



Bridges have always helped bring people together. You can see it today. People from both sides of the river are now more closely connected. But the rainbow arch is also a bridge across time, from the present to the past.

Prof. Tang Huan Cheng
on PBS-Nova
Secrets of Ancient Empires: Chinese Bridge



ABOVE AND BEYOND

Crossing the rainbow bridge

RAINBOWS are a bridge between sky and earth, light and dark, rain and sun. Spanning the infrared and the ultraviolet, the brilliant arches are at once familiar and alien.

But what are they – those dazzling colours that bring everyone joy? Are they simply sunlight split by water droplets? Or is the palette of colours splashed across the sky the awesome power of the Celestial Dragon, the deadly bow of Indra the Hindu rain god, the pathway to heaven, or a reminder from Allah that the Great Flood would never happen again? Perhaps there is truth in all of them.

These are the most splendid and gentle of aerial splendours. Rainbows have all of the energy and magic of lightning, but none of the terror. They symbolise the relief of a storm's aftermath, and the anticipation of the warm sun.

A primary and secondary rainbow decorate the edge of a storm cloud



But where do you find them? Not metaphorically, but literally? And what is on the other side of the rainbow? Would you like to know where to look, when to look and what type of rainbows there are? Do you love those dazzling colours? If you are a seeker dreaming of a rainbow, some days you'll find it just by stumbling upon them. When you are really connected with rainbows, like the lovers, dreamers and meteorologists, then you'll know when rainbows are most likely to be spotted, what causes them and, most importantly, exactly where to look.

HOW DOES A RAINBOW FORM?

When conditions are right, sunlight hits water droplets in the air and forms an optical illusion, relative to the eye of the observer. The white colours of sunlight are scattered and divided into the portions of the *electromagnetic spectrum* – red, orange, yellow, green, blue, indigo, violet – in a continuous flow. It is the interpretation of our eyes that makes the colours look different. Some other animals, as well as human-made sensors, can also perceive infrared

▲ A twilight rainbow is seen, with primary and secondary arcs, in a half-circle shape. The largest rainbow visible from ground level, the half-circle rainbow can only be spotted when the sun is balanced on the horizon in the opposite direction

▶ A wavebow dances on the mists of the ocean surf. Formed in a similar fashion to a standard 42 degree rainbow, these colours result from the combination of salt water and sunlight

colours (beyond red) and ultraviolet colours (beyond violet). On different planets, in different atmospheres with different mists, rainbows may appear in different colours. But the familiar spectrum of a rainbow is consistent for all observers on Earth.

When both sunshine and rain clouds are present, the sky may be ripe for a rainbow. When dark clouds are visible from the side, to the opposite direction of a low sun, when you are underneath bright clear skies, these are best for spotting rainbows. With a bit of conscious observation, you will be able to identify good conditions and know to be on the lookout.

One of the best places in the world to see the colours is over the misty gorge below Niagara Falls. Linking Canada and the US, the Rainbow Bridge provides a perfect vantage point on a sunlit day to see the colourful arcs.

But in what direction would you look? Where can you find rainbows?

The familiar rainbow arc is only the visible section of a complete circle found opposite the sun, at a 42-degree angle from the *anti-solar point*. Imagine a line from the sun to your eyes continuing through you to a point below the horizon, and that point is the anti-solar point. The circular rainbow encircles the anti-solar point at a distance of 42 angular degrees from the line between your eye and the anti-solar point. Red is on the outside and violet is on the inside of the arc. At ground level, you will only see the upper portion of the circle. Below the horizon line, there is usually not enough distance for there to be enough water droplets to catch the light.

A fainter, *secondary rainbow* is found at 50 degrees from the anti-solar point. In this second, larger rainbow, the colours are reversed: red is inside and violet is outside. The dimmer area of eight degrees in between the two arcs is known as *Alexander's Dark Band*, named after the Greek philosopher who wrote about it 1,800 years ago. *Tertiary* and *quaternary* rainbows are exceptionally rare, and appear on the opposite side of the sky to the familiar rainbow arc.



