion. Photons (light waves) are the dominant energy in the Universe. At first, the high density of charged protons, electrons, and nuclei interact with and trap photons. Light cannot move through the Universe. The Universe is effectively opaque. Over time, nuclei capture electrons and become neutral atoms – a process known as **recombination**. More and more Hydrogen and Helium atoms are created by this process until the Universe cools to about 3,000 K.

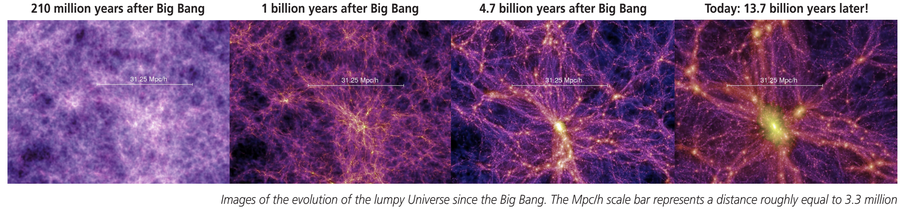
Now, with electrons bound into atoms, photons can travel freely. The Universe becomes transparent. **The cosmic microwave background (CMB)** is a view of this first burst of light in the early Universe.



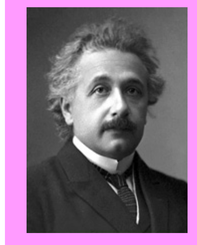
Cosmic Microwave Background Fluctuations showing 13.7-billion-year-old temperature fluctuations (shown as color differences) that correspond to the seeds that grew to become the galaxies. Temperature range is ± 200 microKelvin. COBE mission (header) and WMAP mission (above). © NASA/WMAP Science Team

The Era of Atoms — From 380,000 to 1 billion years

In an otherwise smooth Universe, tiny zones of higher density are seeds from which future galaxies and clusters of galaxies will arise. Gravity pulls matter together, and regions of higher density grow. The Universe becomes more lumpy until we see it as we do today in the last frame of the picture on the right. High-density matter (*shown in orange in the pictures*) is surrounded by empty space (*shown in blue*).



Images of the evolution of the lumpy Universe since the Big Bang. The Mpc/h scale bar represents a distance roughly equal to 3.3 million light years – the distance light travels in 3.3 million years. © The Millennium Simulation Project – Max Planck Institute for Astrophysics.



Albert Einstein

Albert Einstein was born in Württemberg, Germany on March 14, 1879. His family, though of Jewish ancestory, did not observe Jewish religious practices, and Albert attended a Catholic elementary school. When Einstein was five, his father showed him a pocket compass. Einstein realized that in the space around the needle (previously thought to be empty) there must be something that was moving the needle. He later stated that this experience made "a deep and lasting impression." He was introduced early to mathematics and physics and was a top student, but he was not a supporter of traditional education – writing that "the spirit of learning and creative thought were lost in strict rote learning." During High School, Albert and his family moved to Italy. He renounced his German Citizenship to avoid military duty and went to university in Zurich, where he trained as a teacher in physics. He was unable, upon graduation, to find a teaching post, so he accepted a position as technical assistant in the Swiss Patent Office, where, in his spare time, he obtained his doctorate and began the formulation of his theory of space, time, and gravitation – the **General Theory of Relativity**. His equation, **$E=mc^2$**, demonstrates how mass and energy were interchangeable in the conditions of the early Universe. Einstein regarded his major achievements as mere stepping-stones for the next advance.

In 1908 Einstein left the patent office and began a series of posts in Germany, Czechoslovakia, and Switzerland as a professor of theoretical physics. He won the Nobel Prize in Physics in 1921. In 1933, he emigrated to America to take a position at Princeton. In 1940, he became a United States citizen. He retired in 1945. During World War II, Einstein was a leading figure in the World Government Movement. He was offered the Presidency of the State of Israel, which he declined, and he collaborated with Dr. Chaim Weizmann in establishing the Hebrew University of Jerusalem. He was a socialist Zionist and a staunch supporter of the U.S. effort to beat Germany to the production of the Nuclear Bomb. In regards to his personal religious beliefs, Einstein said "I do not believe in a personal god. If something is in me which can be called religious then it is the unbounded admiration for the structure of the world so far as our science can reveal it."

Einstein dwelt much in intellectual solitude and, for relaxation, looked to music. He married Mileva Maric in 1903 and they had a daughter and two sons; their marriage was dissolved in 1919 and in the same year he married his cousin, Elsa Löwenthal, who died in 1936. He died on April 18, 1955 in Princeton, New Jersey.

Max Karl Ernst Ludwig Planck

Max Planck was born in Kiel, Germany, on April 23, 1858. He was a professor of theoretical physics at Berlin University and worked in the areas of thermodynamics and electromagnetic radiation. Some of his most important work centered around the understanding of the behavior of light and other electromagnetic radiation. His work is essential to our understanding of the very beginnings of our Universe, evidenced by the continued use of his name to describe so many of his discoveries. The ratio of the energy of a *photon* (light wave) to its frequency is a constant we know as *Planck's Constant*. *Planck Time* – 10^{-43} seconds – is the smallest meaningful division of time in our Universe. It represents the amount of time required for a photon to travel a *Planck Length:* the smallest distance any two points can be separated before they become indistinguishable from each other. Max Planck's work was the foundation of Quantum Mechanics Theory, for which he won the Nobel Prize in Physics in 1918.

Planck was also a gifted pianist and is said to have at one time considered music as a career. During the period of the Nazi government in Germany, he felt it his duty to remain in his country but was openly opposed to some of its policies, particularly regarding the persecution of the Jews.

In 1885 he married a childhood friend, Marie Merck, who died in 1909. He later married her cousin. Three of his children died young, leaving him with two sons, one of whom was executed for his part in an unsuccessful attempt to assassinate Hitler in 1944. Max Planck died in 1947 at the age of 89.