Moon

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Moon

A BRIEF HISTORY

Bernd Brunner

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Introduction

The light of the sun is our essential source of energy. Without it, not only would Earth's temperature drop to an unimaginable level, but a thick crust of ice would soon cover the planet's surface. Few microorganisms, if any, would survive. If the sun disappeared altogether, our world would even lose its gravitational anchor. The world is simply inconceivable without the sun. But what would the planet be like without the moon? We might assume that the absence of our satellite would affect us less dramatically than the loss of the sun. But the more we recognize how intimately life on Earth is connected with the moon, the more unsettling the idea of life without it becomes. By stabilizing our planet's inclination, the moon has prevented it from going off on seasonal excursions that might have led to completely other consequences for the evolution of life on Earth.

Without our moon, Earth would be a vastly different place. Just *how* different it is difficult to know, but if we imagine Earth with a much weaker ebb and flow of the tides, we get an inkling of the importance of the moon's role. Life itself may not have been possible without the moon. The strong ocean tides have created

pools considered essential for complex biological systems to arise. According to the theory now generally accepted, a body with the dimensions of Mars collided with our planet, flinging off the disk of material that created the moon and gave Earth its axial tilt. What would our planet be like if such an incident had never taken place?

Although there are limits to the credibility of speculative history, some scientists find such thought experiments irresistible. The American astronomer and physics professor Neil F. Comins, for example, draws an elaborate comparison between an Earth on which no impact has occurred, which he calls Solon, and Earth as we know it. According to Comins's hypotheses, Solon rotated much faster—possibly at three times Earth's current speed—which would cause correspondingly stronger movements in the planet's atmosphere. Tall trees or delicate, large leaves would be a rarity in such a world, as would fragile animals with long legs or wings. Humanoid creatures could exist, but their appearance would be quite different. If Comins is right, the moon has therefore played a pivotal role in our development as a species. Although the precise extent of its influence can probably never be determined, Earth's lifeless satellite plays a central part in who we are—along with the sun, the atmosphere, our oceans, and the animals and plants living beside us. The moon's history is intimately related to the Earth's.

Yet the moon's central role in life on Earth is difficult to square with the simple facts we know

about it. Our moon is a bleak, gloomy, lifeless celestial body just a quarter of Earth's size and one-eighty-first of its weight, with a gravitational pull of only one-sixth. It rotates on its own axis once approximately every twenty-eight days, which is very slow compared with the current twenty-four-hour rotation period of the Earth. Its surface is a bit larger than Africa's and Australia's combined. Its very thin atmosphere means that there is no sound and, without a means to retain the warmth of the sun, the surface temperature fluctuates considerably.

In some ways, viewing and scrutinizing the moon gives us a look back to the beginning of the solar system. The position of the moon relative to Earth has changed, though. According to computer models, two billion years ago the moon would have been 24,000 miles away from Earth, orbiting it 3.7 times per day, and causing tides up to a thousand times higher than those observed today. Now at an average distance of 238,900 miles from the Earth—or the equivalent of thirty times the Earth's diameter—the moon is losing energy, slowing down, and receding from us as its orbit expands by 1.5 inches each year, or 250 feet in two thousand years. The tides act as a brake on the rotational speed of both the moon and the Earth. At some distant point in the future, the sun will engulf the Earth and the moon. But for now, the sun will continue to shine, the wind to blow, the seas to surge.

These physical facts and figures alone do not explain what the moon means to us. The impor-

Fig. 52. Wie der Mond um die Erde kreist und ihr immer dieselbe Seite zukehrt.

The moon circles the Earth, while always exposing the same side. The tension of the cord stands for the attraction of the Earth, locking the spin of the moon.

tance of the moon has less to do with its proximity to Earth than with its centrality in the human imagination. The moon's face has been known to inspire admiration, sadness, joy, even longing, and, under certain conditions, fear. Even though we may think we can lasso the moon, it often eludes our grasp. Close, yet really far away—the moon is a paradox. And when we study it, we are also studying an aspect of ourselves.

