

You Are Here in Space

One of the best reasons to study modern astronomy is to learn about your place in the universe. This visual will lead you through the basic levels of structure, starting with the universe as a whole and ending with Earth.

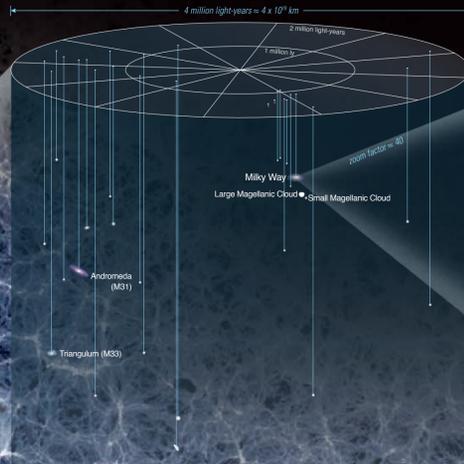
The Observable Universe

The background illustration depicts the overall distribution of galaxies in our observable universe; individual galaxies are microscopic on this scale. The portion of the universe that we can observe is limited by the age of the universe. Because our universe is about 14 billion years old, we can see no more than about 14 billion light-years in any direction. Measurements indicate that the observable universe contains more than 100 billion galaxies.

On the largest scales, galaxies are arranged in giant chains and sheets millions of light-years long.

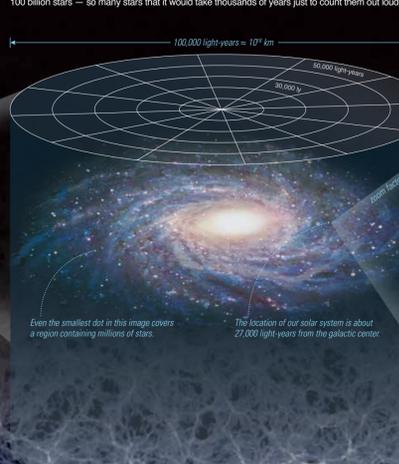
The Local Group

This image shows the largest galaxies in our Local Group. Most galaxies are members of small groups of up to a few dozen galaxies, such as our own Local Group, or larger clusters containing up to a few thousand galaxies.



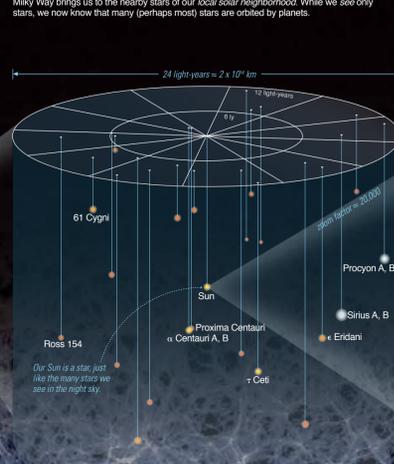
The Milky Way Galaxy

This illustration shows what the Milky Way Galaxy would look like from the outside. Our galaxy is one of the three largest members of the Local Group. The Milky Way contains more than 100 billion stars — so many stars that it would take thousands of years just to count them out loud.



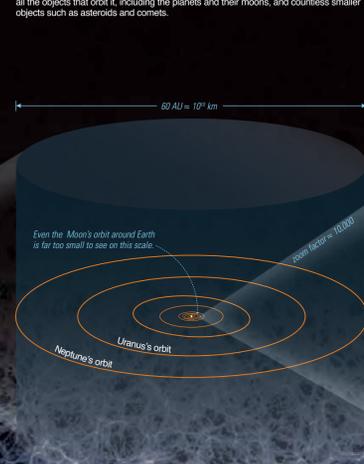
The Nearest Stars

This image shows the locations of nearby stars; stars would be atom-sized on this scale, so their sizes have been greatly exaggerated for visibility. Zooming in on a tiny piece of the Milky Way brings us to the nearby stars of our local solar neighborhood. While we see only stars, we now know that many (perhaps many) stars are orbited by planets.



