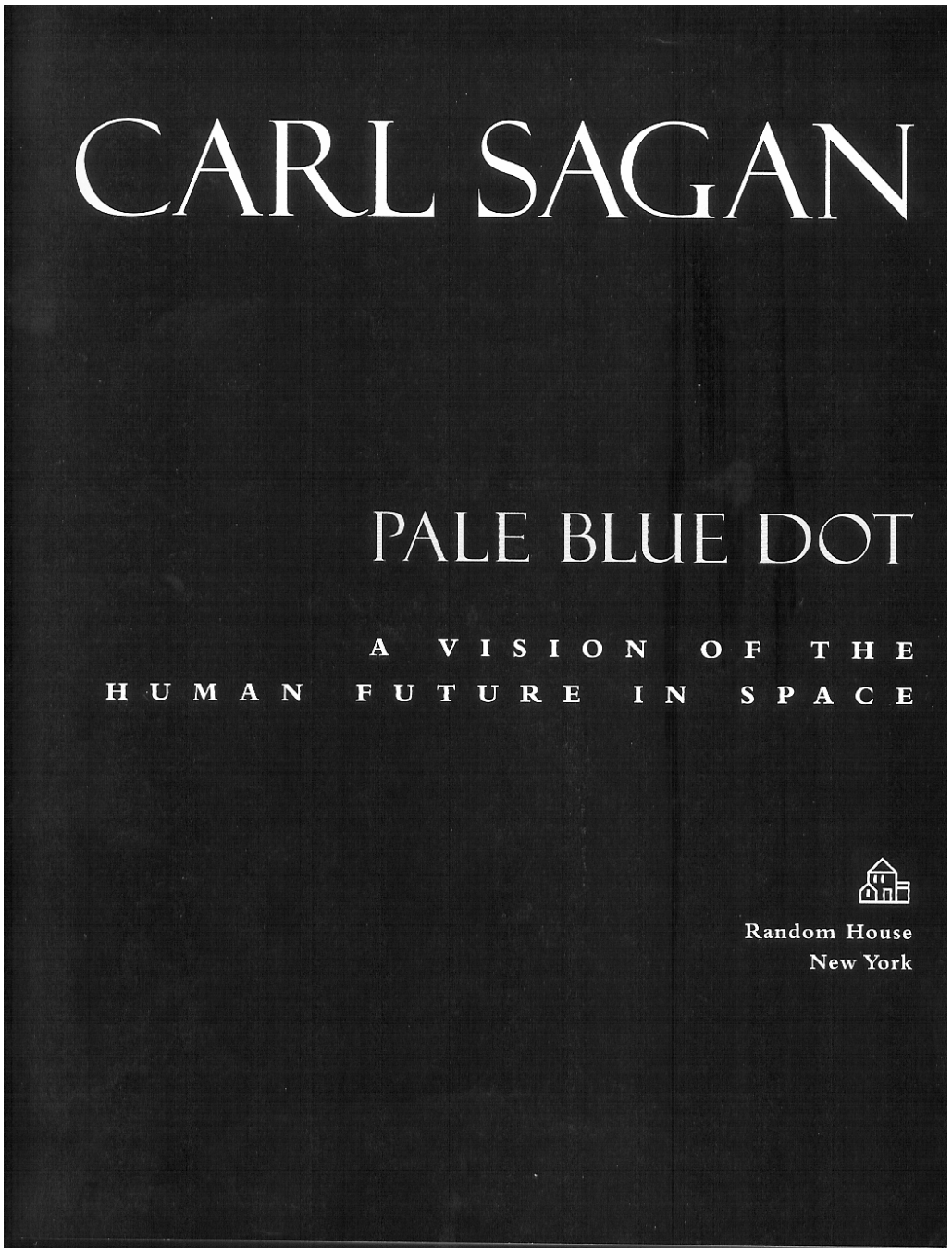


EVERY OTHER PROPOSAL, and their number is legion, to displace us from cosmic center stage has also been resisted, in part for similar reasons. We seem to crave privilege, merited not by our works but by our birth, by the mere fact that, say, we are humans and born on Earth. We might call it the anthropocentric—the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

In the seventeenth century there was still some hope that, even if the Earth was not the center of the Universe, it might be the only "world." But Galileo's telescope revealed that "the Moon certainly does not possess a smooth and polished surface" and that other worlds might look "just like the face of the Earth itself." The Moon and the planets showed unmistakably that they had as much claim to being worlds as the Earth does—with mountains, craters, atmospheres, polar ice caps, clouds, and, in the case of Saturn, a dazzling, unheard-of set of circumferential rings. After millennia of philosophical debate, the issue was settled decisively in favor of "the plurality of worlds." They might be profoundly different from our planet. None of them might be as congenial for life. But the Earth was hardly the only one.

This was the next in the series of Great Demotions, downlifting experiences, demonstrations of our apparent insignificance, wounds that science has, in its search for Galileo's facts, delivered to human pride.

WELL, SOME HOPED, *even if the Earth isn't at the center of the Universe, the Sun is. The Sun is* our *Sun. So the Earth is* approximately *at the center of the Universe.* Perhaps some of our pride could in this way be salvaged. But by the nineteenth century, observational astronomy had made it clear that the Sun is but one lonely star in a great self-gravitating assemblage of suns called the Milky Way Galaxy. Far from being at the center of the Galaxy, our Sun with its entourage of dim and tiny planets lies in an undistinguished sector of an obscure spiral arm. We are thirty thousand light years from the Center.