If Earth had been shrouded in clouds, objects in the sky would never have evolved into symbols, but because we can see the moon wax and wane each month, for example, we take meaning from its periodic journey between complete darkness and a bright, full disk. The moon's nearness also encourages us to ponder what might be "out there." Are there other worlds among the distant stars? Is there another sphere similar or not so similar to ours? The moon's proximity also made it natural that we should make it the destination of our first venture beyond our home planet.

The moon is the most examined object in the sky. For millennia it has been an enigma, a *luna incognita.* The Greek writer Aeschylus (525–456 B.C.) saw in it "the eye of the night." Lucian of Samosata (ca. A.D. 120–185) wrote, "I found the stars dotted quite casually about the sky, and I

wanted to know what the Sun was. Especially the phenomena of the Moon struck me as extraordinary, and quite passed my comprehension; there must be some mystery to account for those many phases, I conjectured." For a long time, the moon had counted among the seven planets moving about a fixed Earth, along with Mercury, Venus, the sun, Mars, Jupiter, and Saturn. In the seventeenth century, as the heliocentric idea of the universe gain wider acceptance, the moon was relegated to a less important position. Now it was just a satellite, not even unique, since most of the planets circling the sun have one or more moons.

This book is a brief history of the imprint the moon has left on the human imagination and of the enduring fascination it has provoked. It is an appreciation of the contributions of various cultures—and of both popular and scientific traditions—in shaping our sense of the moon. An appreciation, too, of the moon's unique power to inspire our capabilities for invention and to nourish our drive to self-understanding. Over the millennia the moon has been the focus of a vast array of human practices. This book is devoted to many questions regarding the moon's role in our lives and the lives of those who went before us. How, for example, has the moon been used to structure time? What kinds of life have both scientists and writers imagined on the moon? How has the moon's origin been accounted for? Why do some people—all the evidence notwithstanding—still claim that the moon landings never happened? My hope is that these investi-

gations, taken together, will be more than a motley collection, that they will provide a sense of the amazing continuity, from the first imagined lunar journeys to the Apollo program, of the moon's eternal place in the life of humankind.

Moon

CHAPTER ONE

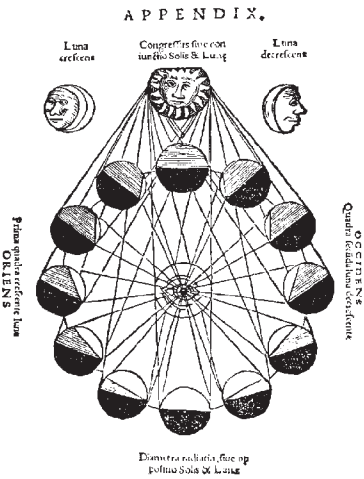
Gazing at the Moon

While the sun is too bright for us to look at it directly, the moon lends itself to gazing and contemplating. Over the course of about one month, the moon makes a perceptible trip through the sky. Its phases are more easily distinguishable than its motion. On the third day after the new moon, its visible surface starts to take the form of a thin semicircle, easily lending to a comparison with a pair of horns or a boomerang. The next night it will be higher above the western horizon than the night before, and not as thin. It also sets later as its month moves on. It develops into a half-moon. During the next seven to eight days, its light increases until its image becomes circular. At the time of the full moon, it is directly opposite the sun, so that the latter illuminates the full surface of the moon visible from Earth throughout the whole night. Next the moon goes again through the same shapes as before: now from oval to last quarter, the phases of the waning moon mirror those of the waxing moon.

The last quarter diminishes, further taking the shape of a crescent, the horns of which are raised on the side farthest from the sun. At some point, by the twenty-seventh day, the moon is visible only for a short period of time before sunrise. During the last hours of darkness it can still be

Moon gazing was all the rage in nineteenth-century Europe.

seen, but it's clearly fading. It approaches the sun and finally gets lost in its rays. The moon is actually part of the daytime sky as often as the nighttime sky, even if it is hardly noticed or sometimes mistaken for a soft cloud. Finally, for the duration of three days, the moon is no longer visible in the sky, neither at day nor at night—except during a solar eclipse, when a sliver of the moon is visible. These regularly recurring phases are a consequence of the moon's movement around the Earth, and the phase of the moon as seen from the Earth is always complementary to that of the Earth from the moon. The moon moves along its path about thirteen times faster than the sun, covering the distance in four weeks that the sun travels in a year.



