In 1609 Galileo Galilei first turned his telescope to the sky. The observations he made of the Moon, the Sun and the moons of Jupiter revolutionised astronomy, had a lasting impact on society and changed our view of the Universe forever.

400 years later, the United Nations is on the eve of celebrating the International Year of Astronomy (IYA2009) under the central theme—'The Universe, Yours to Discover'. The concept is for people across the world to join together in an understanding that we are all part of one Earth under one sky, and the wonders of the Universe are part of our common heritage. The IYA2009 will be a global adventure, helping to empower communities, especially in developing countries, and to preserve the world's dark skies.

**A Visual Journey Through the Wonders of the Universe**

In 2005 NASA created the ‘Blue Marble: Next Generation’, a composite of images from several satellites showing the land, sea, cloud cover and night-time lights of our planet. This view is centred on the North Atlantic Ocean, with the Americas to the left and Europe and Africa to the right where the shadow of night is punctuated by city lights. Seen from space, the defining feature of our planet is its blue colour.

**A few words about distance**

To try to help with a sense of scale, we have included reference objects such as shopping malls, pubs, parks, arboretums and airports.

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**A few words about colours**

All the images you see here are in colour. In many images, the colours are approximately how you would see them if you were close enough and your eyes sensitive enough. However, telescopes can see much more than we can with our eyes. They are more sensitive and can see fainter light and colours, and are also receptive to other kinds of light (electromagnetic waves) outside of the visible spectrum—ultraviolet, infrared, X-rays, radio waves and so on. For images made from these invisible parts of the spectrum, the familiar colours are often assigned so that the ‘reddest’ light is red and the ‘bluest’ light is blue. In this way it is possible to map the invisible light, such as X-rays or infrared light, to make images that we can see.

Some images are taken through special filters that target individual physical processes, such as specific compositions or temperatures, and these are often colour-coded in a way that makes it as simple as possible to understand what we see.
Lunar Eclipse

When the Moon passes through the shadow of the earth, we see a lunar eclipse. Only the red part of sunlight, bent by the earth's atmosphere, reaches the Moon, giving it a vivid coppery colour. This multiple-exposure image was taken during the eclipse of 30th December 1982.

Image made in visible light by Akira Fujii.
Total Solar Eclipse
1.25 (Moon) and 499 (sun) light seconds

The most majestic sight of all is a total solar eclipse. The sun is about 400 times bigger than the Moon, but by complete coincidence it is also about 400 times further away. Once every couple of years, the Moon passes directly between the Earth and the sun, casting its shadow over a small part of the Earth. Inside this shadow, a total solar eclipse is visible, and day turns to night. Most eclipses last only a few minutes, although the longest may last for over seven.

Full Moon
1.25 light seconds

A familiar sight to us all, the full Moon graces the night sky every 29 days. The landscape is a mixture of bright highlands and dark, lava-filled 'seas', both of which show the scars of large impact craters and rays of ejected material.

Chromosphere
499 light seconds

Just above the sun's 'surface' is a layer called the chromosphere. Looking like a field of fiery grass, this layer can be seen only by using a special filter that lets through only one wavelength of light, a reddish colour given off by ionised hydrogen gas (hydrogen alpha). This artificially-coloured image also shows an optical effect known as 'limb brightening', where the edge of the sun appears brighter than the middle.

Image Made in red light by Robert Gendler.
Solar Corona

The turbulent atmosphere of the sun is revealed when we look outside the visible part of the spectrum. Extreme ultraviolet light is given off by atoms heated to incredible temperatures — between one and two million degrees — and are given artificial colour to help us see the huge active areas spouting energy driven by the sun’s magnetic fields.

Coronal Loops

A close-up view of the edge of the sun shows vast looping structures made of blisteringly hot, electrically charged gas (plasma) in the sun’s corona. Here the plasma is caught falling back to the sun following an explosive solar flare in what is known as coronal rain.

Solar Corona

This image depicts the sun’s corona, the tenuous outer atmosphere, with a solar flare in the background. The corona is heated to incredible temperatures by the sun’s magnetic fields, giving off extreme ultraviolet light.

Coronal Loops

This image shows the vast looping structures made of plasma in the sun’s corona. The plasma is heated to incredible temperatures by the sun’s magnetic fields and is given artificial colour to help us see the huge active areas spouting energy driven by the sun's magnetic fields.