Richard Gehly/Corbis

So if you are seeking the mythical leprechaun's pot of gold at the end of the rainbow, where can you expect it to be? Let's presume that you are standing on the ground. In the southern hemisphere, the sun moves to the north at noon, and in the northern hemisphere, to the south. You will therefore find southern hemisphere rainbows in the southern half of the sky, and northern hemisphere rainbows in the northern half of the sky. You will never find an Indonesian rainbow if you are looking north, and you will never find a rainbow in Russia looking south.

In the mornings, rainbows are to the west, and in the evenings, rainbows are to the east. The lower the sun is in the sky, the more of the arc will be visible above the horizon, as the anti-solar point is a smaller angular distance below the horizon. Midday rainbows will be shallower, and when you are on the equator, non-existent.

“You will never find an Indonesian rainbow if you are looking north, and you will never find a rainbow in Russia looking south.”

People in temperate or extreme latitudes will find more opportunities to spot spectacular rainbows than those in the tropics, because the sun spends more time at low elevations. When the sun is low in the sky and shines in a red or orange tint at dawn or sunset, the colours of the rainbow will also be tinted.

VARIETIES OF RAINBOWS

There are several kinds of rainbows. The standard rainbow is a segment of a colourful halo centred on the anti-solar point. But different conditions of water, ice and lighting can create different rainbows. The brightness of the moon can produce rainbows as well. Lunar rainbows or moonbows are dimmer than sunbows, because the light is so much less intense. They are similar to rainbows, found at 42 degrees, but around the *anti-lunar point*. Stacked rainbows or supernumerary rainbows, can be especially brilliant. When conditions are excellent for bright rainbows, a complex interference pattern can result in rainbows having extra bands of colour.

If you are above the ground looking downwards, you may be fortunate to see the fully circular rainbow known as a *glory*. To the wonder of mountain climbers and airplane travellers, this is recognisable immediately as a small

rainbow around the anti-solar point, with the shadow of the observer in the centre. This is known as the “Light of Buddha”, recognised by the Chinese as a signal of wisdom.

For air travellers viewing a glory, the shadow of the airplane may be distinctly recognisable in silhouette at the centre of the halo. For a mountaineer, a large dark form may be seen extending from their feet into the very centre of the glory. It is the shadow of the observer themselves, combined with the mountain upon which they are standing. This eerie figure is the “Spectre of Brocken”, after the highpoint of the German Hartz Mountains.

A *sun halo* is formed by the hexagonal ice crystals in high icy cirrus clouds and is observed as a ring at 22 degrees angular distance around the sun. While not as colourful as a true rainbow arc, it can display colours trending from a red inside to a violet outside. This can also be seen around the moon, as a *moon halo* (not to be confused with a lunar rainbow). A related phenomenon occurs when the crystals of a sun halo are guided by the wind into a vertical orientation – the whimsically named arcs known as *sundogs* or *parhelia*. These are segments of sun haloes that appear as arcs to the left and right of the sun.

A *circumhorizon* arc is part of a giant solar halo 46 degrees in angular size. They do not actually circle the horizon, but the lower parts may appear almost parallel to the horizon. Usually, there is not enough cloud cover to see the entire halo, and only some segments are visible.

In cold weather, with clouds of ice crystals floating in the air, *snowbows* can be seen around the anti-solar point. It is actually a normal rainbow, but it is exciting and special to see in the frigid air.

Cloud shimmers or *iridescences* are rare and beautiful colourations seen on the underside of a cloud. Usually spotted on high, thin cumulus clouds, these spectra form in surreal shapes, rather than predictable arcs. *Fogbows*, *seadogs* or *white rainbows* are rainbows with muted colours seen in thick, low water vapours. They appear around the anti-solar point. *Cloudbows* are fogbows within clouds – if you travel by plane, keep your eyes open and you may see one.