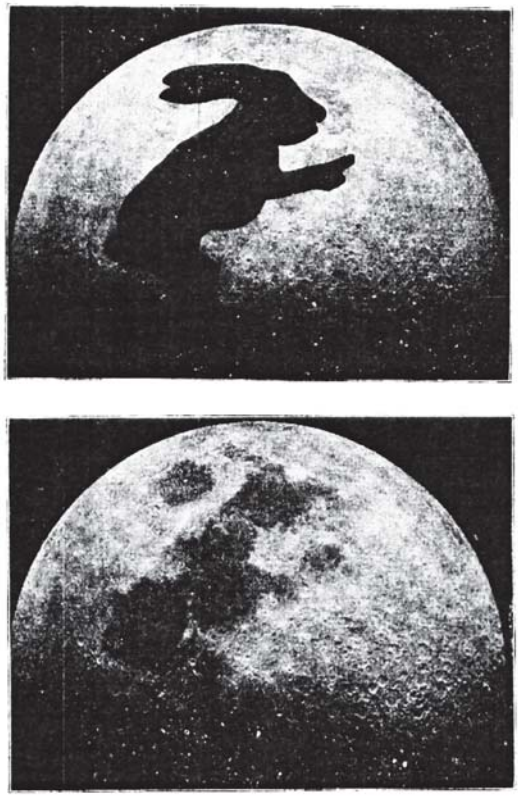
The development of the lunar phases as illustrated in a print by John of Sacrobosco (also known as John of Holywood) from *Tractatus de sphaera,* an important astronomy book of the Middle Ages

During the full moon, details of the lunar surface are indistinguishable; even the mountains of the moon barely cast a shadow. Tycho, for example, the brightest and most conspicuous crater on the moon—named after the Danish astronomer Tycho Brahe (1546–1601)—is eighty-five kilometers wide and, at perhaps 108 million years old, the youngest of the craters on the near side of the moon. It was formed a long time before humans walked the Earth, but dinosaurs could have observed the moment of impact. As the moon waxes,

the appearance of Tycho experiences a remarkable transformation. Initially it is a great gaping crater—reminiscent of the Greek root of the word, meaning "cup" or "bowl"—then it slowly grows to become the epicenter of a complex system of rays extending hundreds or thousands of kilometers into the area around it. It is said that Tycho makes the moon resemble a peeled orange. The lunar scientist Thomas Gwyn Elger (1836–1897) called it "the Metropolitan crater of the Moon."

Long before the discovery of the telescope, humans pondered the particular pattern of lighter and darker areas on the lunar surface, much as they have always studied the shapes of clouds in the sky. The human face imagined on the lunar surface was probably the most ancient, and certainly the most anthropomorphic, perception. In this case, the major dark spots on the lunar surface—the maria—would be associated with certain facial features like eyes, eyebrows, nose, cheek, and lips. When we look at the moon with the naked eye, the maria vaguely suggest a human face. Sometimes the pattern of dark and bright spots is identified with the contours of a woman's face, with her hair bound up on the top of the head. Armed with a little imagination, observers could project a vast repertoire of images on the pattern of dark and light areas: from a broad grinning face or a rabbit with long ears to a crab or even a man with a dog. Often they would discern the features of the proverbial Man in the Moon.

The Tycho crater and the surrounding area



A hare in the moon?

Among the most obvious phenomena related to our neighbor in space are moonrise and moonset. Both can be impressive, though the amount of light involved cannot produce a colorful optical effect as spectacular as the interplay of intense red and orange hues at sunrise or sunset. The moon appears much larger—double or even triple in size—when it rises or sets, dwarfing the houses and trees surrounding it. After its ascension to the sky, this impression disappears. Sev-

eral possible explanations have been advanced to account for the "moon illusion." One is that the close juxtaposition of objects such as houses or trees with the brightly illuminated moon fools us into exaggerating its size compared with the foreground objects. But the illusion may also plausibly be related to the perceived distance of the moon: when it is on the horizon, the brain interprets it to be farther away than when it is above us.