Coronal Rain

This image captures the phenomenon of coronal rain, where plasma is caught falling back to the sun following an explosive solar flare. The plasma is heated to incredible temperatures by the sun’s magnetic fields and is given artificial colour to help us see the huge active areas spouting energy driven by the sun's magnetic fields.

Trace Team

The Trace Team of the Stanford-Lockheed Institute for Space Research and NASA has captured this image of the sun’s corona, showing the vast looping structures made of plasma. The plasma is heated to incredible temperatures by the sun’s magnetic fields and is given artificial colour to help us see the huge active areas spouting energy driven by the sun's magnetic fields.
Saturn

71 light minutes

The glorious ring system around Saturn glows with scattered sunlight in this image made by the Cassini spacecraft as it passed behind the planet in 2006. To Galileo with his early telescope, Saturn appeared to have two large moons, looking like 'ears'. The rings are clearly visible through modern backyard telescopes. This image also contains our home planet – the white dot at the ten o'clock position between the bright main rings and the thinner grey-brown ring.

Image made in infrared, visible and ultraviolet light by the Cassini imaging team at NASA/JPL/Space Science Institute.

Solar System
Transit of Venus

140 (Venus) and 499 (Sun) light seconds

A rare treat for astronomers, this multiple exposure shows Venus in its stately 5-hour transit as it passed between the Earth and the Sun in 2004. Transits occur in pairs eight years apart, but just once a lifetime. The next transit will be in 2012, but if you miss it, you will then have to wait until 2117 and 2125. Venus is more familiar as a bright star-like object seen just before sunrise or just after sunset.

Image made in visible light by Eckhard Slawik.

Great Red Spot

35 light minutes

The Great Red Spot is a vast, stormy anticyclone about three times the size of Earth, found in the southern hemisphere of the gas giant Jupiter. Visible even through a modest telescope, the colour is variable and is thought to be from organic compounds. The storm has been studied for at least 178 years and may even have been recorded as early as 1665. Winds at the edge of the spot tear along at up to 560 kilometres per hour.

Image made in visible light by the Voyager 2 team at JPL/NASA.

Jupiter

35 light minutes

Normally a mix of brown and red hues, this image of Jupiter made in near-infrared light has been colour-coded to show cloud height, from high altitude (white) through blue to low altitude (red). The Great Red Spot and its neighbour Red Spot Junior top out at the highest altitudes, so appear white here. Observers used the Gemini North Telescope in Hawaii to capture this view.

Image made in infrared light by Travis Rector (UA Alaska Anchorage), Chad Trujillo and the Gemini Altair Team, NOAO/AURA/NSF.
Comet C/2001 Q4 (NEAT)

Comets come from the cold outer reaches of the solar system. like ‘dirty snowballs’, they are made of ice, dust and organic compounds. when they venture close to the sun, this evaporates and forms a long, graceful tail. this comet was discovered by the near-earth asteroid tracking (neat) programme in 2001 and made its closest approach to earth in may 2004, when this image was captured by the wiyn telescope in arizona.

Image made in visible light by t. rector (u. alaska anchorage), z. levay and l. frattare (stsci) for noao/aura/nsf.

Comet Hale-Bopp

Comet hale-bopp was a treat mostly for northern hemisphere observers in 1997. its passage through the inner solar system was relatively stately, and was visible to the naked eye for well over a year. at its peak in 1997, hale-bopp developed two tails — the bright white dust tail, and a blue tail made from glowing ionised gas. hale-bopp will come by again — just not for another 2400 years or so!

Image made in visible light by dan schechter.
Stars

Omega Centauri

17,300 light years

A million lights fill this view across the core of Omega Centauri, a huge spherical mass of stars known as a globular cluster, picked out in amazing detail by the Hubble Space Telescope. There are about 200 of these clusters in our galaxy, each containing millions of very old stars clumped together into a ball by gravity.
easy to see on a clear night, the Pleiades form an open cluster of young, blue stars seen in the constellation of Taurus. Greek mythology identifies them as the daughters of Atlas and Pleione (the seven sisters). Six stars are clearly visible, and legend says a seventh (Merope) dimmed with shame after consorting with a mortal. The Pleiades feature in the mythology of cultures all over the world. The Japanese name — Subaru — is used both for a car company and for a huge telescope in Hawaii.

Image made in visible light by Robert Gendler.

The Hercules Globular Cluster, 25,100 light years away, hanging in the sky like a glittering bag of diamonds, is a spherical group of hundreds of thousands of stars. The cluster was discovered by Edmund Halley (of comet fame) in 1714, and is barely visible to the naked eye. In 1974, a radio message was sent towards the cluster on behalf of humanity from the Arecibo Observatory, in the hope that such a dense collection of stars has a higher chance of one harbouring life on one of its planets.

