# The Perimeter of Ignorance

A boundary where scientists face a choice: invoke a deity or continue the quest for knowledge
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Writing in centuries past, many scientists felt compelled to wax poetic about cosmic mysteries and God's handiwork. Perhaps one should not be surprised at this: most scientists back then, as well as many scientists today, identify themselves as spiritually devout.

But a careful reading of older texts, particularly those concerned with the universe itself, shows that the authors invoke divinity only when they reach the boundaries of their understanding. They appeal to a higher power only when staring into the ocean of their own ignorance. They call on God only from the lonely and precarious edge of incomprehension. Where they feel certain about their explanations, however, God gets hardly a mention.

Let's start at the top. Isaac Newton was one of the greatest intellects the world has ever seen. His laws of motion and his universal law of gravitation, conceived in the mid-seventeenth century, account for cosmic phenomena that had eluded philosophers for millennia. Through those laws, one could understand the gravitational attraction of bodies in a system, and thus come to understand orbits.

Newton's law of gravity enables you to calculate the force of attraction between any two objects. If you introduce a third object, then each one attracts the other two, and the orbits they trace become much harder to compute. Add another object, and another, and another, and soon you have the planets in our solar system. Earth and the Sun pull on each other, but Jupiter also pulls on Earth, Saturn pulls on Earth, Mars pulls on Earth, Jupiter pulls on Saturn, Saturn pulls on Mars, and on and on.

Newton feared that all this pulling would render the orbits in the solar system unstable. His equations indicated that the planets should long ago have either fallen into the Sun or flown the coop—leaving the Sun, in either case, devoid of planets. Yet the solar system, as well as the larger cosmos, appeared to be the very model of order and durability. So Newton, in his greatest work, the *Principia,* concludes that God must occasionally step in and make things right:

*The six primary Planets are revolv'd about the Sun, in circles concentric with the Sun, and with motions directed towards the same parts, and almost in the same plane. . . . But it is not to be conceived that mere mechanical causes could give birth to so many regular motions. . . . This most beautiful System of the Sun,*

*Planets, and Comets, could only proceed from the counsel and dominion of an intelligent and powerful Being.*

In the *Principia,* Newton distinguishes between hypotheses and experimental philosophy, and declares, "Hypotheses, whether metaphysical or physical, whether of occult qualities or mechanical, have no place in experimental philosophy." What he wants is data, "inferr'd from the ph¾nomena." But in the absence of data, at the border between what he could explain and what he could only honor—the causes he could identify and those he could not—Newton rapturously invokes God:

*Eternal and Infinite, Omnipotent and Omniscient; . . . he governs all things, and knows all things that are or can be done. . . . We know him only by his most wise and excellent contrivances of things, and final causes; we admire him for his perfections; but we reverence and adore him on account of his dominion.*

A century later, the French astronomer and mathematician Pierre-Simon de Laplace confronted Newton's dilemma of unstable orbits head-on. Rather than view the mysterious stability of the solar system as the unknowable work of God, Laplace declared it a scientific challenge. In his multipart masterpiece, MŽcanique CŽleste, the first volume of which appeared in 1798, Laplace demonstrates that the solar system is stable over periods of time longer than Newton could predict. To do so, Laplace pioneered a new kind of mathematics called perturbation theory, which enabled him to examine the cumulative effects of many small forces. According to an oft-repeated but probably embellished account, when Laplace gave a copy of *MŽcanique CŽleste* to his physics-literate friend Napoleon Bonaparte, Napoleon asked him what role God played in the construction and regulation of the heavens. "Sire," Laplace replied, "I have no need of that hypothesis."

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Laplace notwithstanding, plenty of scientists besides Newton have called on God—or the gods—wherever their comprehension fades to ignorance. Consider the second-century a.d. Alexandrian astronomer Ptolemy. Armed with a description, but no real understanding, of what the planets were doing up there, he could not contain his religious fervor:

*I know that I am mortal by nature, and ephemeral; but when I trace, at my pleasure, the windings to and fro of the heavenly bodies, I no longer touch Earth with my feet: I stand in the presence of Zeus himself and take my fill of ambrosia.*

Or consider the seventeenth-century Dutch astronomer Christiaan Huygens, whose achievements include constructing the first working pendulum clock and discovering the rings of Saturn. In his charming book *The Celestial Worlds Discover'd,* posthumously published in 1696, most of the opening chapter celebrates all that was then known of planetary orbits, shapes, and sizes, as well as the planets' relative brightness and presumed rockiness. The book even includes foldout charts illustrating the structure of the solar system. God is absent from this discussion—even though a mere century earlier, before Newton's achievements, planetary orbits were supreme mysteries.

