YOU ARE HERE

The entire Earth is but a point, and the place of
our own habitation but a minute corner of it.
—MARCUS AURELIUS, ROMAN EMPEROR,
MEDITATIONS, BOOK 4 (CA. 170)

As the astronomers unanimously teach, the circuit of the whole earth,
which to us seems endless, compared with the greatness of the universe
has the likeness of a mere tiny point.
—AMMIANUS MARCELLINUS (CA. 330–395),
THE LAST MAJOR ROMAN HISTORIAN,
IN *THE CHRONICLE OF EVENTS*

The spacecraft was a long way from home, beyond the orbit of the outermost planet and high above the ecliptic plane—which is an imaginary flat surface that we can think of as something like a racetrack in which the orbits of the planets are mainly confined. The ship was speeding away from the Sun at 40,000 miles per hour. But in early February of 1990, it was overtaken by an urgent message from Earth.

Obediently, it turned its cameras back toward the now-distant planets. Slewing its scan platform from one spot in the sky to an-

OPPOSITE: The position of the Earth and Sun (and many of the stars in our night sky) as seen from a vantage point outside the Milky Way. How this scene fits into the structure of our galaxy can be made out by comparing it with pages 386–387. Painting by Jon Lomberg.

other, it snapped 60 pictures and stored them in digital form on its tape recorder. Then, slowly, in March, April, and May, it radioed the data back to Earth. Each image was composed of 640,000 individual picture elements ("pixels"), like the dots in a newspaper wirephoto or a pointillist painting. The spacecraft was 3.7 billion miles away from Earth, so far away that it took each pixel $5^1/_2$ hours, traveling at the speed of light, to reach us. The pictures might have been returned earlier, but the big radio telescopes in California, Spain, and Australia that receive these whispers from the edge of the Solar System had responsibilities to other ships that ply the sea of space—among them, *Magellan,* bound for Venus, and *Galileo* on its tortuous passage to Jupiter.

Voyager 1 was so high above the ecliptic plane because, in 1981, it had made a close pass by Titan, the giant moon of Saturn. Its sister ship, *Voyager 2,* was dispatched on a different trajectory, within the ecliptic plane, and so she was able to perform her celebrated explorations of Uranus and Neptune. The two *Voyager* robots have explored four planets and nearly sixty moons. They are triumphs of human engineering and one of the glories of the American space program. They will be in the history books when much else about our time is forgotten.

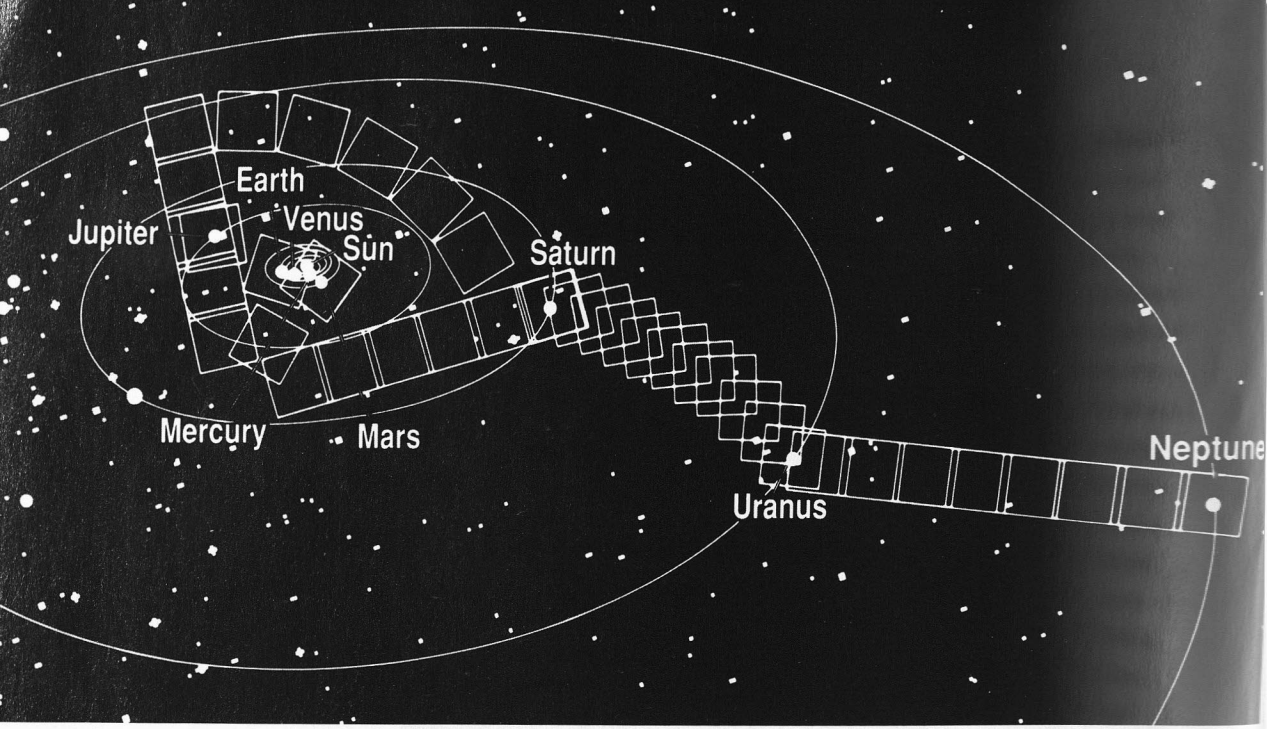
The *Voyager*s were guaranteed to work only until the Saturn encounter. I thought it might be a good idea, just after Saturn, to have them take one last glance homeward. From Saturn, I knew, the Earth would appear too small for *Voyager* to make out any detail. Our planet would be just a point of light, a lonely pixel, hardly distinguishable from the many other points of light *Voyager* could see, nearby planets and far-off suns. But precisely because of the obscurity of our world thus revealed, such a picture might be worth having.