Image made in visible light by Robert Gendler.
Seven main stars form the familiar pattern of the constellation Orion. Four stars mark the shoulders and knees of the mythological hunter, the remaining three forming the famous 'belt'. At the end of Orion's 'sword' is the spectacular Orion nebula, visible from all over the world. Orion has been part of the mythology of many cultures from Finland in the north to the Australian Aboriginals.

The constellation of Ursa Major is a well-known sight in the northern hemisphere. Although often called the Plough or the big dipper, most mythologies have thought of this as a great bear — the three stars on the left being its tail and the four at the right part of its back. The two stars on the far right — called 'the pointers' — trace a line that can be used to find Polaris (the north star), a trick used by travellers for thousands of years.
the most inspiring naked-eye object in the sky is our own galaxy, the Milky Way. This mosaic of photographs taken in Germany and Namibia shows some of the billions of stars that make up our neighborhood, along with reddish clouds of hydrogen gas and a dark obscuring lane of interstellar dust.
Antares Region

600 light years

Probably the most colourful vista in the sky is the region seen around the red supergiant, antares. This star is about 700 times the diameter of our sun, and in our solar system such a sun would have swallowed all the planets as far out as Mars (including us!). Behind antares there are colourful areas of hydrogen gas (pink) and dust (yellow). At right is the triplet star rho Ophiuchi, sitting in its own glowing blue mantle of gas.

Corona Australis Nebula

500 light years

A long tail of interstellar dust shines in the reflected light of nearby stars in this view of the nebula in the constellation corona australis (the southern crown). In parts, the dust accumulates to form dense molecular clouds from which it is thought young stars eventually emerge.

Star Birth
Horsehead Nebula
1500 light years
this close-up view made by the very large telescope Kueyen shows the intricate detail in the head of the horsehead nebula. The nebula is a vast cloud of dark dust, silhouetted against the glowing reddish hydrogen gas behind it. Despite sitting in a region often studied by astronomers, the nebula was first noticed by Williamina Fleming on a photographic plate in 1888.

Orion Complex
1500 light years
this relatively wide-angle telescopic view shows parts of the Orion Molecular cloud complex. The three bright stars are Orion's Belt — alnitak (left), alnilam and Mintaka (right). Just to the left of alnitak is the flame nebula, and just below the star is the famous horsehead nebula. The Orion complex also includes the famous Orion nebula, and a structure called Barnard's loop which covers most of the constellation.
The Cocoon Nebula, 4000 light years away, is strikingly beautiful even by nebula standards. It glows pink in the light of hydrogen gas ionised by the large star at its center. This star formed about 100,000 years ago, and its ultraviolet light has carved this nebula out of a vast, dark cloud of gas and dust. We are looking at the nebula through a hole in the side of this cloud.


The Eagle Nebula, 7000 light years away, is made famous by the Hubble Space Telescope. It is shown in all its glory in this image made at Kitt Peak National Observatory in Arizona. Right in the middle are the dust columns that became known as the Pillars of Creation. Here we see they are just part of a larger hollow shell of star formation, with a young star cluster at its center. The colors are artificial and represent light given off by glowing hydrogen (green), oxygen (blue), and sulfur (red).

Image made in visible light by T. Rector and B. Wolpa for NASA/LoR/NSF.
The Carina Nebula, an immense landscape of dark dust columns silhouetted against glowing gas clouds, which lies about 7500 light years away in the southern sky. The nebula, almost 500 trillion kilometres wide, is both lit and sculpted by the intense radiation of its brilliant young stars.

Image made in visible light by N. Smith (UC Berkeley) and the NASA/ESA Hubble Heritage Team.
The Ant Nebula, 3000 light years away, shows the typical bipolar shape of a planetary nebula when seen from the side. Planetary nebulae have nothing to do with planets; they just resembled planets when seen through early telescopes. Here a sun-like star has shed material from its outer layers until its core is exposed, releasing powerful UV light that makes the gas glow. To obtain this view, astronomers used two space-based instruments — the Hubble Space Telescope (green and red) and the Chandra X-ray Observatory (blue).

Image made in X-ray light by J. Kastner et al. for NASA/CXC/SAO, and in visible light by B. Balick for NASA/STScI/University of Washington.

