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Missing the Night Sky

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"We used to look up in the sky and wonder at our place in the stars," Matthew McConaughey's character says near the beginning of the 2014 movie *Interstellar*. "Now we just look down and worry about our place in the dirt." The filmmakers surely must have intended that remark to serve as a comment on real-life America's diminished appetite for manned space exploration. But there is another reason we no longer marvel at the sky above us as we once did, and it has little to do with withered ambition: the stars themselves are harder to see. Things our grandparents would have been able to spot easily with the naked eye—the Andromeda galaxy, comets, the zodiacal light—are in many parts of today's world outshone by the light emanating from buildings, streets, and parking lots. Even some of the brightest arrangements of stars, such as the constellation Orion or the Pleiades cluster, are no longer fully visible to residents in and around the biggest cities—cities whose glow can illuminate the horizon from over 200 miles away. The lights of Las Vegas, for example, can be seen from eight different national parks.

Although the phenomenon has been documented and decried by professional astronomers and amateur stargazers for decades, most of us barely notice that the nighttime skyscape is fading from view. Living in a world awash in artificial light has become the norm. According to data from the late 1990s, some 40 percent of Americans live in places where it never gets dark enough for human eyes to become dark-adapted, and over two-thirds live in places where it is impossible to see the Milky Way. Virtually none will ever experience a night dark enough for the Milky Way to cast shadows on the ground.

Readers might be tempted to write off the disappearance of the night sky as a "First World problem," the sort of thing we can bother worrying about only because our most pressing needs have been addressed. But of course it is a First World problem in the most literal sense: the phenomenon is more pronounced in industrialized countries like the United States. The expansion of artificial light—and the resulting dimming of the nocturnal lights that humans, as well as other species, have looked to since time immemorial—is a consequence of the modern effort to expand

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human agency to the largest possible swath of surrounding space. This effort has afforded us more time in the day we can devote to work or play and more places where we feel safe. Yet the costs of our sky's increasing artificial illumination range far beyond diminished enjoyment of the stars or opportunity for telescopic research. We also lose a powerful reminder of our finitude.

Lighting the American Night

The story of how we are losing the night sky is first of all a story of improvements in lighting technology. The United States—being the first home to some of the most important innovations—serves as a good example of how the darkness became light. Various parts of this story have been told in several fine histories, including Wolfgang Schivelbusch's *Disenchanted Night* (1988), John A. Jakle's *City Lights* (2001), and Peter C. Baldwin's *In the Watches of the Night* (2012).

Until the mid-eighteenth century, American street lamps were privately operated. This was true even in New York City, where a law enacted in 1697 required "every seventh house" to "cause a lantern and candle to be hung out on a pole" during "the dark time of the moon." Candles were soon supplanted by oil lamps; Ben Franklin describes in his *Autobiography* how a certain John Clifton placed an oil lamp at his door, leaving the people of Philadelphia "impress'd with the idea of enlighting all the city." (Franklin himself contributed to the improvement of oil lamps, suggesting a design that was vented to reduce the nightly buildup of soot on the inside of the lamps and that used glass panes instead of globes to make the lamps easier to clean and repair.) Around this time the transition from private to public lighting began: Philadelphia started assuming responsibility for some street lamps in the 1750s, as did New York in 1761 and Boston roughly a decade later.

Oil lamps eventually gave way to gas lamps (with Baltimore leading the way in 1817), but both of these early forms of street lighting were dim and sparsely distributed—sometimes intended, Baldwin writes, "not to illuminate the street but to serve as navigation beacons." So dark was it still in those nights that unless pedestrians were directly under a lamp they would have had difficulty identifying one another. Baldwin recounts how a New York watchman was killed in the line of duty in 1830: he ran down a poorly lit street and collided with a post.

Darkness began to recede significantly in the early days of electric lighting. Arc lighting, which creates illumination by sending a current

across two carbon rods, became prominent in the 1870s. It was cheaper and much brighter than gas. Schivelbusch writes that "Unlike all earlier innovations in lighting which had been metaphorically compared to the sun, arc lighting really did resemble sunlight." It was the first type of lighting to exhibit, in the words of Jakle, "night-destroying brilliance." Arc lamps generated so much excess heat and glare that they were only suitable for hanging outdoors or in the largest indoor facilities. They could still be found in some American cities as late as the Second World War.