Mariners had painstakingly mapped the coastlines of the continents. Geographers had translated these findings into charts and globes. Photographs of tiny patches of the Earth had been obtained first by balloons and aircraft, then by rockets in brief ballistic flight, and at last by orbiting spacecraft—giving a perspective like the one you achieve by positioning your eyeball about an inch above a large globe. While almost everyone is taught that the Earth

The whole Earth photographed on the *Apollo 17* mission. Courtesy NASA.

is a sphere with all of us somehow glued to it by gravity, the reality of our circumstance did not really begin to sink in until the famous frame-filling *Apollo* photograph of the whole Earth—the one taken by the *Apollo 17* astronauts on the last journey of humans to the Moon.

It has become a kind of icon of our age. There's Antarctica at what Americans and Europeans so readily regard as the bottom, and then all of Africa stretching up above it: You can see Ethiopia, Tanzania, and Kenya, where the earliest humans lived. At top right are Saudi Arabia and what Europeans call the Near East. Just barely peeking out at the top is the Mediterranean Sea, around which so much of our global civilization emerged. You can make out the blue of the ocean, the yellow-red of the Sahara and the Arabian desert, the brown-green of forest and grassland.



Position of the planets against the background of more distant stars at the moment *Voyager 1* took its family portrait of the Solar System. The Sun and the inner planets out to Mars are tightly clustered left of center. The outside four orbits are of Jupiter, Saturn, Uranus, and Neptune. The squares show the positions of the individual spacecraft imaging frames as laid down on the sky. This view is possible only because *Voyager 1* was high above the ecliptic plane in which the planets revolve about the Sun. The Earth is seen as an individual picture element, but Jupiter (and Saturn with its rings) are larger than a single dot. Courtesy JPL/NASA.

And yet there is no sign of humans in this picture, not our reworking of the Earth's surface, not our machines, not ourselves: We are too small and our statecraft is too feeble to be seen by a spacecraft between the Earth and the Moon. From this vantage point, our obsession with nationalism is nowhere in evidence. The *Apollo* pictures of the whole Earth conveyed to multitudes something well known to astronomers: On the scale of worlds—to say nothing of stars or galaxies—humans are inconsequential, a thin film of life on an obscure and solitary lump of rock and metal.

It seemed to me that another picture of the Earth, this one taken from a hundred thousand times farther away, might help in the continuing process of revealing to ourselves our true circumstance and condition. It had been well understood by the scientists and philosophers of classical antiquity that the Earth was a mere point in a vast encompassing Cosmos, but no one had ever *seen* it as such. Here was our first chance (and perhaps also our last for decades to come).

Many in NASA's *Voyager* Project were supportive. But from the outer Solar System the Earth lies very near the Sun, like a moth enthralled around a flame. Did we want to aim the camera so close to the Sun as to risk burning out the spacecraft's vidicon

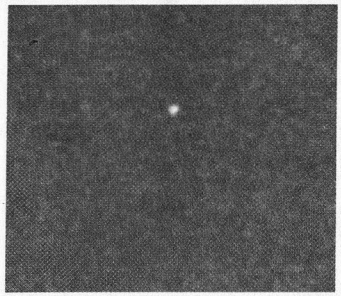
system? Wouldn't it be better to delay until all the scientific images—from Uranus and Neptune, if the spacecraft lasted that long—were taken?