The Helix Nebula, 650 light years away, although it looks like a ring, is actually a trillion-kilometre-long tube of glowing gas seen from one end. The gas was thrown out from a dying sun-like star in the process of changing from a red giant into a white dwarf, creating what is known as a planetary nebula. This image combines a wide view made by the KPNO 0.9 metre telescope in Arizona with the sharpness of an image from the Hubble Space Telescope.


Star Death
Veil Nebula
1440 light years
This image shows a small part of the Veil Nebula, the remains of a supernova, an immense stellar explosion, that happened between 5000 and 8000 years ago. Here we can see the interstellar gas being heated by the incredible shockwave that is still expanding through space at around 170 kilometres per second.


Crab Nebula
6000 light years
The Crab Nebula is the remnant of a supernova explosion recorded by Chinese and Arab astronomers in 1054. At its peak it would have been brighter than every star and planet in the night sky. In its wake the explosion left us the ever-expanding nebula, and a rapidly spinning neutron star called a pulsar at its centre. This image was made by a trio of space-based instruments — the Spitzer Space Telescope (red), the Hubble Space Telescope (green and dark blue) and the Chandra X-ray Observatory (light blue).

Thor’s Helmet

15,000 light years

Thor’s Helmet is a rare example of a Wolf-rayet star. Around 40 times the mass of our sun, it is young and burning extremely brightly—a blue supergiant—and generates a stellar wind that blasts outwards at millions of kilometres per hour. Burning this brightly and shedding this much material, it is thought that Wolf-rayet stars are seen in a brief stage of evolution before exploding as a supernova.


W49B

35,000 light years

This supernova remnant started life as a very large, very bright star that shed much of its outer layers over a million years or so—a mere moment in stellar terms—before collapsing in on itself and then exploding as a gamma-ray burst, momentarily burning with the light of ten billion billion suns. Blue colours reveal gas rich in iron and nickel glowing in X-rays at temperatures of 15 million degrees, green and red shows the infrared glow of hot hydrogen gas.

Image made by J. Keohane et al in X-ray light for NASA/Chandra X-ray Center and infrared light for Palomar/SSC.
Small Magellanic Cloud
185,000 light years
The Small Magellanic Cloud is a dwarf galaxy that orbits the Milky Way. It is one of our three companions in the Local Group of galaxies that can be seen with the naked eye, although only in southern skies. Like many galaxies, it has reddish star-forming regions and star clusters. The bright object at the top of this frame is 47 Tucanae, a globular cluster of stars in our own galaxy.

Large Magellanic Cloud
157,000 light years
Another of our neighbours in the Local Group, the Large Magellanic Cloud, is an irregular galaxy that orbits our own. It is visible in the southern sky as a pale cloud-like object, like an extension of the Milky Way itself. This infrared image from the orbiting Spitzer Space Telescope reveals huge swathes of hot gas and dust, showing that the Large Magellanic Cloud is a hotbed of star formation.

Galaxies
Andromeda Galaxy

2.5 Million light years

the closest spiral galaxy to us, the Andromeda Galaxy (also called Messier 31) would appear eight times the size of the full Moon in the sky if our eyes were sensitive enough. Spanning 150,000 light years, Messier 31 has a shape very much like the Milky Way with older, yellow stars in the centre and younger, blue stars in the spiral arms.

Image made in visible light by Robert Gendler
a superb face-on spiral galaxy, the Whirlpool galaxy, or Messier 51, is a popular target for amateur astronomers. However, to celebrate its 15th anniversary in space, the Hubble Space Telescope was trained toward this perfect spiral. Special filters highlight the red glow of enormous hydrogen gas clouds, and the image shows how Messier 51 is interacting with its much smaller neighbour, the yellowish NGC 5195.

**Whirlpool Galaxy**

Infrared light by the Galaxy Evolution Explorer Team for NASA/ESO.

**Triangulum Galaxy**

3 Million light years

The Triangulum galaxy (or Messier 33) is the third largest member of our local group. Some experienced observers claim to be able to see this galaxy in exceptionally clear conditions, which would make it the most distant object visible with the naked eye. It is easier to spot with a small telescope or binoculars. Messier 33 is a classic spiral galaxy, its spiral arms dotted with the glowing red hydrogen gas of star-forming regions.

**Triangulum Galaxy**

Image made in visible light by Robert Gendler.

**Andromeda Galaxy**

2.5 Million light years

The largest of the galaxies visible with the naked eye, Andromeda is a vast spiral similar in shape to the Milky Way. By using ultraviolet light, astronomers can highlight the structure — blue colours represent the far ultraviolet light given off by brilliant young stars in the spiral arms, while orange tones are from near ultraviolet given off by the older, cooler stars in the galaxy's core.