Well, our Milky Way is the only galaxy. The Milky Way Galaxy is one of billions, perhaps hundreds of billions of galaxies notable neither in mass nor in brightness nor in how its stars are configured and arrayed. Some modern deep sky photographs show more galaxies beyond the Milky Way than stars within the Milky Way. Every one of them is an island universe containing perhaps a hundred billion suns. Such an image is a profound sermon on humility.

Well, then, at least our Galaxy is at the center of the Universe. No, this is wrong too. When the expansion of the Universe was first discovered, many people naturally gravitated to the notion that the

Milky Way was at the center of the expansion, and all the other galaxies running away from us. We now recognize that astronomers on any galaxy would see all the others running away from them; unless they were very careful, they would all conclude that *they* were at the center of the Universe. There is, in fact, *no* center to the expansion, no point of origin of the Big Bang, at least not in ordinary three-dimensional space.

Well, even if there are hundreds of billions of galaxies, each with hundreds of billions of stars, no other star has planets. If there are no other planets beyond our Solar System, perhaps there's no other life in the Universe. Our uniqueness might then be saved. Since planets are small and feebly shine by reflected sunlight, they're hard to find. Although applicable technology is improving with breathtaking speed, even a giant world like Jupiter, orbiting the *nearest* star, Alpha Centauri, would still be difficult to detect. In our ignorance, the geocentrists find hope.

There was once a scientific hypothesis—not just well received but prevailing—that supposed our solar system to have formed through the near collision of the ancient Sun with another star; the gravitational tidal interaction pulled out tendrils of sunstuff that quickly condensed into planets. Since space is mainly empty and near stellar collisions most rare, it was concluded that few other planetary systems exist—perhaps only one, around that other star that long ago co-parented the worlds of our solar system. Early in my studies, I was amazed and disappointed that such a view had ever been taken seriously, that for planets of other stars, absence of evidence had been considered evidence of absence.

Today we have firm evidence for at least three planets orbiting an extremely dense star, the pulsar designated B1257+12, about which I'll say more later. And we've found, for more than half the stars with masses like the Sun's, that early in their careers they're surrounded by great disks of gas and dust out of which planets seem to form. Other planetary systems now look to be a cosmic commonplace, maybe even worlds something like the Earth. We should be able, in the next few decades, to inventory at least the larger planets, if they exist, of hundreds of nearby stars.

Well, if our position in space doesn't reveal our special role, our posi-

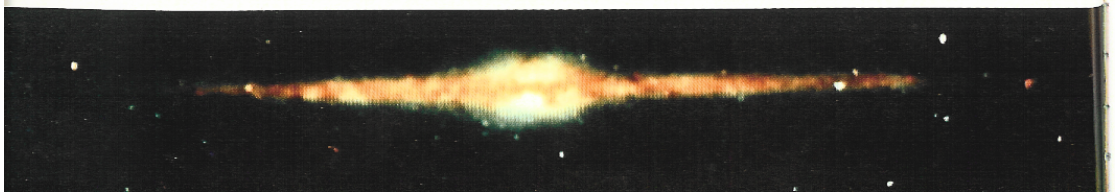
Modern observations confirm Galileo's conclusion that the surface of the Moon is not smooth and polished. *Apollo 17* image, courtesy NASA.

tion in time does: We've been in the Universe since The Beginning (give or take a few days). *We've been given special responsibilities by the Creator.* It once seemed very reasonable to think of the Universe as beginning just a little before our collective memory is obscured by the passage of time and the illiteracy of our ancestors. Generally speaking, that's hundreds or thousands of years ago. Religions that purport to describe the origin of the Universe often specify—implicitly or explicitly—a date of origin of roughly such vintage, a birthday for the world.

If you add up all the "begats" in Genesis, for example, you get an age for the Earth: 6,000 years old, plus or minus a little. The universe is said to be exactly as old as the Earth. This is still the standard of Jewish, Christian, and Moslem fundamentalists and is clearly reflected in the Jewish calendar.

But so young a Universe raises an awkward question: How is it that there are astronomical objects more than 6,000 light-years away? It takes light a year to travel a light-year, 10,000 years to travel 10,000 light-years, and so on. When we look at the center of the Milky Way Galaxy, the light we see left its source 30,000 years ago. The nearest spiral galaxy like our own, M31 in the constellation Andromeda, is 2 million light-years away, so we are seeing it as it was when the light from it set out on its long journey to Earth—2 million years ago. And when we observe distant quasars 5 billion light-years away, we are seeing them as they were 5 billion years ago, before the Earth was formed. (They are, almost certainly, very different today.)

If, despite this, we were to accept the literal truth of such religious books, how could we reconcile the data? The only plausible conclusion, I think, is that God recently made all the photons of light arriving on the Earth in such a coherent format as to mislead generations of astronomers into the misapprehension that there are such things as galaxies and quasars, and intentionally driving them to the spurious conclusion that the Universe is vast and old.



The Milky Way Galaxy seen in infrared light from above the Earth's atmosphere. The spiral arms, of which our Sun is a part, are seen edge-on (because the Sun lies close to the plane of our galaxy). We are almost 30,000 light-years from the center. COBE image, courtesy NASA.