And so we waited, and a good thing too—from 1981 at Saturn, to 1986 at Uranus, to 1989, when both spacecraft had passed the orbits of Neptune and Pluto. At last the time came. But there were a few instrumental calibrations that needed to be done first, and we waited a little longer. Although the spacecraft were in the right spots, the instruments were still working beautifully, and there were no other pictures to take, a few project personnel opposed it. It wasn't science, they said. Then we discovered that the technicians who devise and transmit the radio commands to *Voyager* were, in a cash-strapped NASA, to be laid off immediately or transferred to other jobs. If the picture were to be taken, it had to be done right then. At the last minute—actually, in the midst of the *Voyager 2* encounter with Neptune—the then NASA Administrator, Rear Admiral Richard Truly, stepped in and made sure that these images were obtained. The space scientists Candy Hansen of NASA's Jet Propulsion Laboratory (JPL) and Carolyn Porco of the University of Arizona designed the command sequence and calculated the camera exposure times.

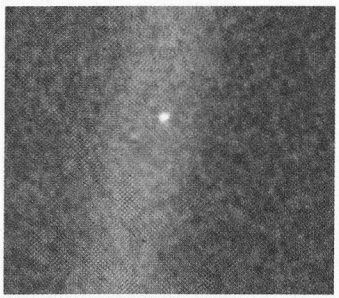
So here they are—a mosaic of squares laid down on top of the planets and a background smattering of more distant stars. We were able to photograph not only the Earth, but also five other of the Sun's nine known planets. Mercury, the innermost, was lost in the glare of the Sun, and Mars and Pluto were too small, too dimly lit, and/or too far away. Uranus and Neptune are so dim that to record their presence required long exposures; accordingly, their images were smeared because of spacecraft motion. This is how the planets would look to an alien spaceship approaching the Solar System after a long interstellar voyage.

From this distance the planets seem only points of light, smeared or unsmeared—even through the high-resolution telescope aboard *Voyager.* They are like the planets seen with the naked eye from the surface of the Earth—luminous dots, brighter than most of the stars. Over a period of months the Earth, like the other planets, would seem to move among the stars. You cannot tell merely by looking at one of these dots what it's like, what's on

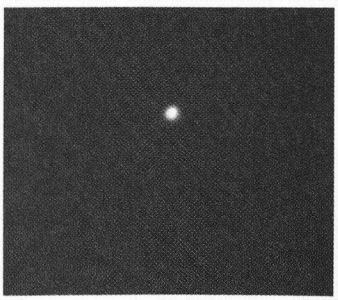
BELOW AND ON THE FOLLOWING PAGE:
Six of the nine planets, photographed on February 14, 1990 from beyond the orbits of Neptune and Pluto by *Voyager 1*. Courtesy JPL and NASA.



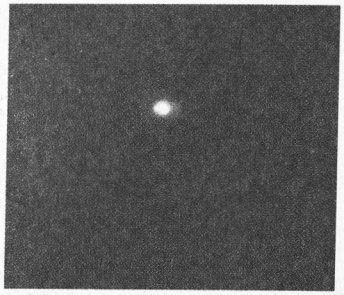
VENUS



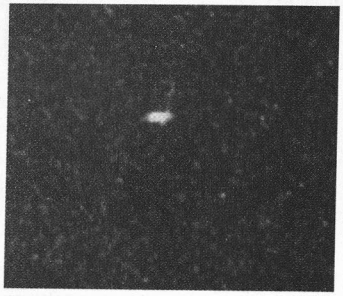
EARTH



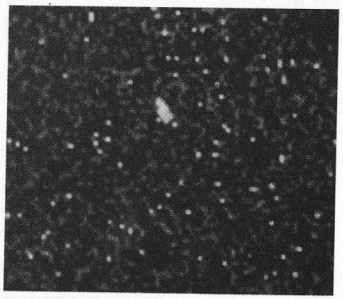
JUPITER



SATURN



URANUS



NEPTUNE

it, what its past has been, and whether, in this particular epoch, anyone lives there.

Because of the reflection of sunlight off the spacecraft, the Earth seems to be sitting in a beam of light, as if there were some special significance to this small world. But it's just an accident of geometry and optics. The Sun emits its radiation equitably in all directions. Had the picture been taken a little earlier or a little later, there would have been no sunbeam highlighting the Earth.

And why that cerulean color? The blue comes partly from the sea, partly from the sky. While water in a glass is transparent, it absorbs slightly more red light than blue. If you have tens of meters of the stuff or more, the red light is absorbed out and what gets reflected back to space is mainly blue. In the same way, a short line of sight through air seems perfectly transparent. Nevertheless—something Leonardo da Vinci excelled at portraying—the more distant the object, the bluer it seems. Why? Because the air scatters blue light around much better than it does red. So the bluish cast of this dot comes from its thick but transparent atmosphere and its deep oceans of liquid water. And the white? The Earth on an average day is about half covered with white water clouds.