Thomas Edison was the foremost pioneer of the next great advance in lighting—not just the safer and longer-lasting incandescent light bulb, but an entire system of generating and transmitting power. As electric utility companies began to proliferate toward the end of the nineteenth century, electric lighting spread with them.

And then the car came. To ensure the safety of both pedestrians and automobile drivers, lights had to be installed at more regular intervals along streets and had to be lit for longer stretches of the night. "White ways," as heavily lighted streets such as Broadway came to be called, criss-crossed the cities, allowing cars, themselves affixed with beams, to safely convey the masses to evening dining, commerce, and entertainment.

Owing in part to improvements in power distribution (including the victory of alternating current over the Edison-backed direct current), by the 1920s electric lighting reached 85 percent of urban dwelling units in the Northeast and Midwest, according to Baldwin. The countryside came along later: when the Tennessee Valley Authority and the Rural Electrification Administration were established in the mid-1930s, only a tenth of farmers had electricity; by the early 1940s, about half did; by the early 1950s, nearly all did. Electric lighting had gone from something of an urban novelty at the start of the century to a nearly universal necessity by the time of the nation's postwar economic boom.

Chasing the Dark

The prevalence of artificial illumination soon became an obstacle for astronomers, whose work requires dark skies. Man-made light that shines or reflects upward scatters in the earth's atmosphere, which makes it much more difficult to pick out the light of stars and other cosmic objects against their now-glowing surroundings. Additionally, light produced from elements such as mercury that exist in some artificial light sources can interfere with spectroscopy, the splitting of light (and other types of

electromagnetic radiation) into its component wavelengths, which is used to help ascertain the chemical composition of distant stars and galaxies.

As early as 1887, Harvard astronomer Arthur Searle noted that artificial lighting in Boston (which first installed electric streetlights in 1882) prevented adequate observations of the zodiacal light—a faint glow just before sunrise or after sunset caused by sunlight reflecting off of space dust, a phenomenon that can now generally be seen only from rural locations. By 1909 the astronomy handbook *Curiosities of the Sky* urged readers to flee to the countryside if they wanted to see the zodiacal light, because "city lights ruin the spectacles of the sky." Astronomer George Ellery Hale, in his 1922 book *The New Heavens*, wrote that readers would lose track counting every visible star in the night sky unless they happened to be near "the glare of cities, which is often strong enough to conceal all but the brighter objects." Warnings such as these only intensified in the decades that followed.

One of the first major astronomical facilities to suffer from artificial light was the Mount Wilson Observatory, which Hale had helped establish beginning in 1904 on a mountainside some seven miles from Pasadena, California. The 100-inch telescope (meaning that the telescope's mirror has a diameter of 100 inches) that was completed at Mount Wilson in 1917 was for many years the largest in the world, and it enabled Edwin Hubble in the early 1920s to settle the "Great Debate" over whether or not the Milky Way galaxy comprised the entirety of the universe. But light projected from rapidly growing nearby cities—downtown Los Angeles was less than twenty miles away—became so strong that the telescope soon became useful only for observations of relatively bright objects and those that emitted in the infrared portion of the light spectrum. Mount Wilson was deemed an unsuitable home for the new 200-inch galaxy-hunting Hale Telescope, which was instead installed, in the late 1940s, on Palomar Mountain, about ninety miles from Los Angeles and fifty from San Diego. However, by the 1960s, its observations too were being hampered by city lights. In the late 1980s it was reported that the night sky around Palomar Observatory was about twice as bright as it would be without interference from surrounding artificial sources.

Astronomers at the Kitt Peak National Observatory in Arizona, one of the many federally funded facilities established to help kick-start the United States in the space race, believed their operations would be safe from urban interference. When Kitt Peak, about forty miles from Tucson, was selected in 1958, the observatory's early director Aden Meinel expected the Tucson Mountains to hide the lights of the city,

and he predicted that the limited availability of water in the area would limit Tucson's growth: "For the foreseeable future there appears to be no serious threat to the astronomical conditions on Kitt Peak." But by 1972, according to an article in *Science* the following year, the growing amount of light extending out from Tucson was "approaching the 1965 level at Palomar; this is far in excess of the most pessimistic predictions made before the construction of the major telescopes at Kitt Peak."