*Celestial Worlds* also brims with speculations about life in the solar system, and that's where Huygens raises questions to which he has no answer. That's where he mentions the biological conundrums of the day, such as the origin of life's complexity. And sure enough, because seventeenth-century physics was more advanced than seventeenth-century biology, Huygens invokes the hand of God only when he talks about biology:

*I suppose no body will deny but that there's somewhat more of Contrivance, somewhat more of Miracle in the production and growth of Plants and Animals than in lifeless heaps of inanimate Bodies. . . . For the finger of God, and the Wisdom of Divine Providence, is in them much more clearly manifested than in the other.*

Today secular philosophers call that kind of divine invocation "God of the gaps"—which comes in handy, because there has never been a shortage of gaps in people's knowledge.

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As reverent as Newton, Huygens, and other great scientists of earlier centuries may have been, they were also empiricists. They did not retreat from the conclusions their evidence forced them to draw, and when their discoveries conflicted with prevailing articles of faith, they upheld the discoveries. That doesn't mean it was easy: sometimes they met fierce opposition, as did Galileo, who had to defend his telescopic evidence against formidable objections drawn from both scripture and "common" sense.

Galileo clearly distinguished the role of religion from the role of science. To him, religion was the service of God and the salvation of souls, whereas science was the source of exact observations and demonstrated truths. In a long, famous, bristly letter written in the summer of 1615 to the Grand Duchess Christina of Tuscany (but, like so many epistles of the day, circulated among the literati), he quotes, in his own defense, an unnamed yet sympathetic church official saying that the Bible "tells you how to go to heaven, not how the heavens go."

The letter to the duchess leaves no doubt about where Galileo stood on the literal word of the Holy Writ:

*In expounding the Bible if one were always to confine oneself to the unadorned grammatical meaning, one might fall into error. . . .*

*Nothing physical which . . . demonstrations prove to us, ought to be called in question (much less condemned) upon the testimony of biblical passages which may have some different meaning beneath their words. . . .*

*I do not feel obliged to believe that the same God who has endowed us with senses, reason and intellect has intended us to forgo their use.*

A rare exception among scientists, Galileo saw the unknown as a place to explore rather than as an eternal mystery controlled by the hand of God.

As long as the celestial sphere was generally regarded as the domain of the divine, the fact that mere mortals could not explain its workings could safely be cited as proof of the higher wisdom and power of God. But beginning in the sixteenth century, the work of Copernicus, Kepler, Galileo, and Newton—not to mention Maxwell, Heisenberg, Einstein, and everybody else who discovered fundamental laws of physics—provided rational explanations for an increasing range of phenomena. Little by little, the universe was subjected to the methods and tools of science, and became a demonstrably knowable place.

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Then, in what amounts to a stunning yet unheralded philosophical inversion, throngs of ecclesiastics and scholars began to declare that it was the laws of physics themselves that served as proof of the wisdom and power of God.

One popular theme of the seventeenth and eighteenth centuries was the "clockwork universe"—an ordered, rational, predictable mechanism fashioned and run by God and his physical laws. The early telescopes, which all relied on visible light, did little to undercut that image of an ordered system. The Moon revolved around Earth. Earth and other planets rotated on their axes and revolved around the Sun. The stars shone. The nebulae floated freely in space.

Not until the nineteenth century was it evident that visible light is just one band of a broad spectrum of electromagnetic radiation—the band that human beings just happen to see. Infrared was discovered in 1800, ultraviolet in 1801, radio waves in 1888, X rays in 1895, and gamma rays in 1900. Decade by decade in the following century, new kinds of telescopes came into use, fitted with detectors that could "see" these formerly invisible parts of the electromagnetic spectrum. Now astrophysicists began to unmask the true character of the universe.

Turns out that some celestial bodies give off more light in the invisible bands of the spectrum than in the visible. And the invisible light picked up by the new telescopes showed that mayhem abounds in the cosmos: monstrous gamma-ray bursts, deadly pulsars, matter-crushing gravitational fields, matter-hungry black holes that flay their bloated stellar neighbors, newborn stars igniting within pockets of collapsing gas. And as our ordinary, optical telescopes got bigger and better, more mayhem emerged: galaxies that collide and cannibalize each other, explosions of supermassive stars, chaotic stellar and planetary orbits. Our own cosmic neighborhood—the inner solar system—turned out to be a shooting gallery, full of rogue asteroids and comets that collide with planets from time to time. Occasionally they've even wiped out stupendous masses of Earth's flora and fauna. The evidence all points to the fact that we occupy not a well-mannered clockwork universe, but a destructive, violent, and hostile zoo.

Of course, Earth can be bad for your health too. On land, grizzly bears want to maul you; in the oceans, sharks want to eat you. Snowdrifts can freeze you, deserts dehydrate you, earthquakes bury you, volcanoes incinerate you. Viruses can infect you, parasites suck your vital fluids, cancers take over your body, congenital diseases force an early death. And even if you have the good luck to be healthy, a swarm of locusts could devour your crops, a tsunami could wash away your family, or a hurricane could blow apart your town.

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So the universe wants to kill us all. But let's ignore that complication for the moment.