This is such a malevolent theology I still have difficulty believing that anyone, no matter how devoted to the divine inspiration of any religious book, could seriously entertain it.

Beyond this, the radioactive dating of rocks, the abundance of impact craters on many worlds, the evolution of the stars, and the expansion of the Universe each provides compelling and independent evidence that our Universe is many billions of years old—despite the confident assertions of revered theologians that a world so old directly contradicts the word of God, and that at any rate information on the antiquity of the world is inaccessible except to faith.* These lines of evidence, as well, would have to be manufactured by a deceptive and malicious deity—unless the world is much older than the literalists in the Judeo-Christian-Islamic religion suppose. Of course, no such problem arises for those many religious people who treat the Bible and the Qur'an as historical and moral guides and great literature, but who recognize that the perspective of these scriptures on the natural world reflects the rudimentary science of the time in which they were written.

Ages rolled by before the Earth began. More ages will run their course before it is destroyed. A distinction needs to be drawn between how old the Earth is (around 4.5 billion years) and how old the Universe is (about 15 billion years since the Big Bang). The immense interval of time between the origin of the Universe and our epoch was two-thirds over before the Earth came to be. Some stars and planetary systems are billions of years younger, others billions of years older. But in Genesis, chapter 1, verse 1, the Universe and the Earth are created on the same day. The Hindu-Buddhist-Jain religion tends not to confound the two events.

* St. Augustine, in *The City of God*, says, "As it is not yet six thousand years since the first man . . . are not those to be ridiculed rather than refuted who try to persuade us of anything regarding a space of time so different from, and contrary to, the ascertained truth? . . . We, being sustained by divine authority in the history of our religion, have no doubt that whatever is opposed to it is most false." He excoriates the ancient Egyptian tradition that the world is as much as a hundred thousand years old as "abominable lies." St. Thomas Aquinas, in the *Summa Theologica*, flatly states that "the newness of the world cannot be demonstrated from the world itself." They were so *sure*.

As for humans, we're latecomers. We appear in the last instant of cosmic time. The history of the Universe till now was 99.998 percent over before our species arrived on the scene. In that vast sweep of aeons, we could not have assumed any special responsibilities for our planet, or life, or anything else. We were not here.

Well, if we can't find anything special about our position or our epoch, maybe there's something special about our motion. Newton and all the other great classical physicists held that the velocity of the Earth in space constituted a "privileged frame of reference." That's actually what it was called. Albert Einstein, a keen critic of prejudice and privilege all his life, considered this "absolute" physics a remnant of an increasingly discredited Earth chauvinism. It seemed to him that the laws of Nature must be the same no matter what the velocity or frame of reference of the observer. With this as his starting point, he developed the Special Theory of Relativity. Its consequences are bizarre, counterintuitive, and grossly contradict common sense—but only at very high speeds. Careful and repeated observations show that his justly celebrated theory is an accurate description of how the world is made. Our commonsense intuitions can be mistaken. Our preferences don't count. We do not live in a privileged reference frame.

One consequence of special relativity is time dilation—the slowing down of time as the observer approaches light speed. You can still find claims that time dilation applies to watches and elementary particles—and, presumably, to circadian and other rhythms in plants, animals, and microbes—but not to human biological clocks. Our species has been granted, it is suggested, special immunity from the laws of Nature, which must accordingly be able to distinguish deserving from undeserving collections of matter. (In fact, the proof Einstein gave for special relativity admits no such distinctions.) The idea of humans as exceptions to relativity seems another incarnation of the notion of special creation:

Well, even if our position, our epoch, our motion, and our world are not unique, maybe we are. We're different from the other animals. We're specially created. The particular devotion of the Creator of the Universe is evident in us. This position was passionately defended on religious and other grounds. But in the middle nineteenth century Charles Darwin showed convincingly how one species can evolve into another by entirely natural processes, which come down to the heartless business of Nature saving the heredities that work and rejecting those that don't. "Man in his arrogance thinks himself a great work worthy [of] the interposition of a deity," Darwin wrote telegraphically in his notebook. "More humble and I think truer to consider him created from animals." The profound and intimate connections of humans with the other life forms on Earth have been compellingly demonstrated in the late twentieth century by the new science of molecular biology.

IN EACH AGE the self-congratulatory chauvinisms are challenged in yet another arena of scientific debate—in this century, for example, in attempts to understand the nature of human sexuality, the existence of the unconscious mind, and the fact that many psychiatric illnesses and character "defects" have a molecular origin. But also:

Well, even if we're closely related to some of the other animals, we're different—not just in degree, but in kind—on what really matters: reasoning, self-consciousness, tool making, ethics, altruism, religion, language, nobility of character. While humans, like all animals, have traits that set them apart—otherwise, how could we distinguish one species from another?—human uniqueness has been exaggerated, sometimes grossly so. Chimps reason, are self-conscious, make tools, show devotion, and so on. Chimps and humans have 99.6 percent of their active genes in common. (Ann Druyan and I run through the evidence in our book *Shadows of Forgotten Ancestors.*)

In popular culture, the very opposite position is also embraced, although it too is driven by human chauvinism (plus a failure of the imagination): Children's stories and cartoons make animals dress in clothes, live in houses, use knives and forks, and speak. The three bears sleep in beds. The owl and the pussycat go to sea in a beautiful pea-green boat. Dinosaur mothers cuddle their young. Pelicans deliver the mail. Dogs drive cars. A worm catches a thief. Pets have human names. Dolls, nutcrackers, cups, and saucers dance and have opinions. The dish runs away with the spoon. In the *Thomas the Tank Engine* series, we even have anthropomorphic locomotives and railway cars, charmingly portrayed. No matter what we're thinking about, animate or inanimate, we tend to invest it with human traits. We can't help

ourselves. The images come readily to mind. Children are clearly fond of them.