Among astronomers this problem had come to be known as "light pollution," a term that had previously referred to possible harmful effects of artificial light on human and other organisms (or that distinguished from any sort of "heavy" pollution). Among the first to study light pollution of the skies was astronomer Merle F. Walker, who had been tasked in the early 1970s with finding California sites for future telescopes. Walker was an astronomer at Lick Observatory, which was experiencing so much interference from the growing city of San Jose that Robert P. Kraft, then the observatory's acting director, declared in the early 1970s, "Lick will be out of the business of observing galaxies, quasars, and other faint objects within a decade." In a 1973 article, Walker used census data and Air Force satellite images to create a map of light pollution in California and Arizona, which showed that "all of the major California observatories and four of the six major observing stations in Arizona are already affected to some extent by light pollution and the remaining two are so close to light sources that future light pollution is a real danger." The sites in California and Arizona had been some of the most ideal in the contiguous United States for astronomical activity because of their high percentage of clear weather and atmospheric transparency. (In addition, the west coasts of continents generally experience less optical turbulence because of their colder ocean currents.) However, the growing threat of light pollution led Walker to recommend that planners consider locations away from the North American continent, such as Hawaii and Chile.

Walker's studies helped individual observatories join their efforts to gain wider recognition of the scourge of light pollution. In 1988, the International Dark-Sky Association was founded to educate the public about the value of the night sky and to lobby for lighting-policy changes. Then, in 2001, a trio of researchers produced "The first World Atlas of the artificial night sky brightness," providing "a nearly global picture of how mankind is proceeding to envelop itself in a luminous fog." They also created similar historical maps for the 1950s and the 1970s, as well as an estimate for 2025. Their images have become for dark-sky advocates what Apollo 17's iconic "Blue Marble" photo was for the environmental movement.

Discussion of light pollution is no longer confined to professional journals and local newspapers; over the last two decades, leading news outlets have slowly brought it into the national consciousness. Extended popular treatments of light pollution include Ian Cheney's documentary *The City Dark* that aired on PBS in 2012 and Paul Bogard's 2013 book *The End of Night*. And Dark Skies Awareness was one of the 2009 International Year of Astronomy's cornerstone projects, helping to celebrate the four-hundredth anniversary of Galileo's first recorded use of an astronomical telescope. As astronomer Tyler Nordgren told Bogard, "Four hundred years ago, everyone in Florence could see the stars, but only Galileo had a telescope. Now everyone has a telescope but no one can see the stars."

Brightness and Biology

Stargazing human beings are not alone in having their activities threatened by unnatural brightness. A growing body of research assembled by naturalists, biologists, and epidemiologists indicates that artificial light has dire consequences for many different species of animals. As early as 1918, the Audubon Association of the Pacific documented the numbers of birds killed by government lighthouses along the California coast. The destruction of birds is "slight," it reported then. But a 1965 report published by the American Ornithologists' Union estimated that lights on TV towers caused at least a million bird deaths each year. Light emanating from buildings, including from lighthouses and skyscrapers, interferes with the natural light of the stars and moon that some nocturnally migrating birds use as an aid in navigation, causing confusion and disorientation.

The danger artificial light poses to sea turtles has also been well documented. Female sea turtles emerge from the ocean to lay their eggs on the beach before returning to the water. To make the journey from sand to sea, both adults and hatchlings use light reflected off the water as a guide. But beachside development has created a competing light source. Many turtles have been found to wander in the opposite direction, towards parking lots and roadways where they are struck dead by vehicles, while others die of exhaustion, dehydration, or predation. In addition to affecting orientation, studies have shown artificial light to disrupt foraging, mating, and communication habits of many different animals, including moths, bats, frogs, and fish.

The ubiquity of artificial light has also been shown to interfere with some aspects of human biology. Some researchers suspect that increased time spent with indoor artificial light rather than in outdoor natural light

has contributed to nearsightedness—a controversial idea that deserves further research. Multiple studies have demonstrated the connection between a disrupted circadian clock and changes in metabolism: excessive amounts of light at night can decrease sleep efficiency and alter the timing of food intake and insulin response, causing weight gain. Exposure right before bed to blue light—the kind produced by the screens of most cell phones, tablets, TVs, and laptops—is believed to disrupt sleep because it suppresses production of melatonin, a hormone that regulates the day-night cycle. Melatonin deficiencies have also been hypothesized as a cause of breast cancer; researchers have repeatedly observed the increased prevalence of breast cancer in night-shift workers, and a 2010 study showed that there are higher breast cancer rates in countries that have higher levels of light at night, although it did not demonstrate a causal association. None of which is to say that the health and safety benefits of artificial lighting for human beings do not far outweigh the costs, but just that the harmful effects are taken for granted, rarely acknowledged, and poorly understood.

