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Laws of Nature, Source Unknown

By DENNIS OVERBYE

Correction Appended

"Gravity," goes the slogan on posters and bumper stickers. "It isn't just a good idea. It's the law."

And what a law. Unlike, say, traffic or drug laws, you don't have a choice about obeying gravity or any of the other laws of physics. Jump and you will come back down. Faith or good intentions have nothing to do with it.

Existence didn't have to be that way, as Einstein reminded us when he said, "The most incomprehensible thing about the universe is that it is comprehensible." Against all the odds, we can send e-mail to Sri Lanka, thread spacecraft through the rings of Saturn, take a pill to chase the inky tendrils of depression, bake a turkey or a soufflé and bury a jump shot from the corner.

Yes, it's a lawful universe. But what kind of laws are these, anyway, that might be inscribed on a T-shirt but apparently not on any stone tablet that we have ever been able to find?

Are they merely fancy bookkeeping, a way of organizing facts about the world? Do they govern nature or just describe it? And does it matter that we don't know and that most scientists don't seem to know or care where they come from?

Apparently it does matter, judging from the reaction to a recent article by Paul Davies, a cosmologist at Arizona State University and author of popular science books, on the Op-Ed page of The New York Times.

Dr. Davies asserted in the article that science, not unlike religion, rested on faith, not in God but in the idea of an orderly universe. Without that presumption a scientist could not function. His argument provoked an avalanche of blog commentary, articles on Edge.org and letters to The Times, pointing out that the order we perceive in nature has been explored and tested for more than 2,000 years by observation and experimentation. That order is precisely the hypothesis that the scientific enterprise is engaged in testing.

David J. Gross, director of the Kavli Institute for Theoretical Physics in Santa Barbara, Calif., and co-winner of the Nobel Prize in physics, told me in an e-mail message, "I have more confidence in the methods of science, based on the amazing record of science and its ability over the centuries to answer unanswerable questions, than I do in the methods of faith (what are they?)."

Reached by e-mail, Dr. Davies acknowledged that his mailbox was "overflowing with vitriol," but said he had been misunderstood. What he had wanted to challenge, he said, was not the existence of laws, but the conventional thinking about their source.

There is in fact a kind of chicken-and-egg problem with the universe and its laws. Which "came" first — the laws or the universe?

If the laws of physics are to have any sticking power at all, to be real laws, one could argue, they have to be good anywhere and at any time, including the Big Bang, the putative Creation. Which gives them a kind of transcendent status outside of space and time.

On the other hand, many thinkers — all the way back to Augustine — suspect that space and time, being attributes of this existence, came into being along with the universe — in the Big Bang, in modern vernacular. So why not the laws themselves?

Dr. Davies complains that the traditional view of transcendent laws is just 17th-century monotheism without God. “Then God got killed off and the laws just free-floated in a conceptual vacuum but retained their theological properties,” he said in his e-mail message.

But the idea of rationality in the cosmos has long existed without monotheism. As far back as the fifth century B.C. the Greek mathematician and philosopher Pythagoras and his followers proclaimed that nature was numbers. Plato envisioned a higher realm of ideal forms, of perfect chairs, circles or galaxies, of which the phenomena of the sensible world were just flawed reflections. Plato set a transcendent tone that has been popular, especially with mathematicians and theoretical physicists, ever since.

Steven Weinberg, a Nobel laureate from the University of Texas, Austin, described himself in an e-mail message as “pretty Platonist,” saying he thinks the laws of nature are as real as “the rocks in the field.” The laws seem to persist, he wrote, “whatever the circumstance of how I look at them, and they are things about which it is possible to be wrong, as when I stub my toe on a rock I had not noticed.”

The ultimate Platonist these days is Max Tegmark, a cosmologist at the Massachusetts Institute of Technology. In talks and papers recently he has speculated that mathematics does not describe the universe — it is the universe.

Dr. Tegmark maintains that we are part of a mathematical structure, albeit one gorgeously more complicated than a hexagon, a multiplication table or even the multidimensional symmetries that describe modern particle physics. Other mathematical structures, he predicts, exist as their own universes in a sort of cosmic Pythagorean democracy, although not all of them would necessarily prove to be as rich as our own.

“Everything in our world is purely mathematical — including you,” he wrote in New Scientist.

This would explain why math works so well in describing the cosmos. It also suggests an answer to the question that Stephen Hawking, the English cosmologist, asked in his book, “A Brief History of Time”: “What is it that breathes fire into the equations and makes a universe for them to describe?” Mathematics itself is on fire.

Not every physicist pledges allegiance to Plato. Pressed, these scientists will describe the laws more pragmatically as a kind of shorthand for nature’s regularity. Sean Carroll, a cosmologist at the California Institute of Technology, put it this way: “A law of physics is a pattern that nature obeys without exception.”

