These subatomic particles repeatedly collided, clashed, and annihilated each other in powerful bursts of energy. There was just slightly more matter than antimatter, such that by the time the universe was one second old, only matter was left. Over the next three minutes, as the expanding universe cooled, some of the basic elements we know today—hydrogen and helium—were created. The universe then entered a long calm period in which it continued to expand and these basic elements combined to provide the building blocks of the first stars and galaxies.

Things to Think About

• Why is it so important for scientists to understand how the world was created and how everything came to be at the beginning of the universe?

• The atoms that were created about 12 billion years ago are still with us today. What other things in our world are remnants of the Big Bang? How does it make you feel when you consider that things in your world have been here for billions and billions of years?

• The Big Bang is now accepted by most scientists as the way the universe was created. What are some of the other major theories advanced over the years on how the universe began? Were they disproved? If so, when and how?

• Think about the concept of gravity. How did Sir Isaac Newton discover it in the 1660s? What have scientists learned about it since that time? Where would we be without gravity?

• The Hubble Space Telescope celebrated its tenth anniversary in the year 2000. Research some of the images it has collected in that time and what astronomers have learned from them.

• Research different cultures' creation myths. What elements, if any, correspond to what scientists believe about the Big Bang?

• What are possible theories that have been proposed about the end of the world? How have these theories changed and evolved over the years?

• T. S. Eliot's poem “The Hollow Men” ends with the following lines:

This is the way the world ends
This is the way the world ends
This is the way the world ends
Not with a bang but a whimper.

Consider how these lines reflect scientific belief about the creation and end of the universe.

Internet Resources

http://www.ncsa.uiuc.edu/Cyberia/Cosmos/Cosmic MysteryTour.html--A general site on the universe from the NCSA at the University of Illinois.

map.gsfc.nasa.gov/html/web_site.html — The Introduction to Cosmology site, with answers to questions about the Big Bang and related topics.

http://www.damtp.cam.ac.uk/user/gr/public/ — Cambridge Cosmology, a page maintained by Cambridge University on the Big Bang and related areas.

www.astro.ucla.edu/~wright/cosmolog.htm—Cosmology tutorial

Other Resources

For students:

Couper, Heather and Nigel Henbest. ***Big Bang.*** Dorling Kindersley, 1997.

Trinh, Xuan Thuan. ***The Birth of the Universe: The Big Bang and After.*** Harry N. Abrams, 1993.

For adults:

Gribbin, John. ***In Search of the Big Bang: The Life and Death of the Universe.*** Penguin, 1999.

Hogan, Craig J. and Martin Rees. ***The Little Book of the Big Bang: A Cosmic Primer.*** Copernicus Books, 1998.

Sternglass, Ernest J. ***Before the Big Bang: The Origins of the Universe.*** Four Walls Eight Windows, 1997.

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THE EXPANDING UNIVERSE

THE BIG BANG

Long ago—some 12 billion years—our universe was formed in the Big Bang, an immense explosion that gave birth to countless galaxies, stars, and planets. Scientists today—trying to understand more about the origin and destiny of the Universe around us—have a better understanding than ever before of when and how the Big Bang took place. Learn the ways in which images from the Hubble Space Telescope have contributed to our knowledge of those first cosmic moments, and how current research is giving rise to theories about the universe’s expansion and eventual end. Discover how cosmologists are closing in on answers to the greatest questions facing the human race: Where did we come from? Where are we now? And where will we ultimately go?

Vocabulary

Alpha Centauri A and B — Stars that are near the Sun, in the same star system as Proxima Centauri.
Andromeda — A spiral galaxy that is the largest in the Local Group. Also the name of a constellation.
antimatter — A type of matter that is composed of particles which have the opposite charge as their matter counterparts but the same mass. When particles of antimatter and matter meet they annihilate each other.
Big Bang — The immense explosion in which the universe is thought to have been born, and in which all matter, space, and time were created.
black hole — A point-like, massive object, whose gravity is so strong that nothing—including light—can escape from it. Black holes are formed from collapsed massive stars, at the centers of galaxies as well as in the early universe.
cosmologist — One who studies the origin, structure, and evolution of the universe.
cosmology — The study of the origin, structure, and evolution of the universe.
dark matter — Matter not visible to our telescopes that is believed to make up the vast majority of all matter in the universe. Dark matter exerts a gravitational pull that can keep galaxy clusters from flying apart.
Doppler Shift — The phenomenon in which light from objects moving away from us shifts to the red end of the visible spectrum, while light from objects moving toward us shifts to the blue end of the visible spectrum.
galaxy — A collection of hundreds of billions of stars, as well as gas and dust, held together by gravity. The Milky Way is an example.
general theory of relativity — A theory, proposed by Albert Einstein in 1915, to explain the motion and interaction of objects through space-time.
gravity — A force that attracts objects in the universe toward one another.
Hubble Deep Field Image — An image of the farthest reaches of the universe taken by the Hubble Space telescope. The first was taken in 1995. It shows some of the faintest and youngest galaxies yet observed in the nearby universe.
Hubble Space Telescope — A telescope with a mirror 2.4 meters wide orbiting the Earth, launched by the shuttle Discovery in 1990, that has provided many wonderful images of a variety of astronomical phenomena.
inflation — The sudden expansion of the universe that