Light Pollution and the Law

The good news is that a few simple lighting-policy decisions can do quite a lot to mitigate many of the ecological, health, and astronomy-related concerns created by excessive ambient light. The International Dark-Sky Association recommends that, whenever possible, lamps should be designed or shielded in such a way that their light shines only down and not up (almost all light that shines upward into the atmosphere is wasted anyway). The intensity of light should be limited only to what is necessary for achieving its purpose, usually human safety. Light fixtures high in blue light content should be prohibited or dimmed with filters. Steps should also be taken to prevent light from spilling into areas it is not intended to illuminate, such as adjacent houses (what is called "light trespass") or animal habitats. All-night lighting should be used only when absolutely necessary. And in the home, doctors advise improving the quality of one's sleep by covering up lights shining from televisions, electric clocks, and other appliances and by avoiding looking at one's smartphone right before bed.

In 1958, Flagstaff, Arizona (home to the Lowell Observatory) adopted what are believed to be the first light-pollution-prevention measures in the United States. Tucson, which in addition to Kitt Peak is also near the Fred Lawrence Whipple Observatory and is the home of the University

of Arizona's Steward Observatory, enacted similar measures in 1972, as have many other communities with nearby observatories in the years since. Light pollution regulations—along with some advances in astronomical technology, such as the invention of charge-coupled device imaging, which allows astronomers to digitally edit out some unwanted light sources—have already helped to extend the life of observatories. They have also helped to preserve the night sky for the general public. For example, San Jose, cooperating with Lick Observatory, agreed in 1980 to switch its mercury vapor streetlights to low-pressure sodium lamps, which emit light on a much smaller range of wavelengths. Kitt Peak, according to a 2010 analysis, has seen its sky brightness stay "remarkably constant" for the past twenty years.

Light pollution mitigation efforts have yielded positive results for wildlife as well. The "Lights Out Chicago" program, an effort that began in 1995 to get building owners to agree to turn off unnecessary lights during migration seasons, is thought to prevent the deaths of 10,000 birds each year. Some other large cities, such as New York and Toronto, have implemented similar programs for bird safety. According to a 2003 article on the *National Geographic* website, photographic surveys of Florida beaches indicated that they had been "getting darker and safer for the sea turtles" thanks to lighting regulations. As of April 2015, over twenty counties and over sixty municipalities along the Florida coast had enacted lighting ordinances, and a recent study of sea turtle nesting patterns offers reason to hope that the laws are having a positive effect.

An added benefit of efforts to mitigate light pollution is that they can save quite a bit of money. According to a 2010 paper in *Ecological Economics*, the cost of wasted outdoor lighting adds up to an estimated $7 billion a year in the United States. The Los Angeles Bureau of Street Lighting reports that the replacement of conventional street lighting in the city with LEDs over a four-year period has reduced energy costs for lighting by over 60 percent, while making streets brighter and skies darker.

Currently, most restrictions on outdoor lighting come from municipal and county legislation. However, these codes are generally written with an eye toward preventing light from spilling onto adjoining neighbors' properties, not into the sky. Statewide legislation can be more effective for addressing overall light pollution, and having a uniform statewide regulation, instead of a mess of sometimes-contradictory local regulations, helps manufacturers to produce standardized dark-sky-friendly lighting devices.

So far, seventeen states, the District of Columbia, and Puerto Rico have laws to help cut down on light pollution. Many of the laws, however, are very limited, regulating for instance only the outdoor lighting for buildings on state property, or prohibiting state funding for certain kinds of lights.