As incredible as it may seem, the French astronomer Frédéric Petit, then the director at the Toulouse Observatory, was convinced he had discovered a second moon with an elliptical orbit while looking through his telescope early one evening in 1846. Jules Verne took up this idea in his book *From the Earth to the Moon.* We cannot reconstruct how Petit arrived at such a conclusion, but a small line of astrologers after him claimed to have seen second or even multiple moons. One was the German Georg Waltemath, who, shortly before the close of the nineteenth century, reported seeing an entire group of midget moons. Two decades later, Walter Gornold—another German—gave the name Lilith to what he claimed was a dark moon visible only when it crossed the sun.

How about other phenomena associated with the moon? Both myth and history bear witness to the overwhelming sensations inspired by the beauty of the full moon. It provided the backdrop for holy marriages between gods and goddesses, as well as for coronations and dancing rituals.

Gautama Buddha is believed to have attained enlightenment on the day of the full moon while sitting under the Bodhi Tree. Many took the full moon as an occasion for unusual behavior. The Chuckchee shamans from northeast Siberia reportedly undressed and exposed themselves to its light, thereby obtaining magical powers. It is doubtful whether we should credit Martin P. Nilsson's assertion that "half Africa dances in the light in the nights of full moon." On the other hand, we know that the boys and girls of the Shona, an ethnolinguistic group centered in Zimbabwe, still like to dance by the light of the full moon to the sound of drums and rattles.

In contrast, the absence of the moon from the sky was frequently accompanied by the fear—contrary to empirical evidence—that it would die, never to return. The Aztecs of central Mexico, for instance, believed that they recognized death in the dark of the moon. Sometimes the phase of the new moon was perceived as a liminal period, a time of prayer for the moon to return. And when the silvery disk finally appeared in the sky, it was greeted joyfully, with exclamations of salvation.

Other spectacular lunar phenomena include eclipses that are caused by or that affect the moon. The word *eclipse* goes back to the Greek *ekleipsis,* meaning "omission" or "abandonment." A total solar eclipse counts among the grandest and most dramatic sights in nature. Solar eclipses occur when the moon happens to pass between the Earth and the sun, with the moon fitting more or less over the sun's face. The phenome-

In this illustration by the French satirical illustrator Grandville (1803–1847) the solar eclipse is represented as a conjugal embrace of the sun and moon (1844).

non, which can last for up to seven minutes, is possible because the sun is about four hundred times larger than the moon and four hundred times as far away—a most curious coincidence. But this kind of eclipse is visible only within that narrow part of the Earth's surface located in the moon's shadow. In contrast, a lunar eclipse, which occurs when the Earth passes between the sun and the moon, lasts for several hours and can be seen from any point on Earth where the moon is above the horizon at the time.

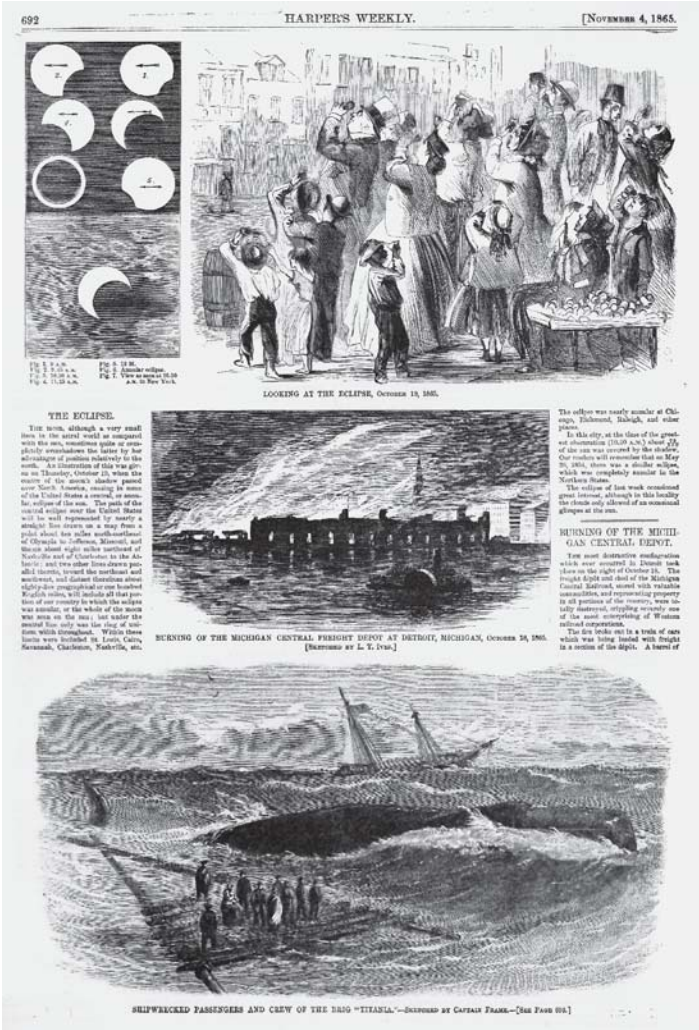
The abrupt turn to blood-red, or "dying," of a full moon must have alarmed early humans, often provoking fear even when it could be pre-