Many, perhaps countless, questions hover at the front lines of science. In some cases, answers have eluded the best minds of our species for decades or even centuries. And in contemporary America, the notion that a higher intelligence is the single answer to all enigmas has been enjoying a resurgence. This present-day version of God of the gaps goes by a fresh name: "intelligent design." The term suggests that some entity, endowed with a mental capacity far greater than the human mind can muster, created or enabled all the things in the physical world that we cannot explain through scientific methods.

An interesting hypothesis.

But why confine ourselves to things too wondrous or intricate for us to understand, whose existence and attributes we then credit to a superintelligence? Instead, why not tally all those things whose design is so clunky, goofy, impractical, or unworkable that they reflect the absence of intelligence?

Take the human form. We eat, drink, and breathe through the same hole in the head, and so, despite Henry J. Heimlich's eponymous maneuver, choking is the fourth leading cause of "unintentional injury death" in the United States. How about drowning, the fifth leading cause? Water covers almost three-quarters of Earth's surface, yet we are land creatures—submerge your head for just a few minutes, and you die.

Or take our collection of useless body parts. What good is the pinky toenail? How about the appendix, which stops functioning after childhood and thereafter serves only as the source of appendicitis? Useful parts, too, can be problematic. I happen to like my knees, but nobody ever accused them of being well protected from bumps and bangs. These days, people with problem knees can get them surgically replaced. As for our pain-prone spine, it may be a while before someone finds a way to swap that out.

How about the silent killers? High blood pressure, colon cancer, and diabetes each cause tens of thousands of deaths in the U.S. every year, but it's possible not to know you're afflicted until your coroner tells you so. Wouldn't it be nice if we had built-in biogauges to warn us of such dangers well in advance? Even cheap cars, after all, have engine gauges.

And what comedian designer configured the region between our legs—an entertainment complex built around a sewage system?

The eye is often held up as a marvel of biological engineering. To the astrophysicist, though, it's only a so-so detector. A better one would be much more sensitive to dark things in the sky and to all the invisible parts of the spectrum. How much more breathtaking sunsets would be if we could see ultraviolet and infrared. How useful it would be if, at a glance, we could see every source of microwaves in the environment, or know which radio station transmitters were active. How helpful it would be if we could spot police radar detectors at night.

Think how easy it would be to navigate an unfamiliar city if we, like birds, could always tell which way was north because of the magnetite in our heads. Think how much better off we'd be if we had gills as well as lungs, how much more productive if we had six arms instead of two. And if we had eight, we could safely drive a car while simultaneously talking on a cell phone, changing the radio station, applying makeup, sipping a drink, and scratching our left ear.

Stupid design could fuel a movement unto itself. It may not be nature's default, but it's ubiquitous. Yet people seem to enjoy thinking that our bodies, our minds, and even our universe represent pinnacles of form and reason. Maybe it's a good antidepressant to think so. But it's not science—not now, not in the past, not ever.

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Another practice that isn't science is *embracing* ignorance. Yet it's fundamental to the philosophy of intelligent design: I don't know what this is. I don't know how it works. It's too complicated for me to figure out. It's too complicated for any human being to figure out. So it must be the product of a higher intelligence.

What do you do with that line of reasoning? Do you just cede the solving of problems to someone smarter than you, someone who's not even human? Do you tell students to pursue only questions with easy answers?

There may be a limit to what the human mind can figure out about our universe. But how presumptuous it would be for me to claim that if I can't solve a problem, neither can any other person who has ever lived or who will ever be born. Suppose Galileo and Laplace had felt that way? Better yet, what if Newton had *not*? He might then have solved Laplace's problem a century earlier, making it possible for Laplace to cross the next frontier of ignorance.

Science is a philosophy of discovery. Intelligent design is a philosophy of ignorance. You cannot build a program of discovery on the assumption that nobody is smart enough to figure out the answer to a problem. Once upon a time, people identified the god Neptune as the source of storms at sea. Today we call these storms hurricanes. We know when and where they start. We know what drives them. We know what mitigates their destructive power. And anyone who has studied global warming can tell you what makes them worse. The only people who still call hurricanes "acts of God" are the people who write insurance forms.

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To deny or erase the rich, colorful history of scientists and other thinkers who have invoked divinity in their work would be intellectually dishonest. Surely there's an appropriate place for intelligent design to live in the academic landscape. How about the history of religion? How about philosophy or psychology? The one place it doesn't belong is the science classroom.

If you're not swayed by academic arguments, consider the financial consequences. Allow intelligent design into science textbooks, lecture halls, and laboratories, and the cost to the frontier of scientific discovery—the frontier that drives the economies of the future—would be incalculable. I don't want students who could make the next major breakthrough in renewable energy sources or space travel to have been taught that anything they don't understand, and that nobody yet understands, is divinely constructed and therefore beyond their intellectual capacity. The day that happens, Americans will just sit in awe of what we don't understand, while we watch the rest of the world boldly go where no mortal has gone before.

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