No substantial federal action on light pollution appears to be imminent. The International Dark-Sky Association organized congressional briefings in 2008, after which eleven members of Congress signed a bipartisan letter to the Environmental Protection Agency requesting that it pay more attention to light pollution in its research and education programs and its publications. The organization also sent the EPA a petition arguing that the agency already has authority to regulate light pollution under certain provisions of the Clean Air Act. (The agency's only apparent response was that it was "considering the issues" and "reviewing what, if any, legal authorities EPA may have to take steps to define and address light pollution.") A different regulatory approach, suggested by attorney Kristen M. Ploetz in a 2002 *New England Law Review* article, would have Congress do for light pollution what it did for tackling noise pollution by passing the Noise Control Act of 1972, which established standards for reducing various kinds of noise. But that precedent does not seem especially promising, since within a decade Congress defunded the EPA office governing noise control.

A major hurdle faced by dark-sky advocates who wish to persuade policymakers and the public is that, while the environmental and health problems light pollution creates are significant, they are nowhere near the scale of other kinds of damage, such as air or water pollution. Attempts have been made to piggyback light pollution onto the climate change issue by highlighting the energy we misuse on unnecessary lighting. The International Dark-Sky Association notes, for example, that the United States would have to plant 875 million additional trees annually to make up for all the carbon dioxide released to produce the energy that is currently wasted in outdoor lighting shining upward into the atmosphere. However, the amount of emissions we could prevent by eliminating this wasted energy is a tiny fraction of total U.S. emissions.

Nor does protecting the quality of our nation's astronomical research seem an argument likely to persuade lawmakers or regulators—not least because planners of many new observatories have chosen locations outside of the continental United States, as Walker recommended in the 1970s. The dormant Hawaiian volcano of Mauna Kea is now home to over a dozen different telescopes, and Chile's Atacama Desert has become a mecca for

astronomers over the past twenty years because of its high altitude, bone-dry climate, and distance from light-polluting cities. Astronomers have also been able to avoid light pollution and other kinds of atmospheric interference altogether by launching instruments into space. The most famous of these is the Hubble Space Telescope; its so-called successor, the James Webb Space Telescope, is due to launch in 2018. Although many big telescopes are still in operation at astronomical facilities in the continental United States, the existence of these other options elsewhere on and above the planet make it less likely that the demands of science will change many minds about cutting back on light pollution.

Awe and Contemplation

What defenders of the night sky need most of all now is not a case against light pollution grounded on astronomy or ecology but one rooted in our cultural heritage. It is precisely by considering the effects of light pollution as a cultural matter that we can most clearly understand what is at stake.

Adam Smith, in his posthumously published essay "The History of Astronomy," calls what we see in the night sky "the most universal objects of the curiosity of mankind." So numerous are the passages of prose and verse and the works of art inspired by the night sky that there would be little point in rattling off a few here. But likely because its cultural value is seemingly so self-evident, dark-sky advocates have too often given it mere lip service. "We can't lose our culture and heritage!" it said at the bottom of a page on the old International Dark-Sky Association website, but the section tellingly explained that "Children who grow up without the experience of a starry night miss invaluable opportunities to speculate about larger questions," and highlights the IDA's programming material "designed specifically for children"—as if cultivating wonder and reflection on larger questions are things one is supposed to grow out of upon reaching adulthood. Of course, the fact that eminent individuals and whole peoples have in the past found the night sky worthy of awe and contemplation is irrelevant if we cannot understand why their reasons for doing so remain compelling to us today.

Attempts to defend the night sky on cultural grounds must show how the qualities it embodies are unique to it. It is not enough simply to suggest, as many dark-sky advocates have, that the sky's cultural value lies in its natural beauty that produces wonder and inspires us. Natural beauty can be found in many other places too—and for that matter, thanks to our

space telescopes, we can now in a sense see the sky more clearly than ever before. Nor is it helpful to point to the many beautiful aesthetic creations the night sky has prompted. Perhaps van Gogh, had he lived under today's light-polluted skies, would not have painted *The Starry Night*, but the vast majority of works of art about nature do not focus on the night sky, and so its disappearance would not end artistic creativity and appreciation.

If we do not understand more fully how the night sky as seen from the ground through the naked eye embodies beauty uniquely, the cause of preserving it remains vulnerable to economist John Kenneth Galbraith's quip that "The conservationist is a man who concerns himself with the beauties of nature in roughly inverse proportion to the number of people who can enjoy them."