All of these optical phenomena are wondrous combinations of cloud, vapour and sun. But perhaps the most magical of all are the *wavebows*. If you are on a coastline facing westwards to the ocean, you may be fortunate to see rainbows dancing on the waves at the earliest moments of the sunrise. If you are on the east coast, look carefully at the waves in the last moments of the day, and perhaps you will see the colour spectrum. These rare wavebows are actually found at slightly smaller angles than those in the sky. The salt water splits light at a different angle than the fresh water found in clouds and mist. Pay close attention to the waves – these are rare and magical rainbows!

HOW TO CONJURE A RAINBOW

We’ve looked at the conditions to form rainbows, the directions you must look to see them and the types of rainbows that you may find. But what about conjuring them, and capturing them?

You can conjure rainbows with the help of a garden hose or spray bottle in the midday sun. Direct the water

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Peter Turnley/Corbis

◀ A Somali refugee stands with the sunlight on his face, before primary and secondary rainbow arcs

▶ ▲ At high latitudes, a group of penguins congregates beneath the glow of an afternoon rainbow



away from the sun. You can use the reflection of a CD, or a cut glass prism, to create compact disk rainbows or prism spectra. One of the simplest ways to form a rainbow is to fill a glass of water and place it in a dark, shady place where the sun reaches it from one direction only. The edge of the water divides the white light, which creates a colourful glass-of-water spectrum.

To capture a rainbow, one needs only a camera and the knowledge of where to look. The well-equipped rainbow seeker will find themselves, camera at the ready, on high ground or a mountain peak, with the morning or evening sun to their back, and dark clouds ahead. When a rainbow is spotted, the photographer can try to move to a location that will make the rainbow appear to land at a point of interest.

To conjure a truly wild rainbow, visit a misty waterfall on a sunny day. For a tamer rainbow, try a large fountain shooting water upwards. Depending on where you are relative to the cascade – above, below or to the side, you may find different shapes and intensities of spectra. You have conjured a rainbow!

Experimenting with your camera settings, making the picture darker and the colours more vivid, can yield more impressive photographic images. If there is a subject of interest in the foreground, such as another human being,

using the flash on the camera can fill in the details of the closer environment, which would otherwise be silhouetted. Two colourful, yet unwanted phenomena, which can be used for dramatic effect, are the scratched lens shimmer and the dirty lens flare, which show up unpredictably in damaged or dirty camera equipment. If you wear eyeglasses, you may be all too familiar with these special rainbows.

THE OTHER SIDE

The question remains: Just what is on the other side of the rainbow? This question has been a famous one among philosophers and dreamers, astronomers and cloudspotters. Rainbows span an impossibly long distance: from earth to heaven, from life to death, from deep red to remote purple.

What is on the other side? You'll have to cross the rainbow bridge to find the answer. **AG**

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RAINBOWS AS BRIDGES

RAINBOWS have been identified as arching bridges. They span extremes, from the eternal heavens to the endless hell. They have been traversed by deities and spirits, both upwards and downwards.

In the far east of Asia, the mythological Japanese creator spirits, Izanami and Izanagi, used the rainbow bridge as a pathway down from the celestial skies to the as-yet unformed chaos ocean, where they would conjure the land from the underwater volcanoes. Similarly, on the Indonesian island of Celebes, the Makarese people remember that the son of the sky god descended on the rainbow to make ready the world for humans.

In the far west, the Zoroastrians of ancient Persia believe that Chinvat Bridge – the rainbow – was the pathway to heaven, upon which the personification of good, Ahura Mazda, ascended from the mundane world. Four days after their death, the spirits of the virtuous will follow him along the coloured bridge into the unknown, but the wicked will lose their balance, and in terror

fall from the bridge. In the Qur'an, As-Sirat is mentioned, a razor bridge as sharp as a sword, which climbs to heaven above and spans hell below. This may be describing the rainbow. The virtuous will pass with ease to paradise, and the unjust will fall to hell beneath. For the Alaskan Tlingit people, the rainbow is the path of the dead.