dicted. An eclipse has often been interpreted as a suspension of the natural order. The Maasai people of east Africa are reported to have thrown sand into the air during an eclipse. Some North American Indians are said to have banged and rattled pots and pans (and probably drums before pans became available) or shot flaming arrows in the direction of the moon to kill the predator consuming its light. People from the Orinoco region of Venezuela buried their fire under the ground in case the moon's fire went out.

During the minutes before a total solar eclipse, with sunlight arriving only from the edge of the sun, colors turn more intense and shadows more distinct. As the temperature drops, an eclipse wind is produced, and shortly before the total eclipse so-called shadow bands appear: shimmering dark lines produced by atmospheric temperature cells produced by the remaining rays of the sun. During a solar eclipse all objects on Earth assume an unforgettable pallor, often described as mainly olive green with tinges of copper.

The French Catalan astronomer François Arago (1786–1853) described the emotions of the witnesses to a total eclipse of the sun that he observed in the eastern Pyrenees on July 8, 1842. Nearly twenty thousand people had assembled with smoked glasses, only the sick staying inside, and

> when the Sun, reduced to a narrow thread, commenced to throw on our horizon a much-enfeebled light, a sort of uneasiness


692 HARPER'S WEEKLY. [NOVEMBER 4, 1865.

LOOKING AT THE ECLIPSE, OCTOBER 19, 1865.

THE ECLIPSE.

BURNING OF THE MICHIGAN CENTRAL FREIGHT DEPOT AT DETROIT, MICHIGAN, OCTOBER 20, 1865.

BURNING OF THE MICHIGAN CENTRAL DEPOT.

SHIPWRECKED PASSENGERS AND CREW OF THE BRIG "TITANIA."—SKETCHED BY CAPTAIN FRAME.—[SEE PAGE 693.]

A solar eclipse that passed over the North American continent on October 19, 1865, shared newspaper space with a fire and a shipwreck.

> took possession of everyone. Each felt the need of communicating his impressions to those who surrounded him: hence a murmuring sound like that of a distant sea after a storm. The noise became louder as the solar crescent was reduced. The crescent at last disappeared, darkness suddenly succeeded the light, and an absolute silence marked this phase of the eclipse, so that we clearly heard the pendulum of our astronomical clock. . . . A profound calm reigned in the air; the birds sang no more. After a solemn waiting of about two minutes, transports of joy, frantic applause, salute, with the same accord, the same spontaneity, the reappearance of the first solar rays.