When we talk about a "threatening" sky, a "troubled" sea, diamonds "resisting" being scratched, the Earth "attracting" a passing asteroid, or an atom being "excited," we are again drawn to a kind of animist worldview. We reify. Some ancient level of our thinking endows inanimate Nature with life, passions, and forethought.

The notion that the Earth is self-aware has lately been growing at the fringes of the "Gaia" hypothesis. But this was a commonplace belief of both the ancient Greeks and the early Christians. Origen wondered whether "the earth also, according to its own nature, is accountable for some sin." A host of ancient scholars thought the stars alive. This was also the position of Origen, of St. Ambrose (the mentor of St. Augustine), and even, in a more qualified form, of St. Thomas Aquinas. The Stoic philosophical position on the Sun's nature was stated by Cicero, in the first century B.C.: "Since the Sun resembles those fires which are contained in the bodies of living creatures, the Sun must also be alive."

Animist attitudes in general seem to have been spreading recently. In a 1954 American survey, 75 percent of people polled were willing to state that the Sun is not alive; in 1989, only 30 percent would support so rash a proposition. On whether an automobile tire can feel anything, 90 percent of respondents denied it emotions in 1954, but only 73 percent in 1989.

We can recognize here a shortcoming—in some circumstances serious—in our ability to understand the world. Characteristically, willy-nilly, we seem compelled to project our own nature onto Nature. Although this may result in a consistently distorted view of the world, it does have one great virtue—projection is the essential precondition for compassion.

Okay, maybe we're not much, maybe we're humiliatingly related to apes, but at least we're the best there is. God and angels aside, we're the only intelligent beings in the Universe. One correspondent writes to me, "I am as sure of this as anything in my experience. There is no conscious life anywhere else in the Universe. Mankind thus returns to its rightful position as center of the Universe." However, partly through the influence of science and science fiction, most people today, in the United States at least, reject this proposition—

for reasons essentially stated by the ancient Greek philosopher Chrysippus: "For any human being in existence to think that there is nothing in the whole world superior to himself would be an insane piece of arrogance."

But the simple fact is that we have not yet found extraterrestrial life. We are in the earliest stages of looking. The question is wide open. If I had to guess—especially considering our long sequence of failed chauvinisms—I would guess that the Universe is filled with beings far more intelligent, far more advanced than we are. But of course I might be wrong. Such a conclusion is at best based on a plausibility argument, derived from the numbers of planets, the ubiquity of organic matter, the immense timescales available for evolution, and so on. It is not a scientific demonstration. The question is among the most fascinating in all of science. As described in this book, we are just developing the tools to treat it seriously.

What about the related matter of whether we are capable of creating intelligences smarter than ourselves? Computers routinely do mathematics that no unaided human can manage, outperform world champions in checkers and grand masters in chess, speak and understand English and other languages, write presentable short stories and musical compositions, learn from their mistakes, and competently pilot ships, airplanes, and spacecraft. Their abilities steadily improve. They're getting smaller, faster, and cheaper. Each year, the tide of scientific advance laps a little further ashore on the island of human intellectual uniqueness with its embattled castaways. If, at so early a stage in our technological evolution, we have been able to go so far in creating intelligence out of silicon and metal, what will be possible in the following decades and centuries? What happens when smart machines are able to manufacture smarter machines?

PERHAPS THE CLEAREST INDICATION that the search for an unmerited privileged position for humans will never be wholly abandoned is what in physics and astronomy is called the Anthropic Principle. It would be better named the Anthropocentric Principle. It comes in various forms. The "Weak" Anthropic Principle merely notes that if the laws of Nature and the physical constants—such as the speed

of light, the electrical charge of the electron, the Newtonian gravitational constant, or Planck's quantum mechanical constant—had been different, the course of events leading to the origin of humans would never have transpired. Under other laws and constants, atoms would not hold together, stars would evolve too quickly to leave sufficient time for life to evolve on nearby planets, the chemical elements of which life is made would never have been generated, and so on. Different laws, no humans.

There is no controversy about the Weak Anthropic Principle: Change the laws and constants of Nature, if you could, and a very different universe may emerge—in many cases, a universe incompatible with life.* The mere fact that we exist implies (but does not impose) constraints on the laws of Nature. By contrast, the various "Strong" Anthropic Principles go much further; some of their advocates come close to deducing that the laws of Nature and the values of the physical constants were established (don't ask how or by Whom) *so that* humans would eventually come to be. Almost all of the other possible universes, they say, are inhospitable. In this way, the ancient conceit that the Universe was made for us is resuscitated.