We can explain the wan blueness of this little world because we know it well. Whether an alien scientist newly arrived at the outskirts of our solar system could reliably deduce oceans and clouds and a thickish atmosphere is less certain. Neptune, for instance, is blue, but chiefly for different reasons. From this distant vantage point, the Earth might not seem of any particular interest.

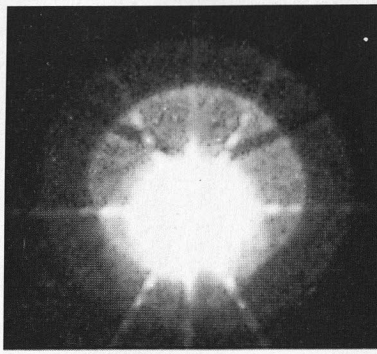
But for us, it's different. Look again at that dot. That's here. That's home. That's us. On it everyone you love, everyone you know, everyone you ever heard of, every human being who ever was, lived out their lives. The aggregate of our joy and suffering, thousands of confident religions, ideologies, and economic doctrines, every hunter and forager, every hero and coward, every creator and destroyer of civilization, every king and peasant, every young couple in love, every mother and father, hopeful child, inventor and explorer, every teacher of morals, every corrupt politician, every "superstar," every "supreme leader," every saint and sinner in the history of our species lived there—on a mote of dust suspended in a sunbeam.

The Earth is a very small stage in a vast cosmic arena. Think of the rivers of blood spilled by all those generals and emperors so that, in glory and triumph, they could become the momentary masters of a fraction of a dot. Think of the endless cruelties visited by the inhabitants of one corner of this pixel on the scarcely distinguishable inhabitants of some other corner, how frequent their misunderstandings, how eager they are to kill one another, how fervent their hatreds.

Our posturings, our imagined self-importance, the delusion that we have some privileged position in the Universe, are challenged by this point of pale light. Our planet is a lonely speck in the great enveloping cosmic dark. In our obscurity, in all this vastness, there is no hint that help will come from elsewhere to save us from ourselves.

The Earth is the only world known so far to harbor life. There is nowhere else, at least in the near future, to which our species could migrate. Visit, yes. Settle, not yet. Like it or not, for the moment the Earth is where we make our stand.

It has been said that astronomy is a humbling and character-building experience. There is perhaps no better demonstration of the folly of human conceits than this distant image of our tiny world. To me, it underscores our responsibility to deal more kindly with one another, and to preserve and cherish the pale blue dot, the only home we've ever known.



The Sun as seen by the *Voyager 1* wide-angle camera through its darkest filter and with the shortest possible exposure (0.005 seconds). From beyond the outermost planet, the Sun is only about 1/40 its size as seen from Earth. But it is still almost 8 million times brighter than Sirius, the brightest star in our sky. Courtesy JPL/NASA.

ABERRATIONS OF LIGHT

If man were taken away from the world, the rest would seem to be all astray, without aim or purpose . . . and to be leading to nothing.

—FRANCIS BACON, *WISDOM OF THE ANCIENTS* (1619)

Ann Druyan suggests an experiment: Look back again at the pale blue dot of the preceding chapter. Take a good long look at it. Stare at the dot for any length of time and then try to convince yourself that God created the whole Universe for one of the 10 million or so species of life that inhabit that speck of dust. Now take it a step further: Imagine that everything was made just for a single shade of that species, or gender, or ethnic or religious subdivision. If this doesn't strike you as unlikely, pick another dot. Imagine *it* to be inhabited by a different form of intelligent life. They, too, cherish the notion of a God who has created everything for their benefit. How seriously do you take *their* claim?

OPPOSITE: The stars rise and set around us, encouraging the belief that the Earth is at the center of the Universe. In this time exposure, the center of the Milky Way in the constellation Sagittarius is seen. Every star is a sun. There are about 400 billion of them in the Milky Way. Photographed by Frank Zullo, Superstition Mountains, Arizona. Copyright ©1987 by Frank Zullo

The nebula surrounding the dying star Eta Carinae. The nebula is formed from a succession of violent outbursts by the star. (The last outburst was observed in 1841, when despite its distance—over 10,000 light-years from Earth—Eta Carinae briefly became the second brightest star in our sky.) Were we as far from Eta Carinae as we are in fact from the Sun, it would appear 4 million times brighter than the Sun. The surface of the Earth would melt—rocks, mountains, and all. Courtesy Anglo-Australian Observatory. Photograph by David Malin.