**Andromeda Galaxy**

Image made in infrared light by the Galaxy Evolution Explorer Team for NASA/ESA.
Fornax A
62 million light years
two vast 'Dumbo' ears of radio emissions surround the galaxy ngC 1316, forming an object that radio astronomers call Fornax a. The emission, picked up by the very large array radio telescope and shown in orange, is generated as charged particles are blasted from the core of the galaxy and crash into the intergalactic gas. The particles come from near the black hole at the core of ngC 1316, and result from it devouring material from its smaller neighbour.

image made in radio waves by J. Uson for NOAO/AUI and in visible light by the second Palomar sky survey.

Cartwheel Galaxy
400 million light years
the unusual shape of the cartwheel galaxy results from one of the smaller galaxies to the left passing through it about 100 million years ago. this created a huge compression wave, like a ripple in a pond, and this wave triggers intense bouts of star formation. Four of NASA's orbiting observatories collaborated to make this image: the Chandra X-ray observatory (purple), gALEX in ultraviolet (blue), the Hubble space telescope (green) and the infrared Spitzer space telescope (red).

composite image made by P. Appledorn et al. for NASA/JPL-Caltech/ESA.

Antennae Galaxies
45 million light years
the antennae are two galaxies that are in the process of merging. the cores of the galaxies are seen in yellow, while blue stars and red star-forming regions show the spiral arms in their complex interweaving dance. astronomers think this is the fate awaiting the Milky Way and our neighbour, the Andromeda galaxy, in a few billion years from now.

image made in visible light by the NASA/ESA Hubble heritage team.
**Stephan's Quintet**

300 million light years

This group of five is really a group of four, with the fifth coincidentally in the line of sight. The spiral galaxy at the upper right of center is about eight times closer to us than the other four, something not discovered until 1961. The rest of the galaxies show signs of complex interaction and seem to be on a collision course.

*Image made in Visible light by T. Recett (U. Alaska Anchorage) for the Gemini North Observatory.*

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**Hickson Compact Group 44**

60 million light years

Seen from a wider perspective, we see that many galaxies form into groups, just as stars do, under the influence of gravity. This group of four galaxies is the brightest in the Hickson catalogue, and can be seen through a good amateur telescope. We live in a compact group ourselves—formed by the Milky Way and its neighbors.

*Image made in Visible light by Russell Croman.*
Bullet Cluster

3.4 billion light years as galaxies collide, so do clusters of galaxies. The Bullet Cluster is a result of two clusters colliding — an event that released more energy than anything since the big bang. Visible light images from the Magellan and Hubble space telescopes show the clusters, while pink areas show the X-ray emission from colliding hot gases detected by the Chandra X-ray observatory. The blue patches show where most of the mass lies in the clusters — the invisible so-called dark matter.

Gravitational lensing

5 billion light years the combined gravity of a cluster of galaxies can act as a cosmic lens. In this Hubble Space Telescope image, a rich cluster (yellow) bends the light from more distant galaxies, leaving them as blue streaked arcs. Studying the shapes and positions of these images, astronomers find there isn’t enough visible matter to account for the distortions, so there must be a large amount of invisible dark matter present.

The Outer Limit

Einstein Cross

400–8000 Million light years a chance alignment of a galaxy and a quasar results in this amazing sight captured by the Hubble Space Telescope. The gravitational field of the galaxy (centre) bends the light in its path from a quasar, a super-bright galaxy, about 20 times further away. The exact shape of the gravity field determines how many images of the quasar are seen, and what shape they have.
Cosmic Microwave Background

13.7 billion light years

the ultimate limit of our vision, the cosmic microwave background (CMB) is the remnant of the big bang fireball in which the whole Universe was created. This image made by the WMAP satellite shows the whole sky unfolded onto a flat image, and is covered with tiny variations in temperature (different colors). These are thought to be the structures that prompted the formation of the galaxies in the very early Universe.

Hubble Ultra Deep Field

13 billion light years

This view made with the Hubble Space Telescope is the farthest we have yet seen with visible light. Using an exposure time of over 11 days, Hubble has recorded objects of 30th magnitude, a hundred million times fainter than can be seen with the naked eye. The most distant galaxies are seen as they were a few hundred million years after the big bang, and show surprising similarities to the galaxies of today.

Image Made in Microwave by the WMAP Science Team for NASA.