To me it echoes Dr. Pangloss in Voltaire's *Candide,* convinced that this world, with all its imperfections, is the best possible. It sounds like playing my first hand of bridge, winning, knowing that there are 54 billion billion billion (5.4×10^{28}) possible other hands that I was equally likely to have been dealt . . . and then foolishly concluding that a god of bridge exists and favors me, a god who arranged the cards and the shuffle with my victory foreordained from The Beginning. We do not know how many other winning hands there are in the cosmic deck, how many other kinds of universes, laws of Nature, and physical constants that could also lead

* Our universe is *almost* incompatible with life—or at least what we understand as necessary for life: Even if every star in a hundred billion galaxies had an Earthlike planet, without heroic technological measures life could prosper in only about 10^{-37} the volume of the Universe. For clarity, let's write it out: only 0.000 000 000 000 000 000 000 000 000 000 000 000 1 of our universe is hospitable to life. Thirty-six zeroes before the one. The rest is cold, radiation-riddled black vacuum.

to life and intelligence and perhaps even delusions of self-importance. Since we know next to nothing about how the Universe was made—or even *if* it was made—it's difficult to pursue these notions productively.

Voltaire asked "Why is there anything?" Einstein's formulation was to ask whether God had any choice in creating the Universe. But if the Universe is infinitely old—if the Big Bang some 15 billion years ago is only the most recent cusp in an infinite series of cosmic contractions and expansions—then it was never created and the question of why it is as it is is rendered meaningless.

If, on the other hand, the Universe has a finite age, why is it the way it is? Why wasn't it given a very different character? Which laws of Nature go with which others? Are there meta-laws specifying the connections? Can we possibly discover them? Of all conceivable laws of gravity, say, which ones can exist simultaneously with which conceivable laws of quantum physics that determine the very existence of macroscopic matter? Are all laws we can think of possible, or is there only a restricted number that can somehow be brought into existence? Clearly we have not a glimmering of how to determine which laws of Nature are "possible" and which are not. Nor do we have more than the most rudimentary notion of what correlations of natural laws are "permitted."

For example, Newton's universal law of gravitation specifies that the mutual gravitational force attracting two bodies towards each other is inversely proportional to the square of how far they are apart. You move twice as far from the center of the Earth and you weigh a quarter as much; ten times farther and you weigh only a hundredth of your ordinary weight; etc. It is this inverse square law that permits the exquisite circular and elliptical orbits of planets around the Sun, and moons around the planets—as well as the precision trajectories of our interplanetary spacecraft. If r is the distance between the centers of two masses, we say that the gravitational force varies as $1/r^2$.

But if this exponent were different—if the gravitational law were $1/r^4$, say, rather than $1/r^2$—then the orbits would not close; over billions of revolutions, the planets would spiral in and be consumed in the fiery depths of the Sun, or spiral out and be lost to

interstellar space. If the Universe were constructed with an inverse fourth power law rather than an inverse square law, soon there would be no planets for living beings to inhabit.

So of all the possible gravitational force laws, why are we so lucky as to live in a universe sporting a law consistent with life? First, of course, we're so "lucky," because if we weren't, we wouldn't be here to ask the question. It is no mystery that inquisitive beings who evolve on planets can be found only in universes that admit planets. Second, the inverse square law is *not* the only one consistent with stability over billions of years. Any power law less steep than $1/r^3$ ($1/r^{2.99}$ or $1/r$, for example) will keep a planet in the *vicinity* of a circular orbit even if it's given a shove. We have a tendency to overlook the possibility that other conceivable laws of Nature might also be consistent with life.

But there's a further point: It's not arbitrary that we have an inverse square law of gravitation. When Newton's theory is understood in terms of the more encompassing general theory of relativity, we recognize that the exponent of the gravity law is 2 because the number of physical dimensions we live in is 3. All gravity laws aren't available, free for a Creator's choosing. Even given an infinite number of three-dimensional universes for some great god to tinker with, the gravity law would always have to be the law of the inverse square. Newtonian gravity, we might say, is not a contingent facet of our universe, but a necessary one.

In general relativity, gravity is *due to* the dimensionality and curvature of space. When we talk about gravity we are talking about local dimples in space-time. This is by no means obvious and even affronts commonsense notions. But when examined deeply, the ideas of gravity and mass are not separate matters, but ramifications of the underlying geometry of space-time.

I wonder if something like this doesn't apply generally to all anthropic hypotheses. The laws or physical constants on which our lives depend turn out to be members of a class, perhaps even a vast class, of other laws and other physical constants—but some of these are also compatible with a kind of life. Often we do not (or cannot) work through what those other universes allow. Beyond that, not every arbitrary choice of a law of Nature or a physical constant may be available, even to a maker of universes. Our understanding of which laws of Nature and which physical constants are up for grabs is fragmentary at best.

The barred spiral galaxy NGC 1365. Courtesy Anglo-Australian Observatory. Photograph by David Malin.

Moreover, we have no access to any of those putative alternative universes. We have no experimental method by which anthropic hypotheses may be tested. Even if the existence of such universes were to follow firmly from well-established theories—of quantum mechanics or gravitation, say—we could not be sure that there weren't better theories that predict no alternative universes. Until that time comes, if it ever does, it seems to me premature to put faith in the Anthropic Principle as an argument for human centrality or uniqueness.

Finally, even if the Universe were *intentionally* created to allow for the emergence of life or intelligence, other beings may exist on countless worlds. If so, it would be cold comfort to an-

thropocentrists that we inhabit one of the few universes that allow life and intelligence.

