Moon Phases: Crash Course Astronomy #4

Crash Course: Astronomy
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Besides the Sun, the Moon is the most obvious object in the sky. Bright, silvery, with tantalizing features on its face, itâ€™s been the target of imagination, poetry, science, and even the occasional rocket. If you pay even the most cursory attention to it, youâ€™ll see that it changes every day; sometimes itâ€™s up in the day, sometimes at night, and its shape is always changing. What causes this behavior? The Moon is basically a giant ball of rock 3500 kilometers across hanging in space. Its surface is actually pretty dark, with about the same reflectivity as a chalkboard or asphalt. However, it looks bright to us because itâ€™s sitting in full sunlight; the Sun illuminates it, and it reflects that light down to us here on Earth. And because itâ€™s a sphere, and orbiting the Earth, the way we see it lit by the Sun changes with time. Thatâ€™s what causes its phases: geometry. The important thing to remember through all this is, because the Moon is a ball and in space, half of it is always illuminated by the Sun! This is true for the Earth, too, and every spherical object in space; half faces the Sun, half faces away. We call the part facing the Sun the daylight or bright side, and the half facing away the night or dark side. The phase of the Moon refers to what shape the Moon appears to us; how much of it we see illuminated from the Earth. The key to all this is this line, dividing the lit day side from the unlit night side. We call that line the terminator. If youâ€™re facing the moon, with the sun behind you, youâ€™re seeing the half of the moon that is fully illuminated by sunlight and it looks full. If youâ€™re off to the side you see half of the lit side and half of the dark side and we say the moon is half full. If the sun is on the other side of the moon, youâ€™re look at the unlit half, and it looks dark. Now, mind you, I havenâ€™t moved anything except our point of view here, so at all times the Moon is always half lit, and half dark. Remember that. The phase of the Moon we see depends on from what direction the sunlightâ€™s hitting it, and the angle we see that from Earth. The Moon orbits the Earth roughly once per month. In fact, thatâ€™s where the word â€œmonthâ€• comes from; â€œmonthâ€• and â€œMoonâ€• are cognates, words that have similar etymological histories, and in most languages, including English, the two words are very similar. The length of time we call the month is derived from the length of time it takes the Moon to go through all its phases -- 29.5 days. So. To describe the phases, letâ€™s start at the beginning: New Moon. New Moon happens when the Sun, Moon, and Earth are all more or less in a line. The Moonâ€™s orbit is actually tipped a bit to the Earthâ€™s, so sometimes new Moon happens when the Moon is â€œbelowâ€• the Sun, or â€œaboveâ€• it. But at some point in its orbit, at some point in the month, it appears to be as close to the Sun as it can. What does this look like from Earth? The Moon is between the Earth and the Sun, so from our perspective we only see the dark half, the unilluminated half, of the Moon. The other side, the far side, of the Moon is lit, but we canâ€™t see it. It makes sense then to call this the beginning of the Moonâ€™s cycle, hence the term â€œNew Moonâ€•. Now think about this for a sec: Because the Moon is near the Sun in the sky, it travels across the sky with the Sun. Itâ€™s up during the day! You can only see it from the part of the Earth thatâ€™s lit, which is when itâ€™s daytime. Itâ€™s a very common misconception that the Moon is only up at night, but itâ€™s up during the day literally just as often. At New Moon, the Moon stays near the Sun, so it rises at sunrise, and sets at sunset. This makes it extremely difficult to see; it is, after all, sitting next to the brightest object in the sky, and only a little bit of it is lit from our perspective. But not for long. Because the Moon is orbiting the Earth, after a couple of days itâ€™s moved a bit to the east. Now weâ€™re seeing it along a slight angle, and we can see a little bit of the illuminated half of the Moon on its side toward the Sun. The terminator, the day/night line, appears curved around the Moon, so what we see is a thin illuminated crescent Moon. At this point the crescent is still very thin, with the horns of the crescent pointing away from the Sun. Note that the Moon is still pretty close to the Sun in the sky, just a bit to the east, rising maybe an hour or two after sunrise. But this means itâ€™s up all day, and then sets after the Sun does. This is the best time to see the crescent Moon, when the Sun has already set and the sky starts to get dark. The Moon will be low over the western horizon, and it will set soon after the Sun does. Letâ€™s wait a couple of days. OK, now the Moon has moved a bit more in its orbit around the Earth, and is farther from the Sun in the sky. We see a little more of the illuminated part, and the crescent is wider. Since itâ€™s getting thicker, we say this is a â€œwaxing crescentâ€• Moon; waxing means growing or getting bigger. Itâ€™s also well away from the Sun now, so itâ€™s easier to spot, even during the day before sunset. Seven or so days after new Moon we get to our first milestone: the Moon is now one-quarter of the way around its