BIG BANG TIMELINE

1929 — Edwin Hubble discovers that the universe is expanding.
1948 — Physicist George Gamov publishes a paper proposing the modern theory of the Big Bang in which all the elements were formed in a hot, expanding fireball.
— The Steady State theory is proposed counter to the Big Bang, asserting that the universe looks the same in every region of space and different areas of time and that, as the universe expands, new galaxies are formed to fill in the empty space; it is proven wrong in 1965.
1950s — Astronomer Martin Ryle uses a radio telescope to observe distant galaxies; he shows that galaxies were more tightly packed in the past and that the universe in its early stages was dominated by quasars (small, highly luminous, active young galaxies).
1965 — Physicists Robert Wilson and Arno Penzias, using a radio telescope, detect microwave radiation from the early stages of the universe—the faint afterglow of the Big Bang.
1980 — Physicist Alan Guth proposes the theory of cosmic inflation to explain the expansion of the universe after the Big Bang.
1989 — NASA launches the Cosmic Microwave Background Explorer to examine the background radiation that fills space.
1990 — The shuttle *Discovery* launches the Hubble Space Telescope, which will provide cosmologists with distant views of the early universe, black hole candidates, and supernovae, among other celestial phenomena.
1991 — The shuttle *Atlantis* launches the Compton Gamma Ray Observatory to detect gamma rays produced by solar flares, supernova, and other phenomena. It functiones for nine years.
1992 — The Cosmic Microwave Background Explorer (COBE) for the first time detects structure in the cosmic microwave background — radiation that supports the theory of cosmic inflation.
1995 — The Hubble Space Telescope provides the first Hubble Deep Field Image, the deepest image of the nearby universe collected to date.
1997 — Scientists find that the rate of expansion of the universe has not decreased since the Big Bang due to an insufficient amount of matter contained within it.
— ACE (Advanced Composition Explorer) is launched to collect observations of particles from the Sun, interstellar space, and other origins
1998 — Astronomers report evidence of an energetic explosion at the far edge of the universe 12 billion light years away, possibly caused when two black holes, two neutron stars or a black hole and a neutron star collided.
1999 — Researchers say that by using information about distant variable stars called Cepheids obtained by the Hubble Space Telescope, they have determined that the universe is about 12 billion years old. Different ages for the Universe also have been estimated using supernovae and collections of stars called globular clusters.
—The shuttle *Columbia* launches the Chandra X-ray Observatory—the most sensitive X-ray telescope ever—to detect high energy radiation from black holes, quasars, gas clouds, supernovae and the center of our galaxy.
2000 — A team of Italian physicists say they have detected dark matter WIMPs (weakly interacting massive particles), but U.S. scientists—who think they may have detected a few WIMPs themselves—dispute the Italian findings.
— Astronomers working with the Sloan Sky Survey discover the most distant object ever detected, a quasar—a galaxy with an extremely energetic nucleus—it formed less than a billion years after the Big Bang
— Using the Boomerang experiment — a telescope carried by a balloon above Antarctica — scientists produce the highest resolution map of the structure of cosmic microwave background radiation to date.

took place fractions of a second after the Big Bang.
Local Group — The name given to a cluster of about 30 galaxies, including the Milky Way. These galaxies can be considered our nearest neighbors.
matter — The substance that makes up much of our familiar world. It is composed of atoms with positively charged nuclei surrounded by negatively charged electrons.
Milky Way — The galaxy in which our solar system is located.
Proxima Centauri — The nearest star to our Sun.
Sloan Sky Survey — An ambitious project to map and create a fully interactive, three-dimensional guide to the nearby universe.
solar system — A star and the objects orbiting it—planets, moons, etc. In our solar system, nine planets circle the Sun: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune, and Pluto.
spiral galaxy — A type of galaxy that has arms in a spiral shape. The Milky Way is an example.
star — A large ball of primarily very hot hydrogen and helium gas that produces copious amounts of light. The Sun is an example.
supernova — The explosive event in which a star, originally much more massive than our Sun, ends its life and turns into a white dwarf or neutron star.
WIMPs — Weakly Interacting Massive Particles, heavy particles that almost always pass through other matter without a trace due to their inability to interact with it. They are believed to be a possible source of dark matter.
wormhole — A hypothetical point in space where it might be possible to travel from one part of our universe to another or to an entirely different universe.

Stages in the Big Bang

Most scientists believe that the universe began some 12 billion years ago with the Big Bang, when the whole universe that we can see, the visible universe, was concentrated in a single point. Immediately after the Big Bang, the visible universe was terribly hot and tiny, about the size of an atom. But within fractions of a second, the universe—propelled by a change in its energy structure—expanded for a short while at an exponential rate.
The young universe was ragingly hot and full of energy and radiation so intense that it spontaneously created pairs of matter and its opposite antimatter.