There is something stunningly narrow about how the Anthropic Principle is phrased. Yes, only certain laws and constants of nature are consistent with our kind of life. But essentially the same laws and constants are required to make a rock. So why not talk about a Universe designed so rocks could one day come to be, and strong and weak Lithic Principles? If stones could philosophize, I imagine Lithic Principles would be at the intellectual frontiers.

There are cosmological models being formulated today in which even the entire Universe is nothing special. Andrei Linde, formerly of the Lebedev Physical Institute in Moscow and now at Stanford University, has incorporated current understanding of the strong and weak nuclear forces and quantum physics into a new cosmological model. Linde envisions a vast Cosmos, much larger than our Universe—perhaps extending to infinity both in space and time—not the paltry 15 billion light-years or so in radius and 15 billion years in age which are the usual understanding. In this Cosmos there is, as here, a kind of quantum fluff in which tiny structures much smaller than an electron are everywhere forming, reshaping, and dissipating; in which, as here, fluctuations in absolutely empty space create pairs of elementary particles—an electron and a positron, for example. In the froth of quantum bubbles, the vast majority remain submicroscopic. But a tiny fraction inflate, grow, and achieve respectable universehood. They are so far away from us, though—much farther than the 15 billion light-years that is the conventional scale of our universe—that, if they exist, they appear to be wholly inaccessible and undetectable.

Most of these other universes reach a maximum size and then collapse, contract to a point, and disappear forever. Others may oscillate. Still others may expand without limit. In different universes there will be different laws of nature. We live, Linde argues, in one such universe—one in which the physics is congenial for growth, inflation, expansion, galaxies, stars, worlds, life. We imagine our universe to be unique, but it is one of an immense number—perhaps an infinite number—of equally valid, equally independent, equally isolated universes. There will be life in some, and not in others. In this view the observable Universe is just a newly formed backwater of a much vaster, infinitely old, and wholly unobservable Cosmos. If something like this is right, even our residual pride, pallid as it must be, of living in the only universe is denied to us.*

Maybe someday, despite current evidence, a means will be devised to peer into adjacent universes, sporting very different laws of nature, and we will see what else is possible. Or perhaps inhabitants of adjacent universes can peer into ours. Of course, in such speculations we have far exceeded the bounds of knowledge. But if something like Linde's Cosmos is true, there is—amazingly—still another devastating deprovincialization awaiting us.

Our powers are far from adequate to be creating universes anytime soon. Strong Anthropic Principle ideas are not amenable to proof (although Linde's cosmology does have some testable features). Extraterrestrial life aside, if self-congratulatory pretensions to centrality have now retreated to such bastions impervious to experiment, then the sequence of scientific battles with human chauvinism would seem to have been, at least largely, won.

THE LONG-STANDING VIEW, as summarized by the philosopher Immanuel Kant, that "without man . . . the whole of creation would be a mere wilderness, a thing in vain, and have no final end" is revealed to be self-indulgent folly. A Principle of Mediocrity seems to apply to all our circumstances. We could not have known beforehand that the evidence would be, so repeatedly and thoroughly, incompatible with the proposition that human beings are at center stage in the Universe. But most of the debates have now been settled decisively in favor of a position that, however painful, can be encapsulated in a single sentence: We have not been given the lead in the cosmic drama.

Perhaps someone else has. Perhaps no one else has. In either case, we have good reason for humility.

* For such ideas, words tend to fail us. A German locution for Universe is [*das*] *All*—which makes the inclusiveness quite unmistakable. We might say that our universe is but one in a "Multiverse," but I prefer to use "Cosmos" for everything and "Universe" for the only one we can know about.

Nathaniel Hawthorne found Herman Melville: "He can neither believe, nor be comfortable in his unbelief." Or Jean-Jacques Rousseau: "They had not persuaded me, but they had troubled me. Their arguments had shaken me without ever convincing me . . . It is hard to prevent oneself from believing what one so keenly desires." As the belief systems taught by the secular and religious authorities are undermined, respect for authority in general probably does erode. The lesson is clear: Even political leaders must be wary of embracing false doctrine. This is not a failing of science, but one of its graces.

Of course, worldview consensus is comforting, while clashes of opinion may be unsettling, and demand more of us. But unless we insist, against all evidence, that our ancestors were perfect, the advance of knowledge requires us to unravel and then restitch the consensus they established.

In some respects, science has far surpassed religion in delivering awe. How is it that hardly any major religion has looked at science and concluded, "This is better than we thought! The Universe is much bigger than our prophets said, grander, more subtle, more elegant. God must be even greater than we dreamed"? Instead they say, "No, no, no! My god is a little god, and I want him to stay that way." A religion, old or new, that stressed the magnificence of the Universe as revealed by modern science might be able to draw forth reserves of reverence and awe hardly tapped by the conventional faiths. Sooner or later, such a religion will emerge.