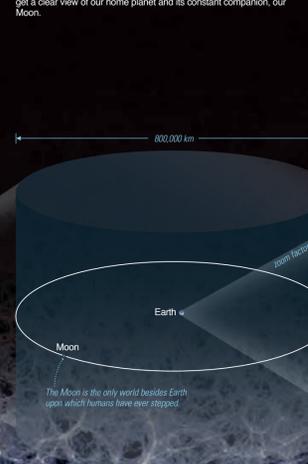
The Solar System

This diagram shows the orbits of the planets around the Sun; the planets themselves are microscopic on this scale. Our solar system consists of the Sun and all the objects that orbit it, including the planets and their moons, and countless smaller objects such as asteroids and comets.



The Earth-Moon System

This diagram shows Earth, the Moon, and the Moon's orbit to scale. We must magnify the image of our solar system another 10,000 times to get a clear view of our home planet and its constant companion, our Moon.



Earth

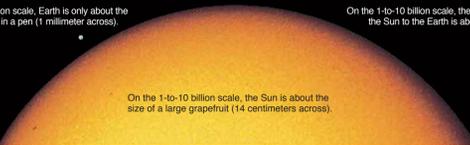
You are here. The physical sizes of human beings and even the planet on which we live are almost unimaginably small compared to the vastness of space. Yet in spite of this fact, we have managed to measure the size of the observable universe and to discover how our lives are related to the stars.

Putting Space in Perspective

One good way to put the vast sizes and distances of astronomical objects into perspective is with a scale model. In this book, we'll build perspective using a model that shows our solar system at one-ten-billionth its actual size.

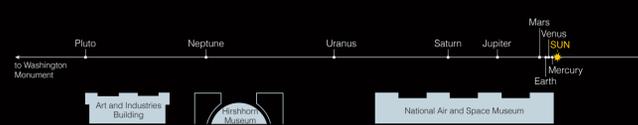
On the 1-to-10 billion scale, Earth is only about the size of a ballpoint in a pen (1 millimeter across).

On the 1-to-10 billion scale, the distance from the Sun to the Earth is about 15 meters.



On the 1-to-10 billion scale, the Sun is about the size of a large grapefruit (14 centimeters across).

The Voyage scale model solar system in Washington, D.C. uses this 1-to-10 billion scale, making it possible to walk to the outermost planets in just a few minutes.



This map shows planet locations in the Voyage model. Keep in mind that planets actually follow orbits that go all the way around the Sun.

On the 1-to-10 billion scale, you'd have to cross the United States to reach the nearest stars.



One light-year becomes 1,000 kilometers on the Voyage scale, so even the nearest stars are more than 400 kilometers away, equivalent to the distance across the United States.

A water molecule is a million times smaller than a grain of sand. On the 1-to-10 billion scale, you would be slightly smaller than a water molecule.



These comparisons show how tiny we are compared to the solar system in which we live, but we've only just begun to cover the range of scales in the universe.

- To appreciate the size of our galaxy, consider that the stars on this scale are like grapes (a few kilometers apart), yet there are so many that it would take you thousands of years to count them one-by-one.
- And with more than 100 billion galaxies, the observable universe contains a total number of stars comparable to the number of grains of dry sand on all the beaches on Earth combined.



This photo of the Hubble Ultra Deep Field shows galaxies visible in a patch of sky that you could cover with a grain of sand held at arm's length.

You Are Here in Time

How does your life fit into the scale of time? We can gain perspective on this question with a cosmic calendar on which the 14-billion-year history of the universe is scaled down using a single calendar year. The Big Bang occurs at the stroke of midnight on January 1, and the present is the last instant of December 31.

The Early Universe

Observations indicate that the universe began about 14 billion years ago in what we call the Big Bang. All matter and energy in the universe came into being at that time. The expansion of the universe also began at that time, and continues to this day.