According to the French science writer Camille Flammarion (1842–1925), in Africa on July 18, 1860, men and women were seen either praying or fleeing to their dwellings. "We also saw animals proceeding towards the villages as at the approach of night, ducks collected into crowded groups, swallows hurling themselves against the houses, butterflies hiding, flowers—and notably those of the Hibiscus Africanus—closing their corollas," Flammarion writes. On July 28, 1851, the sky was too cloudy to yield an astronomical observation of any kind in the town of Brest in Belarus, so the astronomer Johann Heinrich von Mädler focused his attention on the fauna. Ex-

cept for the horses, all animals showed some kind of restlessness, beginning fifteen minutes before the actual eclipse. Geese and ducks fell asleep, and chickens scurried to their roosts. The aurochs, one of the last of its kind, became uneasy, soon hiding in the thicket and uttering a call that had rarely been heard. Before the total solar eclipse passed over north India on October 24, 1995, where it happened to coincide with the annual Festival of Light or Divali, astrologers recommended avoiding the shadow of the moon while it crossed the sun to circumvent misfortunes. The eclipse lasted less than a minute and was visible on a path less than twenty-seven miles wide, but many observers fasted or jumped into rivers to be cleansed. A Western traveler observed the eclipse from Khanua, Rajasthan: "I noticed it had begun to darken in the West. The clear sky turned a deeper blue than normal. As more and more of the Sun disappeared, the colors changed and gave the landscape an evening glow. Somebody described it as 'spooky.' Even the villagers quietened down as a chill filled the air. The light was very eerie and it continued to darken, the light changing as I watched. Two dogs sped across the fields heading for home, their tails between their legs. Parakeets squawked and circled uncertainly. The monkeys had disappeared. I could see the black lunar shadow approaching rapidly. I looked up to see the thin crescent of the Sun condense into a point, flicker, and go out."

In some instances anticipation of an eclipse has been used to increase one's credibility and ad-

Christopher Columbus and the Jamaicans at the moment of the lunar eclipse

vance an agenda. When Christopher Columbus was on his fourth trip to the New World, worms in the timbers of his ship caused it to leak and become unstable. He had to land in St. Anne's Bay, Jamaica, to repair it. Ultimately, he and his crew had to spend more than a year on the island, whose indigenous people refused to defer to the Europeans. Finally, Columbus, having calculated that a total eclipse of the moon would occur on February 29, 1504, gained an advantage. The night before this event, he called a meeting of the tribal leaders, invoked the Almighty, and warned that if the natives did not cooperate, the moon would disappear from the sky. When the warning came true, the terrified natives begged Columbus

to bring the moon back, providing his crew with food and assistance.

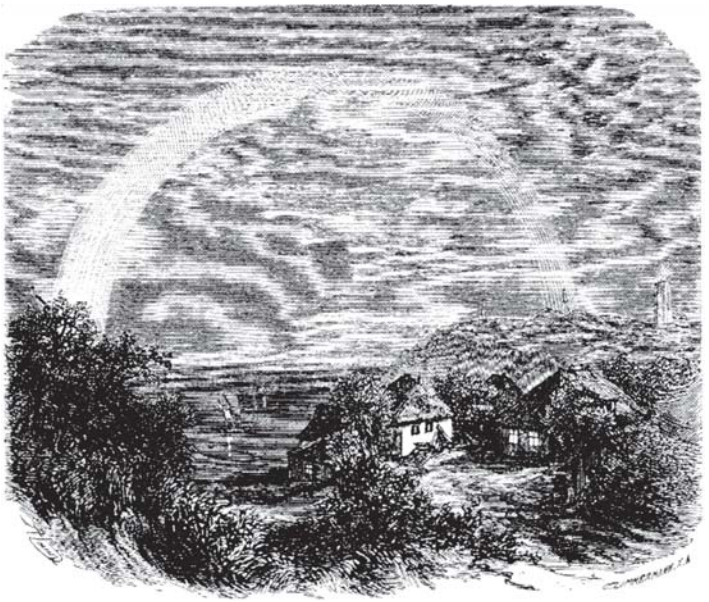
Thanks to precise knowledge of the motion of the sun, moon, and Earth, it is possible to calculate eclipses for thousands of years, in the past as in the future. The Austrian astronomer and mathematician Theodor von Oppolzer (1841–1886), in his *Canon of eclipses* (1887) accomplished the feat of compiling eight thousand solar and fifty-two hundred lunar eclipses covering the time span from 1200 B.C. until A.D. 2161.