Plato and the whole idea of an independent reality, moreover, took a shot to the mouth in the 1920s with the advent of quantum mechanics. According to that weird theory, which, among other things, explains why our computers turn on every morning, there is an irreducible randomness at the microscopic heart of reality that leaves an elementary particle, an electron, say, in a sort of fog of being everywhere or anywhere, or being a wave or a particle, until some measurement fixes it in place.

In that case, according to the standard interpretation of the subject, physics is not about the world at all, but about only the outcomes of experiments, of our clumsy interactions with that world. But 75 years later, those are still fighting words. Einstein grumbled about God not playing dice.

Steven Weinstein, a philosopher of science at the University of Waterloo, in Ontario, termed the phrase “law of nature” as “a kind of honorific” bestowed on principles that seem suitably general, useful and deep. How general and deep the laws really are, he said, is partly up to nature and partly up to us, since we are the ones who have to use them.

But perhaps, as Dr. Davies complains, Plato is really dead and there are no timeless laws or truths. A handful of poet-physicists harkening for more contingent nonabsolutist laws not engraved in stone have tried to come up with prescriptions for what John Wheeler, a physicist from Princeton and the University of Texas in Austin, called “law without law.”

As one example, Lee Smolin, a physicist at the Perimeter Institute for Theoretical Physics, has invented a theory in which the laws of nature change with time. It envisions universes nested like Russian dolls inside black holes, which are spawned with slightly different characteristics each time around. But his theory lacks a meta law that would prescribe how and why the laws change from generation to generation.

Holger Bech Nielsen, a Danish physicist at the Niels Bohr Institute in Copenhagen, and one of the early pioneers of string theory, has for a long time pursued a project he calls Random Dynamics, which tries to show how the laws of physics could evolve naturally from a more general notion he calls “world machinery.”

On his Web site, Random Dynamics, he writes, “The ambition of Random Dynamics is to ‘derive’ all the known physical laws as an almost unavoidable consequence of a random fundamental ‘world machinery.’”

Dr. Wheeler has suggested that the laws of nature could emerge “higgledy-piggledy” from primordial chaos, perhaps as a result of quantum uncertainty. It’s a notion known as “it from bit.” Following that logic, some physicists have suggested we should be looking not so much for the ultimate law as for the ultimate program.

Anton Zeilinger, a physicist and quantum trickster at the University of Vienna, and a fan of Dr. Wheeler’s idea, has speculated that reality is ultimately composed of information. He said recently that he suspected the universe was fundamentally unpredictable.

I love this idea of intrinsic randomness much for the same reason that I love the idea of natural selection in biology, because it and only it ensures that every possibility will be tried, every circumstance tested, every niche inhabited, every escape hatch explored. It’s a prescription for novelty, and what more could you ask for if you want to hatch a fecund universe?

But too much fecundity can be a problem. Einstein hoped that the universe was unique: given a few deep principles, there would be only one consistent theory. So far Einstein’s dream has not been fulfilled. Cosmologists and physicists have recently found themselves confronted by the idea of the multiverse, with zillions of universes, each with different laws, occupying a vast realm known in the trade as the landscape.

In this case there is meta law — one law or equation, perhaps printable on a T-shirt — to rule them all. This prospective lord of the laws would be string theory, the alleged theory of everything, which apparently has 10^{500} solutions. Call it Einstein’s nightmare.

But it is soon for any Einsteinian to throw in his or her hand. Since cosmologists don’t know how the universe came into being, or even have a convincing theory, they have no way of addressing the conundrum of where the laws of nature come from or whether those laws are unique and inevitable or flaky as a leaf in the wind.

These kinds of speculation are fun, but they are not science, yet. “Philosophy of science is about as useful to scientists as ornithology is to birds,” goes the saying attributed to Richard Feynman, the late Caltech Nobelist, and repeated by Dr. Weinberg.

Maybe both alternatives — Plato’s eternal stone tablet and Dr. Wheeler’s higgledy-piggledy process — will somehow turn out to be true. The dichotomy between forever and emergent might turn out to be as false eventually as the dichotomy between waves and particles as a description of light. Who knows?

The law of no law, of course, is still a law.

When I was young and still had all my brain cells I was a bridge fan, and one hand I once read about in the newspaper bridge column has stuck with me as a good metaphor for the plight of the scientist, or of the citizen cosmologist. The winning bidder had overbid his hand. When the dummy cards were laid, he realized that his only chance of making his contract was if his opponents’ cards were distributed just so.

He could have played defensively, to minimize his losses. Instead he played as if the cards were where they had to be. And he won.

We don’t know, and might never know, if science has overbid its hand. When in doubt, confronted with the complexities of the world, scientists have no choice but to play their cards as if they can win, as if the universe is indeed comprehensible. That is what they have been doing for more than 2,000 years, and they are still winning.

Correction: December 19, 2007

An article in Science Times on Tuesday about the laws of physics and nature misstated the time in which Plato was forming his idea of a higher realm of ideal forms. It was in the fourth century B.C.; it was not “a few hundred years” after the fifth century B.C., when the Greek mathematician and philosopher Pythagoras and his followers proclaimed that nature was numbers.