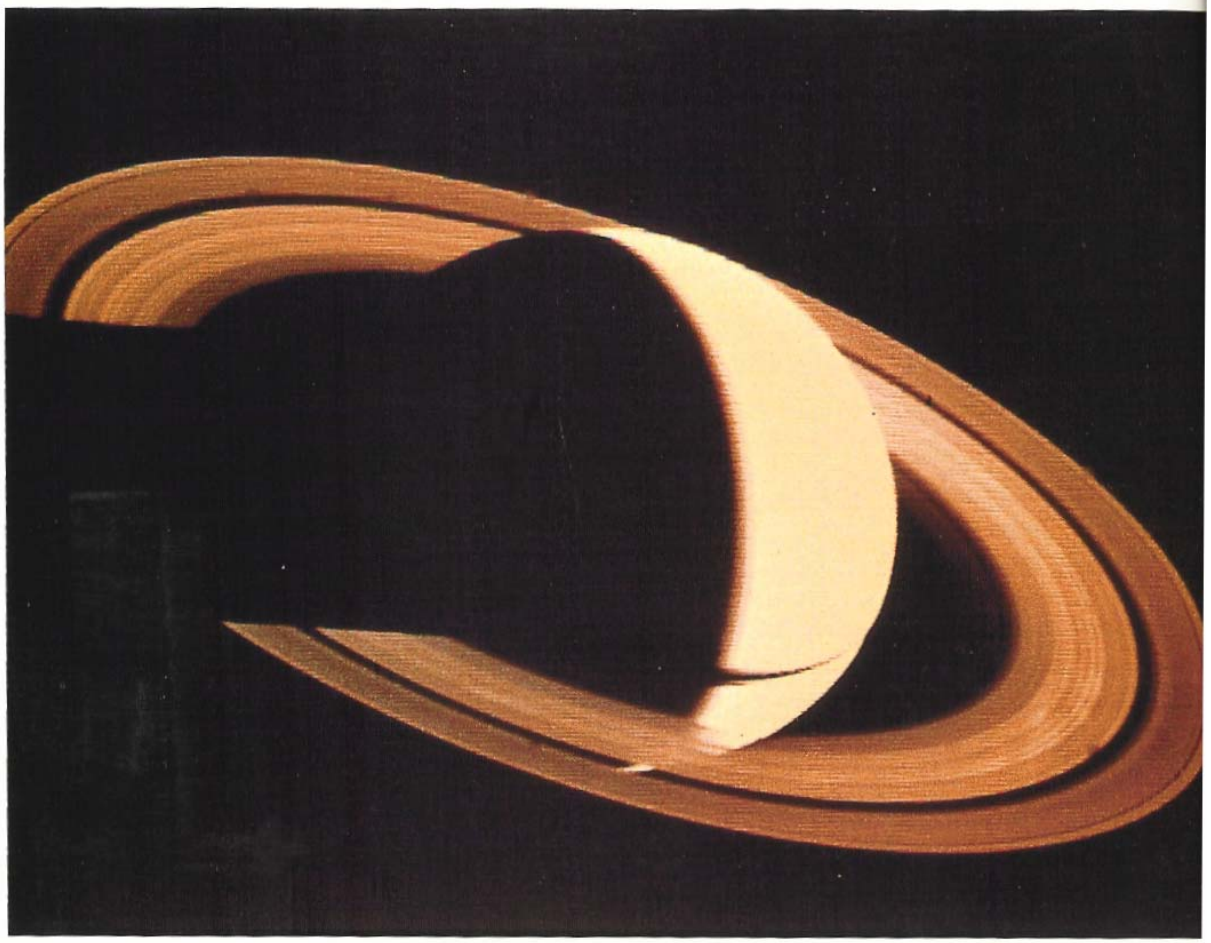
IF YOU LIVED two or three millennia ago, there was no shame in holding that the Universe was made for us. It was an appealing thesis consistent with everything we knew; it was what the most learned among us taught without qualification. But we have found out much since then. Defending such a position today amounts to willful disregard of the evidence, and a flight from self-knowledge.

Still, for many of us, these deprovincializations rankle. Even if they do not fully carry the day, they erode confidence—unlike the happy anthropocentric certitudes, rippling with social utility, of an earlier age. We long to be here for a purpose, even though, despite much self-deception, none is evident. "The meaningless absurdity of life," wrote Leo Tolstoy, "is the only incontestable knowledge accessible to man." Our time is burdened under the cumulative weight of successive debunkings of our conceits: We're Johnny-come-latelies. We live in the cosmic boondocks. We emerged from microbes and muck. Apes are our cousins. Our thoughts and feelings are not fully under our own control. There may be much smarter and very different beings elsewhere. And on top of all this, we're making a mess of our planet and becoming a danger to ourselves.

The trapdoor beneath our feet swings open. We find ourselves in bottomless free fall. We are lost in a great darkness, and there's no one to send out a search party. Given so harsh a reality, of course we're tempted to shut our eyes and pretend that we're safe and snug at home, that the fall is only a bad dream.

We lack consensus about our place in the Universe. There is no generally agreed upon long-term vision of the goal of our species—other than, perhaps, simple survival. Especially when times are hard, we become desperate for encouragement, unreceptive to the litany of great demotions and dashed hopes, and much more willing to hear that we're special, never mind if the evidence is paper-thin. If it takes a little myth and ritual to get us through a night that seems endless, who among us cannot sympathize and understand?