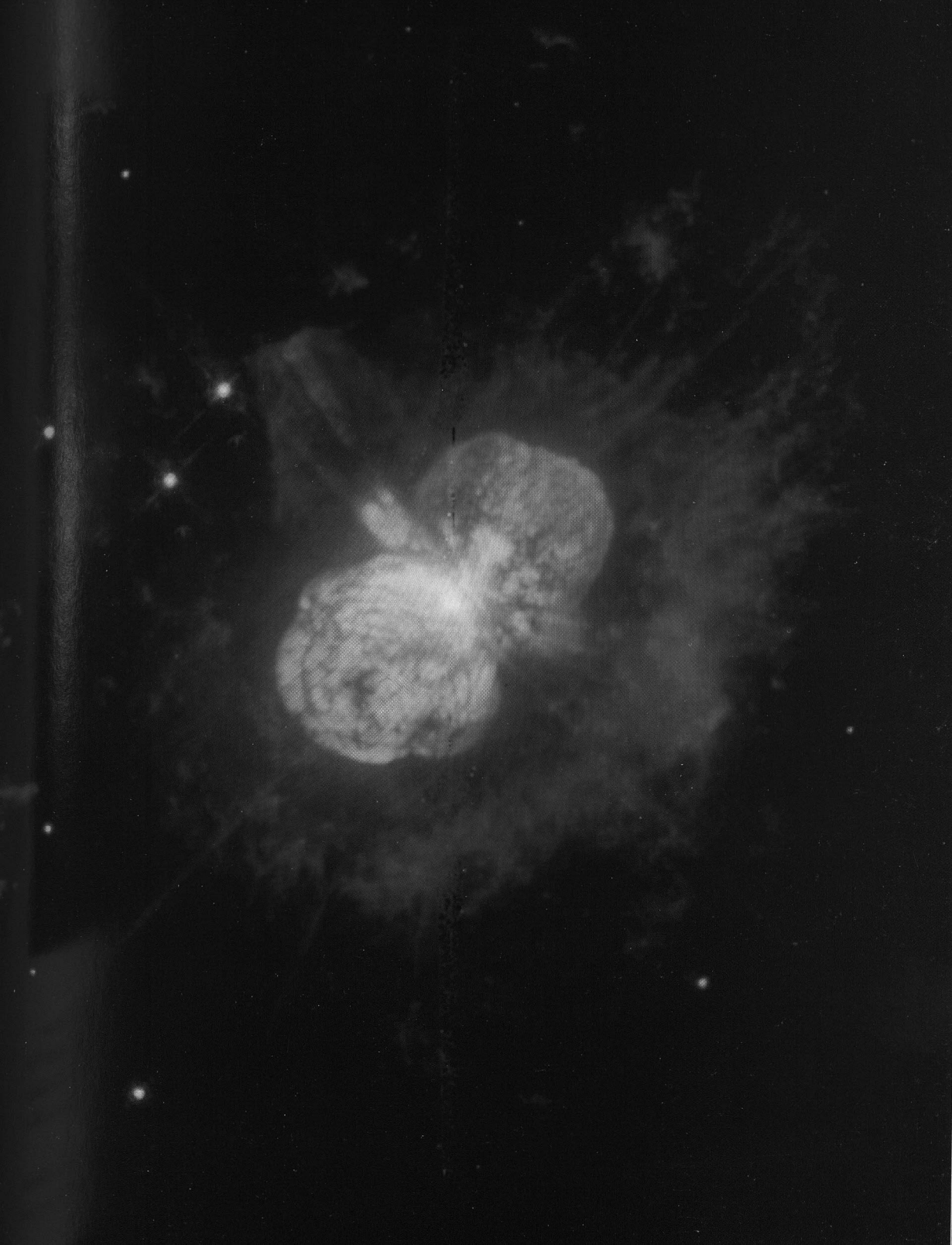
OPPOSITE: A close-up of Eta Carinae before civilization arose on Earth—as seen by the Hubble Space Telescope. Two vast clouds of starstuff have been expelled, one (to the left) traveling approximately in our direction, and the other (upper right) traveling away. Scenes of cosmic violence are a staple of modern astronomy. Courtesy J. Hester, Arizona State University and NASA.

"SEE THAT STAR?"

"You mean the bright red one?" his daughter asks in return.

"Yes. You know, it might not be there anymore. It might be gone by now—exploded or something. Its light is still crossing space, just reaching our eyes now. But we don't see it as it is. We see it as it was."

Many people experience a stirring sense of wonder when they first confront this simple truth. Why? Why should it be so



compelling? On our little world light travels, for all practical purposes, instantaneously. If a lightbulb is glowing, then of course it's physically where we see it, shining away. We reach out our hand and touch it: It's there all right, and unpleasantly hot. If the filament fails, then the light goes out. We don't see it in the same place, glowing, illuminating the room years after the bulb breaks and it's removed from its socket. The very notion seems nonsensical. But if we're far enough away, an entire sun can go out and we'll continue to see it shining brightly; we won't learn of its death, it may be, for ages to come—in fact, for how long it takes light, which travels fast but not infinitely fast, to cross the intervening vastness.