The same goes for the concept of infinity that one might point to as an invaluable property of a starry night. (According to astronomer and writer Bob Berman, "an observer needs to see four hundred fifty stars at a time to get that feeling of infinitude, and be swept away.") While the night sky's immensity is undeniably impressive, unless we can explain the distinctive nature of the stars' infinitude—that is, unless we can explain how it differs from, say, the countless grains of sand on the beach, or, for that matter, the vast array of shimmering pixels on the dome of a planetarium—we have not made a convincing case for why the stars should remain visible to us.

Such a case must show that the night sky is not culturally valuable merely as a relic of the past; rather, if it were more visible to us, it would teach us an important lesson even for our present and future, a lesson that perhaps nothing else in nature can teach us quite as well. We will see this more clearly if we recognize that the loss of the night sky was not an incidental consequence of the invention of particular lighting technologies but rather a direct implication of the modern scientific project. The unique importance of the night sky is that it reminds us of the limits of that project.

The Dawn of Modernity

It helps to remember that people's experience of the night prior to modern lighting was vastly more terrifying than the rhapsodies of today's dark-sky advocates might suggest. When the sun went down, navigation of terrain became more treacherous, nocturnal predators began their prowl, the threat of succumbing to illness seemed to intensify, and the risk of fires from candles and oil lamps rose. Pillaging, murder, theft, drunkenness,

and prostitution were often deeds of the dark, after the government and church powers that ruled the day had ceased their activities. On top of all this, dark spiritual powers could instill dread in people's hearts, whether it was the stars and planets cursing men's fates, or the legions of evil forces—ghosts and spirits, witches and demons, and other mystical and diabolical entities—looking for prey. As A. Roger Ekirch—whose 2005 book *At Day's Close* richly catalogues these many dangers of the night from the time before artificial lighting—puts it, "Darkness in the early modern world summoned the worst elements in man, nature, and the cosmos."

And so, when against this backdrop some of the modern scientific pioneers first began calling for more light—figuratively speaking—to overcome what they thought of as the darkness of preceding eras, their arguments drew rhetorical power from the fact that real darkness was so perilous. Francis Bacon, for example, described "the kindling of this new light in the darkness of philosophy." Bacon, of course, was not the first to describe wisdom as a light; the metaphor exists in almost every previous religious and philosophic tradition. But what was special about the desire for light in the early modern era was that its advocates conceived of the Kingdom of Darkness as vulnerable not only to spiritual and intellectual forces but chiefly to technological arts, and as ultimately conquerable by them. Bacon remarked that "the greatest error of all the rest is the mistaking or misplacing of the last or furthest end of knowledge." This end, he argued, was to produce useful means for easing nature's burden on mankind, and natural darkness was one of the obvious ways of symbolically representing that burden.

At the beginning of *The Great Instauration*, where Bacon lays out his plans for the kind of science that would make this end possible, he says he is convinced that "the human intellect makes its own difficulties, not using the true helps which are at man's disposal soberly and judiciously; whence follows manifold ignorance of things, and by reason of that ignorance mischiefs innumerable." Bacon casts the problem of ignorance as one that is largely self-inflicted rather than a permanent fixture of the world. This means that there is hope for restoring the connection between the human mind and the nature of the world "to its perfect and original condition." To do this, though, we will need to create "helps for the sense" to make up for our failings.

Previous eras, Bacon thought, had ignored such "true helps"; by placing their faith in received opinions, abstract ideas, traditions, and texts, they had doomed themselves to false understanding, putting too much of a burden on the human mind to mediate and interpret sources that

were far removed from man's physical surroundings. Because the original sources of wisdom were no longer directly accessible, the process of retrieval would always be subject to controversy, misunderstanding, and abuse, yielding little in the way of practical results and instead animating conflicts when consensus could not be reached.

Bacon hoped to avoid all these problems by placing human knowledge on a more solid foundation: the facts of nature. Systematic experimentation would reveal nature's hidden truths, which could then be used to help produce tools of all kinds to alleviate human burdens and to push back the limits nature imposes on us. One of the more apparent such transformations is that the night is no longer very dark and that many of our activities are no longer dependent on daylight.

It is worth reminding ourselves that the connection between technology and our scientific knowledge is rarely as neat as Bacon imagined, and even he was well aware that the mechanical arts advanced at times without much theoretical insight. Nevertheless, the way popular understanding conceives of modern science and even the Enlightenment at large follows a vaguely Baconian line of thinking: the figurative light of reason and experiment that dispels the fancies of older and darker ages is one and the same as the literal light that helps us to see—through technologies such as microscopes and telescopes—into all corners of the natural world. Modern technology, according to this conception, is the fruit we reap from leaving behind the darkness of the past, and the modern scientific project, we like to conclude, offers the only sure means to receiving the bright light of facts.