In other cultures, divinity or death is not an essential requirement to cross the rainbow bridge. Siberian shamans climb the rainbow in a psychedelic spirit trance, spiritually launching into the sky from a sacred birch tree. In California, the Chumash people recall how they arrived in their coastal homeland from an island offshore. The Earth Goddess built them a rainbow bridge towards their new home, and they crossed over to the mainland. Some, in fright, looked down from the rainbow and slipped through the colour bands. They fell an immense distance into the ocean, and upon splashing down, were transformed into dolphins.

For the ancient Greeks, the swift-winged Iris was a messenger

A rainbow corona is seen closely ringing, with a more subtle gradation of colour than a standard rainbow

A rainbow looms above a 75-year-old pastoralist as she gazes out of her traditional Gabbra shelter in Kalacha, Kenya, shortly after one of the first rainstorms, which broke the devastating three-year drought in the region

for the gods. She travelled along the rainbow, bringing news and messages from Mount Olympus down to the mortal world. She never carried good news, but brought stern warnings and strict commands. In the farthest northwest of the Eurasian mainland, the Vikings in their snowbound halls told stories of Bifrost, the rainbow bridge to heavenly Asgard. Upon this bridge, the sentry Heimdall stood watch eternally alert, with unsurpassed vision and hearing. None but the gods were allowed to cross the bridge, save the brave warriors who had died in battle. As they were slain, the Valkyrie spirits would tap them on the shoulder, and hand in hand lift their souls to travel the rainbow bridge to the heavenly afterlife.

A much more modern tale stems from an anonymous poem written in the 1980s. In this story, shared with grieving children worldwide, pet animals that have died await their owners in a sunlit meadow. They will play there, happily, until their owners pass away, and then together they will travel over the rainbow bridge to heaven.

RAINBOWS MADE SOLID

Tangible arches have been named and identified as rainbow bridges. In the Grand Canyon of the Colorado River of North America, the Navajo people view a spectacular natural sandstone bridge as a rainbow. In the celebrated ruins of Angkor Wat, Cambodia, there are rainbow bridges carved from stone that lead to the gates of the city. In modern Tokyo, a suspension bridge – the world's 60th longest – was named Rainbow Bridge by popular vote. Solar-powered lights bring colour to the bridge at night.

A famous rainbow bridge of the Chinese Song Dynasty was recently rebuilt, following the design shown in the most famous of all Chinese paintings. In the Qing Ming Scroll, the artist Zhang Zeduan illustrates a riverfront scene in the capital of Kaifeng, as it appeared to him 900 years ago. An arched bridge prominently spans the river, known to scholars as the Rainbow Bridge, but it has long since been destroyed. **AG**

CURIOUS RAINBOW RUDIMENTS

The division of rainbows into seven colours – red, orange, yellow, green, blue, indigo, violet – was formalised by the British scientist Isaac Newton to align with European musical theories. The spectrum can be divided into as many segments as your eye can see.

Exoplanetary astronomers have proposed that infrared rainbows in methane mist may be present on Saturn's moon Titan.

The Mongolian word for rainbow – *solongos* – is the same word they use to refer to Korean people.

Skydivers leaping out of aeroplanes can jump through the centre of circular rainbows... but they are only visible to observers still in the plane.

Rainbows are mentioned in the ancient Sumerian epic of Gilgamesh the King, the world's oldest hero story. After a cataclysmic Great Flood, the goddess Ishtar creates the rainbow as a reminder and promise of the future. This is the same symbology of the rainbow found in Islam, Judaism and Christianity.

Australian Aboriginals recognise the mythical Rainbow Serpent, the life-giving creator of the world responsible for the topography of the landscape.

Moonbows were described in 350 BC by Aristotle

Rainbows have been a mystery since ancient times. Nine hundred and fifty years ago, the Chinese philosopher Shen Kuo correctly described the process by which rainbows appear, as did the Persian scientist Qutb al-Din al-Shirazi two centuries later.

The central part of your eye, the iris, is named after the Greek messenger goddess of the rainbow.