The immense distances to the stars and the galaxies mean that we see everything in space in the past—some as they were before the Earth came to be. Telescopes are time machines. Long ago, when an early galaxy began to pour light out into the surrounding darkness, no witness could have known that billions of years later some remote clumps of rock and metal, ice and organic molecules would fall together to make a place called Earth; or that life would arise and thinking beings evolve who would one day capture a little of that galactic light, and try to puzzle out what had sent it on its way.

And after the Earth dies, some 5 billion years from now, after it is burned to a crisp or even swallowed by the Sun, there will be other worlds and stars and galaxies coming into being—and they will know nothing of a place once called Earth.

IT ALMOST NEVER FEELS like prejudice. Instead, it seems fitting and just—the idea that, because of an accident of birth, *our* group (whichever one it is) should have a central position in the social universe. Among Pharaonic princelings and Plantagenet pretenders, children of robber barons and Central Committee bureaucrats, street gangs and conquerors of nations, members of confident majorities, obscure sects, and reviled minorities, this self-serving attitude seems as natural as breathing. It draws sustenance from the same psychic wellsprings as sexism, racism, nationalism, and the other deadly chauvinisms that plague our species. Uncom-

mon strength of character is needed to resist the blandishments of those who assure us that we have an obvious, even God-given, superiority over our fellows. The more precarious our self-esteem, the greater our vulnerability to such appeals.

Since scientists are people, it is not surprising that comparable pretensions have insinuated themselves into the scientific worldview. Indeed, many of the central debates in the history of science seem to be, in part at least, contests over whether humans are special. Almost always, the going-in assumption is that we *are* special. After the premise is closely examined, though, it turns out—in dishearteningly many cases—that we are not.

Our ancestors lived out of doors. They were as familiar with the night sky as most of us are with our favorite television programs. The Sun, the Moon, the stars, and the planets all rose in the east and set in the west, traversing the sky overhead in the interim. The motion of the heavenly bodies was not merely a diversion, eliciting a reverential nod and grunt; it was the only way to tell the time of day and the seasons. For hunters and gatherers, as well as for agricultural peoples, knowing about the sky was a matter of life and death.

How lucky for us that the Sun, the Moon, the planets, and the stars are part of some elegantly configured cosmic clockwork! It seemed to be no accident. They were put here for a purpose, for our benefit. Who else makes use of them? What else are they good for?

And if the lights in the sky rise and set around us, isn't it evident that we're at the center of the Universe? These celestial bodies—so clearly suffused with unearthly powers, especially the Sun on which we depend for light and heat—circle us like courtiers fawning on a king. Even if we had not already guessed, the most elementary examination of the heavens reveals that we *are* special. The Universe seems designed for human beings. It's difficult to contemplate these circumstances without experiencing stirrings of pride and reassurance. The entire Universe, made for us! We must really be something.

This satisfying demonstration of our importance, buttressed by daily observations of the heavens, made the geocentrist conceit

A token of the astonishing richness of the Milky Way. In the original image there are perhaps ten thousand stars in this picture, a large number, but constituting less than one ten-millionth of the number of stars in the Galaxy. The nebula glowing in hydrogen gas at top left is M17. Courtesy ROE/Anglo-Australian Observatory. Photograph by David Malin.

a transcultural truth—taught in the schools, built into the language, part and parcel of great literature and sacred scripture. Dissenters were discouraged, sometimes with torture and death. It is no wonder that for the vast bulk of human history, no one questioned it.

It was doubtless the view of our foraging and hunting ancestors. The great astronomer of antiquity, Claudius Ptolemaeus (Ptolemy), in the second century knew that the Earth was a sphere, knew that its size was "a point" compared to the distance of the stars, and taught that it lay "right in the middle of the heavens." Aristotle, Plato, St. Augustine, St. Thomas Aquinas, and almost all the great philosophers and scientists of all cultures over the 3,000 years ending in the seventeenth century bought into this delusion. Some busied themselves figuring out how the Sun, the Moon, the stars, and the planets could be cunningly attached to perfectly transparent, crystalline spheres—the big spheres, of course, centered on the Earth—that would explain the complex motions of the celestial bodies so meticulously chronicled by generations of astronomers. And they succeeded: With later modifications, the geocentric hypothesis adequately accounted for the facts of planetary motion as known in the second century, and in the sixteenth.

From there it was only a slight extrapolation to an even more grandiose claim—that the "perfection" of the world would be incomplete without humans, as Plato asserted in the *Timaeus*. "Man . . . is all," the poet and cleric John Donne wrote in 1625. "He is not a piece of the world, but the world itself; and next to the glory of God, the reason why there is a world."

And yet—never mind how many kings, popes, philosophers, scientists, and poets insisted on the contrary—the Earth through those millennia stubbornly persisted in orbiting the Sun. You might imagine an uncharitable extraterrestrial observer looking down on our species over all that time—with us excitedly chattering, "The Universe created for us! We're at the center! Everything pays homage to us!"—and concluding that our pretensions are amusing, our aspirations pathetic, that this must be the planet of the idiots.