orbit. Itâ€™s 90Â° away from the Sun in the sky, which means weâ€™re looking straight down on the terminator, the Moonâ€™s day/night line. It cuts right down the middle of the visible face of the Moon, so itâ€™s half lit, with the sunward side of the Moon visible and the other side dark. Confusingly, this phase is properly named â€œfirst quarterâ€• because the Moon is Â¼ of the way through its cycle, Â¼ of the way through its orbit around the Earth, even though it looks half full. So itâ€™s not really the half-full moon -- astronomers prefer â€œfirst quarter,â€• so if you want to sound all astronomer-y, then you should call it that. But time marches on. The Moon continues on its gravitational dance with Earth, swinging around its orbit. Now more than half full, we say its shape is â€œgibbousâ€•, which means swollen or convex. Since itâ€™s getting wider, this is actually the waxing gibbous phase of the Moon. It rises in the late afternoon, and is up most of the night. Our next big step comes two weeks after new Moon, when itâ€™s moved halfway through its orbit. It is now opposite the Sun in the sky, 180Â° around. The Earth is between the Moon and Sun, so weâ€™re looking at the fully-illuminated half of the Moon. This is the full Moon. Because itâ€™s opposite the Sun, it rises at sunset and sets and sunrise; itâ€™s up all night shining down on the Earth. But again, wait a couple of days and things change. When the Moon is full itâ€™s 180Â° around the sky from the Sun, so as it continues to move around the Earth in a circle the distance between it and the Sun is now starting to decrease, even as it continues on in the same direction. As before, it keeps rising and setting later, but now it rises after sunset, and sets after sunrise. If you get up early in the morning as the Sun is just rising in the east, youâ€™ll see the nearly-but-not-quite full Moon setting in the west. Not only that, but weâ€™re about to go through all the phases again, but in reverse order. A few days after full Moon the lit side is shrinking. Itâ€™s in the waning, or shrinking, gibbous phase. Then, three weeks or so after new Moon, and a week after full, the Moon is once again half lit, the terminator splitting the Moonâ€™s face in two even halves. This is the â€œthird quarterâ€• Moon, because the Moon is Â¾ of the way through its cycle. Itâ€™s a lot like the first quarter, but the side that was lit is now dark, and vice versa. Itâ€™s 270Â° around the sky from the Sun. It rises at midnight and sets at noon. A few days later and the Moon is a crescent again, getting thinner. Itâ€™s now a â€œwaning crescent.â€• It rises just a couple of hours before sunrise, and sets a couple of hours before sunset. Then, finally, weâ€™re back where we started. One month after new Moon, the Moon has traveled 360Â° around the sky, and is once again as close to the Sun as it can get. Itâ€™s new Moon, and the cycle starts up again as it has for time immemorial. An interesting thing happens if you move your perspective from the Earth to the Moon. The phases of the Moon we see from Earth depend on the angle of the Moon and Sun in the sky. But on the Moon, the angles are exactly 180Â° reversed; at new Moon, when the Moon is between the Earth and Sun, the Earth is opposite the Sun as seen from the Moon. Itâ€™s full Earth! All the other phases are opposite too, so when we see a full Moon, a Moon-dweller would see a new Earth, and so on. Have you ever looked at the thin crescent Moon and seen the ghostly face of the rest of the unlit side? Thatâ€™s because itâ€™s not really unlit: the nearly full Earth is reflecting sunlight on the Moon, lighting up the otherwise dark part. The Earth is bigger and more reflective than the Moon, so itâ€™s actually 50 times brighter than a full Moon! This glow is called Earthshine, a term I quite like. Even more poetically, itâ€™s been called â€œthe old

Moon in the new Moonâ€™s armsâ€•, referring to the unlit part surrounded by the crescent new Moonâ€™s horns. Thatâ€™s lovely, isnâ€™t it? The Moon is one of the most beautiful and most gratifying objects in the sky to observe. Itâ€™s different every day! Yet itâ€™s also the same, because we see, more or less, the same half of it, the same face all the time. Itâ€™s big and bright, and the features on its surface discernible by eye (and even better with binoculars or a small telescope). As the phases change, inexorably, day after day, the angle of sunlight hitting the surface changes, bringing new things into our view. The motions become comforting, even familiar. Itâ€™s a reminder that the Universe may seem strange and complicated and forbidding at first, but over time, as you get outside and experience it, it becomes your neighborhood. Welcome home. Today you learned why the Moon has phases: Itâ€™s a sphere, and it orbits the Earth, so the angle at which we see its lit side changes. It goes from new, to waxing crescent, to half full, waxing gibbous, full, waning gibbous, half full, waning crescent, and then the cycle starts all over again. This also affects when it rises and sets, and what we see on the surface. Crash Course is produced in association with PBS Digital Studios. This episode was written by me, Phil Plait. The script was edited by Blake de Pastino, and our consultant is Dr. Michelle Thaller. It was co-directed by Nicholas Jenkins and Michael Aranda, and the graphics team is Thought CafÃ©.