But if our objective is deep knowledge rather than shallow reassurance, the gains from this new perspective far outweigh the losses. Once we overcome our fear of being tiny, we find ourselves on the threshold of a vast and awesome Universe that utterly dwarfs—in time, in space, and in potential—the tidy anthropocentric proscenium of our ancestors. We gaze across billions of light-years of space to view the Universe shortly after the Big Bang, and plumb the fine structure of matter. We peer down into the core of our planet, and the blazing interior of our star. We read the genetic language in which is written the diverse skills and propensities of every being on Earth. We uncover hidden chapters in the record of our own origins, and with some anguish better understand our nature and prospects. We invent and refine agriculture, without



ABOVE AND OPPOSITE PAGE:
Order in Nature. Does the exquisite regularity of planetary ring systems (left) or spiral galaxies (right) indicate direct intervention by a deity who considers order a grace? (Saturn, backlit, seen by *Voyager 2* after passing it on the spacecraft's way to Uranus, courtesy JPL/NASA.)

which almost all of us would starve to death. We create medicines and vaccines that save the lives of billions. We communicate at the speed of light, and whip around the Earth in an hour and a half. We have sent dozens of ships to more than seventy worlds, and four spacecraft to the stars. We are right to rejoice in our accomplishments, to be proud that our species has been able to see so far, and to judge our merit in part by the very science that has so deflated our pretensions.

To our ancestors there was much in Nature to be afraid of—

Messier 100, in the Virgo Cluster of galaxies, about 62 million light-years away. Courtesy Anglo-Australian Observatory. Photograph by David Malin.

lightning, storms, earthquakes, volcanos, plagues, drought, long winters. Religions arose in part as attempts to propitiate and control, if not much to understand, the disorderly aspect of Nature. The scientific revolution permitted us to glimpse an underlying ordered Universe in which there was a literal harmony of the worlds (Johannes Kepler's phrase). If we understand Nature, there is a prospect of controlling it or at least mitigating the harm it may bring. In this sense, science brought hope.

Most of the great deprovincializing debates were entered into

with no thought for their practical implications. Passionate and curious humans wished to understand their actual circumstances, how unique or pedestrian they and their world are, their ultimate origins and destinies, how the Universe works. Surprisingly, some of these debates have yielded the most profound practical benefits. The very method of mathematical reasoning that Isaac Newton introduced to explain the motion of the planets around the Sun has led to most of the technology of our modern world. The Industrial Revolution, for all its shortcomings, is still the global model of how an agricultural nation can emerge from poverty. These debates have bread-and-butter consequences.

It might have been otherwise. It might have been that the balance lay elsewhere, that humans by and large did not want to know about a disquieting Universe, that we were unwilling to permit challenges to the prevailing wisdom. Despite determined resistance in every age, it is very much to our credit that we have allowed ourselves to follow the evidence, to draw conclusions that at first seem daunting: a Universe so much larger and older that our personal and historical experience is dwarfed and humbled, a Universe in which, every day, suns are born and worlds obliterated, a Universe in which humanity, newly arrived, clings to an obscure clod of matter.

How much more satisfying had we been placed in a garden custom-made for us, its other occupants put there for us to use as we saw fit. There is a celebrated story in the Western tradition like this, except that not quite everything was there for us. There was one particular tree of which we were not to partake, a tree of knowledge. Knowledge and understanding and wisdom were forbidden to us in this story. We were to be kept ignorant. But we couldn't help ourselves. We were starving for knowledge—created hungry, you might say. This was the origin of all our troubles. In particular, it is why we no longer live in a garden: We found out too much. So long as we were incurious and obedient, I imagine, we could console ourselves with our importance and centrality, and tell ourselves that we were the reason the Universe was made. As we began to indulge our curiosity, though, to explore, to learn how the Universe really is, we expelled ourselves from Eden. Angels with a flaming sword were set as sentries at the gates of Paradise to bar our return. The gardeners became exiles and wanderers. Occasionally we mourn that lost world, but that, it seems to me, is maudlin and sentimental. We could not happily have remained ignorant forever.

There is in this Universe much of what seems to be design. Every time we come upon it, we breathe a sigh of relief. We are forever hoping to find, or at least safely deduce, a Designer. But instead, we repeatedly discover that natural processes—collisional selection of worlds, say, or natural selection of gene pools, or even the convection pattern in a pot of boiling water—can extract order out of chaos, and deceive us into deducing purpose where there is none. In everyday life, we often sense—in the bedrooms of teenagers, or in national politics—that chaos is natural, and order imposed from above. While there are deeper regularities in the Universe than the simple circumstances we generally describe as orderly, all that order, simple and complex, seems to derive from laws of Nature established at the Big Bang (or earlier), rather than as a consequence of belated intervention by an imperfect deity. "God is to be found in the details" is the famous dictum of the German scholar Aby Warburg. But, amid much elegance and precision, the details of life and the Universe also exhibit haphazard, jury-rigged arrangements and much poor planning. What shall we make of this: an edifice abandoned early in construction by the architect?

The evidence, so far at least and laws of Nature aside, does not require a Designer. Maybe there is one hiding, maddeningly unwilling to be revealed. Sometimes it seems a very slender hope.

The significance of our lives and our fragile planet is then determined only by our own wisdom and courage. *We* are the custodians of life's meaning. We long for a Parent to care for us, to forgive us our errors, to save us from our childish mistakes. But knowledge is preferable to ignorance. Better by far to embrace the hard truth than a reassuring fable.

If we crave some cosmic purpose, then let us find ourselves a worthy goal.