But when we treat the light that science provides as the only true light there is, we lose the older lights of philosophic insight. Dismissing the old philosophers, Bacon remarked that "their discourses are as the stars, which give little light because they are so high." This is analogous to how modern lighting technology has resulted in the loss of the stars, which throughout human history had been a source of philosophic wonder and a constant reminder of the limitations of what we know. The cultural value of the starry night is that it confronts us with the reality that our powers over nature and our insights into its inner workings are really quite limited, not only in themselves but also against the backdrop of other kinds of knowledge. Sure, our telescopes see farther than our eyes ever could, but our natural vision is now restricted mostly to the small sphere over which we have control.

This interpretation of how modern lighting technologies affect our understanding of ourselves appears already in some older texts. For example, when Robert Louis Stevenson looked back at the introduction of gas lighting, he wrote: "The work of Prometheus had advanced by another

stride. Mankind and its supper parties were no longer at the mercy of a few miles of sea-fog; sundown no longer emptied the promenade; and the day was lengthened out to every man's fancy. The city-folk had stars of their own; biddable, domesticated stars."

The last part of Stevenson's remark is a reminder that Prometheus' gift of artificial light, fire, to mankind came at the expense of a higher source of light. One of the consequences of regarding nature largely with a view toward how we can use it for our material benefit is that we have less use for nature as it is, including the starry heavens. Once we have our own biddable stars for lighting—and other technologies to replace other celestial functions, such as keeping track of time or helping with navigation—the real stars overhead concern us little in our everyday affairs. In one of Nietzsche's most famous passages, a madman carries a lantern on a bright morning because man has "unchained this earth from its sun." It is a description of what it means that man has killed God, but we might extend the notion a bit and say that our artificial lights conceal what a starry night—even better than a sunny day—can teach us: that we are small creatures dependent on vast forces we cannot possibly control. Our forgetfulness of this lesson is in part responsible for our forgetfulness of the intellectual, spiritual, and artistic traditions that were once inspired by it.

But though we imagine that we have no practical use for the stars, they still exist, and perhaps because of their persistence some thinkers have gone so far as to express outright disdain for them, and even for the moon. The Italian Futurists of the early twentieth century, who were among the more radical voices of modernism, broadcast the slogan "Let's kill the moonlight!" and one of the movement's leading poets published a manifesto that begins with a declaration of war against the night sky:

> We have been up all night, my friends and I, beneath mosque lamps whose brass cupolas are bright as our souls, because like them they were illuminated by the internal glow of electric hearts....
>
> Our hearts were filled with an immense pride at feeling ourselves standing quite alone, like lighthouses or like the sentinels in an outpost, facing the army of enemy stars encamped in their celestial bivouacs.

The tract concludes: "Standing on the world's summit we launch once again our insolent challenge to the stars!" One cannot help but think that the stars only become the object of such rage, even if just symbolically, because they point to something fundamentally flawed in the modern project: that our mastery of nature will never be total but will, as great as it may grow, meet with ultimate frustration.

A Light in the Dark

Observers from Alexis de Tocqueville to Frederick Jackson Turner have remarked that America is a land and people deeply shaped by the experience of the conquest of nature, the challenge of developing "out of the primitive economic and political conditions of the frontier into the complexity of city life," as Turner wrote. After the U.S. Census pronounced in 1890 that the American frontier had closed, Turner declared, "He would be a rash prophet who should assert that the expansive character of American life has now entirely ceased. Movement has been its dominant fact, and, unless this training has no effect upon a people, the American energy will continually demand a wider field for its exercise."

Indeed, we continue to apply the language as well as the spirit of conquest to various frontiers: the scientific, the technical, the biomedical, and of course what science fiction has taught us to call the "final" frontier—outer space. There has been talk, including in these pages, of establishing a "transorbital railroad" to open up travel to the Moon and to Mars and beyond. Many movies set in space consciously borrow tropes from old Westerns. "We're still pioneers," one of the main characters reminds us in *Interstellar*, after saying, "We've always defined ourselves by the ability to overcome the impossible. And we count these moments… when we dare to aim higher, to break barriers, to reach for the stars, to make the unknown known…as our proudest achievements."