Eclipses are rare, but the very notion of rareness evokes another lunar phenomenon. To say that something happens "once in a blue moon" is to say, literally, that it happens as often as a second full moon sneaks in during a calendar month. In an unrelated phenomenon, the moon may in fact appear bluish when the Earth's atmosphere contains a high concentration of very small smoke or dust particles. Particles measuring about one micron in diameter—thus wider than the wavelength of red light—strongly scatter red light, while allowing other colors to pass, so that white moonbeams shining through the clouds emerge as blue and sometimes as green. This phenomenon has also been described as resembling electric glimmer. When the volcano Krakatoa erupted in 1883, plumes of ash rose to the top of Earth's atmosphere; as a result, the moon appeared to be blue for about two years. Forest fires can have the same effect.

Among the rarer optical effects associated with the moon are also moonbows or lunar rainbows.

Although the cause is the same as for a sun's rainbow—light refracted through water droplets—the moon's bow is much weaker, usually appearing as less brightly colored and less discernible in the sky. After crossing from Nassau to Miami on June 16, 1938, the geographer Armin Kohl Lobeck of Columbia University delivered a dramatic account in *Time* magazine. "Tumultuous trade wind clouds towered to gigantic heights and there were occasional squalls of rain. About 11 o'clock, when the moon was well up in the southeast sky, the rainbow appeared in the northwest, where a thunderstorm was in progress. The prismatic colors were fairly distinguishable. The arc was complete, the two ends dipping into the sea." There are also so-called moon coronas produced by high, thin clouds, forming a close fringe around the moon. A lunar halo, a large colored ring surrounding the moon, is sometimes visible when there are ice crystals in the upper atmosphere. Moon pillars, pale shafts of light that extend out either above or below the moon, can be seen when the moon is rising or setting near the horizon. They appear when ice crystals reflect light forward from a strong light source such as the moon.

A number of people claim to have seen red glows, flashes, glows, mists, obscurations, temporary colorations of the lunar soil, and shadow effects when looking at the moon. Claims of such sightings, typically discernible only during short intervals, go far back in time, with some having been observed independently by several

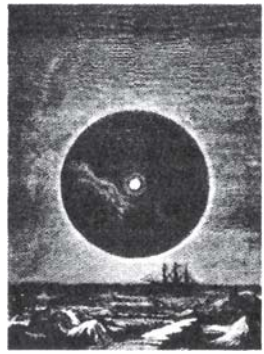


A moonbow

witnesses or reputable scientists. In fact, lunar transient phenomena or LTPs, as they are now called, continue to be seen. Some topographical formations, such as the surface of the lunar impact crater Aristarchus and its satellite craters, seem to be particularly prone to the phenomenon, accounting for a third of all such observations. Lunar missions have established a higher occurrence of alpha particles caused by the emission of radon-222 from Aristarchus. This may be the source of the transient light phenomena observed.

LTPs are hard to analyze, though, in part because they are irreproducible. Reports of LTPs rarely make it into scientific publications, and many events probably arise from causes in the

terrestrial atmosphere. To be considered as a genuine lunar phenomenon, an event would have to be observed from two places on Earth at the same time—a hard task for something no one can predict.



A lunar halo

If LTPs are somewhat dubious and irregular, impacts are undeniable, and they occur continually on the lunar surface. The most common impacts are those associated with micrometeorites. Impact flashes from such events have been detected simultaneously at multiple Earth locations. Most lunar scientists acknowledge that such transient events such as the emission of gases from the surface and impact cratering do occur. The controversy lies in the frequency of such events.

A category of another order are "observations" of life forms on the moon. A digression is in order. The idea of lunar life has been part of the human imagination for millennia, long before the invention of the telescope, but the English clergyman John Wilkins (1614–1672) was among the first modern scientists to purport such a view. "'Tis probable there may be inhabitants in this other World," Wilkins wrote in *The Discovery of a World in the Moone* (1638), "but of what kinde they are is uncertaine." Johann Hieronymus Schröter (1745–1818), a German astronomer known for his elaborate drawings of Mars was, "fully convinced that every celestial body may be so arranged physically by the Almighty as to be filled with living creatures." He attributed color changes he ob-