But such a judgment is too harsh. We did the best we could. There was an unlucky coincidence between everyday appearance and our secret hopes. We tend not to be especially critical when presented with evidence that seems to confirm our prejudices. And there was little countervailing evidence.

In muted counterpoint, a few dissenting voices, counseling humility and perspective, could be heard down through the centuries. At the dawn of science, the atomist philosophers of ancient Greece and Rome—those who first suggested that matter is made of atoms—Democritus, Epicurus, and their followers (and Lucretius, the first popularizer of science) scandalously proposed many worlds and many alien life forms, all made of the same kinds of atoms as we. They offered for our consideration infinities in space and time. But in the prevailing canons of the West, secular and sacerdotal, pagan and Christian, atomist ideas were reviled. Instead, the heavens were not at all like our world. They were unalterable and "perfect." The Earth was mutable and "corrupt." The Roman statesman and philosopher Cicero summarized the common view: "In the heavens . . . there is nothing of chance or hazard, no error, no frustration, but absolute order, accuracy, calculation and regularity."

Philosophy and religion cautioned that the gods (or God) were far more powerful than we, jealous of their prerogatives and quick to mete out justice for insufferable arrogance. At the same time, these disciplines had not a clue that their own teaching of how the Universe is ordered was a conceit and a delusion.

Philosophy and religion presented mere opinion—opinion that might be overturned by observation and experiment—as certainty. This worried them not at all. That some of their deeply held beliefs might turn out to be mistakes was a possibility hardly considered. Doctrinal humility was to be practiced by others. Their own teachings were inerrant and infallible. In truth, they had better reason to be humble than they knew.

BEGINNING WITH COPERNICUS in the middle sixteenth century, the issue was formally joined. The picture of the Sun rather than the Earth at the center of the Universe was understood to be danger-

ous. Obligingly, many scholars were quick to assure the religious hierarchy that this newfangled hypothesis represented no serious challenge to conventional wisdom. In a kind of split-brain compromise, the Sun-centered system was treated as a mere computational convenience, not an astronomical reality—that is, the Earth was *really* at the center of the Universe, as everybody knew; but if you wished to predict where Jupiter would be on the second Tuesday of November the year after next, you were permitted to pretend that the Sun was at the center. Then you could calculate away and not affront the Authorities.*

"This has no danger in it," wrote Robert Cardinal Bellarmine, the foremost Vatican theologian in the early seventeenth century,

> and suffices for the mathematicians. But, to affirm that the Sun is really fixed in the center of the heavens and that the Earth revolves very swiftly around the Sun is a dangerous thing, not only irritating the theologians and philosophers, but injuring our holy faith and making the sacred scripture false.

"Freedom of belief is pernicious," Bellarmine wrote on another occasion. "It is nothing but the freedom to be wrong."

Besides, if the Earth was going around the Sun, nearby stars should seem to move against the background of more distant stars as, every six months, we shift our perspective from one side of the Earth's orbit to the other. No such "annual parallax" had been found. The Copernicans argued that this was because the stars were extremely far away—maybe a million times more distant than the Earth is from the Sun. Perhaps better telescopes, in future

* Copernicus' famous book was first published with an introduction by the theologian Andrew Osiander, inserted without the knowledge of the dying astronomer. Osiander's well-meaning attempt to reconcile religion and Copernican astronomy ended with these words: "[L]et no one expect anything in the way of certainty of astronomy, since astronomy can offer us nothing certain, lest, if anyone take as true that which has been constructed for another use, he go away from this discipline a bigger fool than when he came to it." Certainty could be found only in religion.

times, would find an annual parallax. The geocentrists considered this a desperate attempt to save a flawed hypothesis, and ludicrous on the face of it.

When Galileo turned the first astronomical telescope to the sky, the tide began to turn. He discovered that Jupiter had a little retinue of moons circling it, the inner ones orbiting faster than the outer ones, just as Copernicus had deduced for the motion of the planets about the Sun. He found that Mercury and Venus went through phases like the Moon (showing they orbited the Sun). Moreover, the cratered Moon and the spotted Sun challenged the perfection of the heavens. This may in part constitute the sort of trouble Tertullian was worried about thirteen hundred years earlier, when he pleaded, "If you have any sense or modesty, have done with prying into the regions of the sky, into the destiny and secrets of the universe."

In contrast, Galileo taught that we can interrogate Nature by observation and experiment. Then, "facts which at first sight seem improbable will, even on scant explanation, drop the cloak which had hidden them and stand forth in naked and simple beauty." Are not these facts, available even for skeptics to confirm, a surer insight into God's Universe than all the speculations of the theologians? But what if these facts contradict the beliefs of those who hold their religion incapable of making mistakes? The princes of the Church threatened the aged astronomer with torture if he persisted in teaching the abominable doctrine that the Earth moved. He was sentenced to a kind of house arrest for the remainder of his life.