Galaxy Formation

Galaxies like our Milky Way gradually grew over the next few billion years. Small collections of stars and gas formed first, and these smaller objects merged to form larger galaxies.

Element Production by Stars

The early universe contained just three chemical elements: hydrogen, helium, and a tiny amount of lithium. Essentially all of the other elements were manufactured by nuclear fusion in stars, or by the explosions that end stellar lives. The elements that now make up Earth — and life — were created by stars that lived before our solar system was born.

Birth of Our Solar System

Our solar system was born from the gravitational collapse of an interstellar cloud of gas about 4.5 billion years ago, or about September 3 on the cosmic calendar. The Sun formed at the center of the cloud while the planets, including Earth, formed in a disk surrounding it.

Life on Earth

We do not know exactly when life arose on Earth, but fossil evidence indicates that it was within a few hundred million years after Earth's formation. Nearly three billion more years passed before complex plant and animal life evolved.

Human History

On the cosmic calendar, our hominid ancestors arose only a few hours ago, and all of recorded human history has occurred in just the last 15 seconds before midnight.

You

The average human life span is only about two-thirds of a second on the cosmic calendar.

JANUARY 1 (Midnight): The Big Bang occurs.

FEBRUARY 1 (12:00 a.m.): Globular clusters containing up to a million stars were among the first objects to form in the universe. This cluster (M80) formed more than 12 billion years ago, about February 1 on the cosmic calendar.

MARCH 2 (1:00 a.m.): Many young galaxies grew by colliding and merging with other galaxies. This image shows a collision that occurred about 11.4 billion years ago, around March 2 on the cosmic calendar, but the collision is so far away that the light from it is just reaching us now.

SEPTEMBER 3 (3:00 a.m.): Stars are born in clouds of gas and dust; planets may form in surrounding disks.

SEPTEMBER 22 (3:50 a.m.): This rock formation in West Greenland holds the oldest known evidence of life on Earth, dating to more than 3.85 billion years ago, or September 22 on the cosmic calendar.

SEPTEMBER 26 (4:00 a.m.): Stars shine with energy released by nuclear fusion, which ultimately manufactures all elements heavier than hydrogen and helium.

SEPTEMBER 26 (4:00 a.m.): Massive stars explode when they die, scattering the elements they've produced into space.

SEPTEMBER 26 (4:00 a.m.): Each new generation of stars is born from gas that has been recycled and enriched with new elements from prior generations of stars. This cycle started with the first generation of stars and continues to this day.

SEPTEMBER 26 (4:00 a.m.): This illustration shows what the solar system may have looked like shortly before the Sun and planets finished forming.

SEPTEMBER 26 (4:00 a.m.): Fossil evidence shows a remarkable increase in animal diversity beginning about 540 million years ago — December 11 on the cosmic calendar. We call this the Cambrian explosion.

SEPTEMBER 26 (4:00 a.m.): Dinosaurs arose about 225 million years ago — December 26 on the cosmic calendar. Mammals arose around the same time.

SEPTEMBER 26 (4:00 a.m.): Dinosaurs went extinct, probably due to an asteroid or comet impact, about 65 million years ago, which was only yesterday (December 30) on the cosmic calendar.

DECEMBER 31 (11:59:59 p.m.): Our early ancestors had smaller brains, but probably were walking upright by about 5 million years ago — December 31, 9 PM on the cosmic calendar.

DECEMBER 31 (11:59:59 p.m.): Modern humans arose about 40,000 years ago, which is only about two minutes ago (December 31, 11:59 PM) on the cosmic calendar.

DECEMBER 31 (11:59:59 p.m.): The Egyptians built the pyramids only 11 seconds ago...

DECEMBER 31 (11:59:59 p.m.): We learned that Earth is a planet orbiting the Sun only 1 second ago...

DECEMBER 31 (11:59:59 p.m.): ...and a typical college student was born only 0.05 second ago.

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