Unlike the American continent, outer space is practically infinite; there is no endpoint. But we can go only a very short distance before coming up against a barrier not "out there" but in ourselves: death. The fact of our finitude means we will explore only a small sphere of the total sum of space, and not an arbitrary sphere but only the one around our planet Earth. Sending people to Mars and other unvisited points in our own solar system will likely be possible in the next few decades, but traveling even to "nearby" stars would require complicated new technologies and trips lasting decades or centuries. A journey to Andromeda, the nearest neighboring galaxy, would take 2.5 million years at the speed of light. Besides, many of the starry objects themselves have already died long before their light reaches our eyes.

Thus, the inaccessibility of the stars reminds us that we are not and cannot be at home everywhere in the physical universe, that we are bound in time and place to a relatively tiny sphere of influence. Astronomy, arguably the most ancient of the sciences, has always understood what my professor on the first day of an introductory astronomy class called the

"Tantalus Principle": we can look but we cannot touch. The full meaning of light pollution for our understanding of ourselves is that the finitude that defines our own inhabitable sphere comes to light (so to speak) only in our encounter with the contrasting infinite background beyond. Our attempt to extend the light of our bedside lamps throughout our lived world has whited out this background, blinding our eyes to realms of the universe in which mankind has no agency. With the flood of artificial light blotting out the stars, we are, to borrow from Hamlet, "bounded in a nutshell" and counting ourselves "king of infinite space." Seen in this way, our reliance on artificial light is not a Promethean defiance of our fate but a cowardly refusal to face it. Such is the picture W. H. Auden presents in his poem "September 1, 1939":

> …Faces along the bar
> Cling to their average day:
> The lights must never go out,
> The music must always play,
> All the conventions conspire
> To make this fort assume
> The furniture of home;
> Lest we should see where we are,
> Lost in a haunted wood,
> Children afraid of the night
> Who have never been happy or good.…

Auden's poem was written at the outset of World War II. It is worth noting that blackouts in major population centers during the war introduced many city dwellers to night skies they had never experienced before. Printers began churning out astronomy volumes to explain to the curious the things they were now seeing, and astronomer Walter Baade at Mount Wilson was able to take advantage of a wartime blackout in Los Angeles to peer deeper into the Andromeda galaxy than had previously been possible, leading to observations that showed the universe was double the size of what Edwin Hubble had calculated.

Indeed, some of the few other times the stars have shone brightly above our large cities in the past century have been occasions when natural disasters challenged our technical prowess of mastering the night. The only occasion the Milky Way has been visible in real detail from Manhattan in the past fifty years was when a severe thunderstorm in 1977 knocked out power across New York. (The view during both the 1965 and the large 2003 blackouts was reportedly not quite as good, in

part because of a fuller moon.) After an earthquake triggered a massive power outage in Los Angeles in 1994, residents called in to emergency crews, radio stations, and observatories to express alarm at the strange cloud that had appeared overhead. They were seeing the Milky Way for the first time. And the 2012 power outages caused by Hurricane Sandy gave some urbanites on the East Coast a look at a sky more starry than they were used to.

Without such disasters—a word that comes to us from the Latin for "ill-starred event"—and if the public attitude toward light pollution does not change, future generations of Americans will have little left of the night sky. This is already the case along most of the East Coast. West of the Mississippi, star-filled skies can still be found, but darkness is receding there as well. Of course, we can imagine an astral tourism industry emerging to bring well-to-do urban families to visit the few "dark-sky reserves" that activists establish, likely in national parks; and perhaps more small night-sky-friendly communities will pop up, modeled after Arizona Sky Village in the town of Portal. But these will be the exceptions, a few ironic specks of dark in an otherwise light-filled sky. For the majority of Americans, the infinite stars and their intimations of our finitude will be out of sight and so out of mind.

Preserving our experience of the non-human realm above does not mean returning to the dark ages; nor need it mean having to choose between city and sky. It is up to the planners and fabricators of our lights, buildings, and cities to make conscious decisions to prevent our self-envelopment from becoming complete. And it is up to us to encourage the thoughtful and creative arrangement of lights in our lived places—so that we might, as Dante put it in the last line of his *Inferno*, "emerge again to see the stars."