A generation or two later, by the time Isaac Newton demonstrated that simple and elegant physics could quantitatively explain—and predict—all the observed lunar and planetary motions (provided you assumed the Sun at the center of the Solar System), the geocentrist conceit eroded further.

In 1725, in an attempt to discover stellar parallax, the painstaking English amateur astronomer James Bradley stumbled on the aberration of light. The term "aberration," I suppose, conveys something of the unexpectedness of the discovery. When observed over the course of a year, stars were found to trace little

The Horsehead Nebula and IC434. Courtesy ROE/Anglo-Australian Observatory. Photograph by David Malin.

ellipses against the sky. But all the stars were found to do so. This could not be stellar parallax, where we would expect a big parallax for nearby stars and an indetectible one for faraway stars. Instead, aberration is similar to how raindrops falling directly down on a speeding auto seem to the passengers to be falling at a slant; the faster the car goes, the steeper the slant. If the Earth were stationary at the center of the Universe, and not speeding in its orbit around the Sun, Bradley would not have found the aberration of light. It was a compelling demonstration that the Earth revolved about the Sun. It convinced most astronomers and some others but not, Bradley thought, the "Anti-Copernicans."

But not until 1837 did direct observations of the stars prove in the clearest way that the Earth is indeed circling the Sun. The long-debated annual parallax was at last discovered—not by better

arguments, but by better instruments. Because explaining what it means is much more straightforward than explaining the aberration of light, its discovery was very important. It pounded the final nail into the coffin of geocentrism. You need only look at your finger with your left eye and then with your right and see it seem to move. Everyone can understand parallax.

By the nineteenth century, all scientific geocentrists had been converted or rendered extinct. Once most scientists had been convinced, informed public opinion had swiftly changed, in some countries in a mere three or four generations. Of course, in the time of Galileo and Newton and even much later, there were still some who objected, who tried to prevent the new Sun-centered Universe from becoming accepted, or even known. And there were many who at least harbored secret reservations.

By the late twentieth century, just in case there were any holdouts, we have been able to settle the matter directly. We've been able to test whether we live in an Earth-centered system with planets affixed to transparent crystal spheres, or in a Sun-centered system with planets controlled at a distance by the gravity of the Sun. We have, for example, probed the planets with radar. When we bounce a signal off a moon of Saturn, we receive no radio echo from a nearer crystal sphere attached to Jupiter. Our spacecraft arrive at their appointed destinations with astonishing precision, exactly as predicted by Newtonian gravitation. When our ships fly to Mars, say, their instruments do not hear a tinkling sound or detect shards of broken crystal as they crash through the "spheres" that—according to the authoritative opinions that prevailed for millennia—propel Venus or the Sun in their dutiful motions about the central Earth.

When *Voyager 2* scanned the Solar System from beyond the outermost planet, it saw, just as Copernicus and Galileo had said we would, the Sun in the middle and the planets in concentric orbits about it. Far from being the center of the Universe, the Earth is just one of the orbiting dots. No longer confined to a single world, we are now able to reach out to others and determine decisively what kind of planetary system we inhabit.

EVERY OTHER PROPOSAL, and their number is legion, to displace us from cosmic center stage has also been resisted, in part for similar reasons. We seem to crave privilege, merited not by our works but by our birth, by the mere fact that, say, we are humans and born on Earth. We might call it the anthropocentric—the "human-centered"—conceit.

This conceit is brought close to culmination in the notion that we are created in God's image: The Creator and Ruler of the entire Universe looks just like me. My, what a coincidence! How convenient and satisfying! The sixth-century-B.C. Greek philosopher Xenophanes understood the arrogance of this perspective:

> The Ethiopians make their gods black and snub-nosed; the Thracians say theirs have blue eyes and red hair . . . Yes, and if oxen and horses or lions had hands, and could paint with their hands, and produce works of art as men do, horses would paint the forms of the gods like horses, and oxen like oxen . . .

Such attitudes were once described as "provincial"—the naive expectation that the political hierarchies and social conventions of an obscure province extend to a vast empire composed of many different traditions and cultures; that the familiar boondocks, *our* boondocks, are the center of the world. The country bumpkins know almost nothing about what else is possible. They fail to grasp the insignificance of their province or the diversity of the Empire. With ease, they apply their own standards and customs to the rest of the planet. But plopped down in Vienna, say, or Hamburg, or New York, ruefully they recognize how limited their perspective has been. They become "deprovincialized."

Modern science has been a voyage into the unknown, with a lesson in humility waiting at every stop. Many passengers would rather have stayed home.