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## Science's Big Query: What Can We Know, And What Can't We?

**WHAT IF STALACTITES** could talk? If these icicle-shaped mineral deposits somehow preserved the sound waves that impinged on them as they grew, drop by drop, from the ceilings of caves, and if scientists figured out how to recover the precise characteristics of those waves, then maybe they would also be able to use stalactites like natural voice recorders and recover the conversations of ancient cave dwellers. Is it more far-fetched than recovering conversations from magnetized particles on an audio tape?

Such blue-sky speculation lies at the heart of an ambitious enterprise: To parse the natural world into the known, the unknown and the unknowable.



Rachel Salomon

At one level, it's a practical quest. If experts could make the case that, for instance, atmospheric scientists will never know the details of how global climate change will affect regions smaller than continents, then policy makers could move beyond demands for "more research" and start debating how to act in the face of scientific uncertainty (as actuaries pricing storm insurance do all the time). But at another level, separating the known from the unknowable is an esoteric exercise in epistemology, probing the limits of science.

**THE 20TH CENTURY** offered reasons for both hubris and humility on this front. It saw an explosion of scientific knowledge—deciphering the genetic code, inferring how the universe began and evolved, discovering relativity and quantum mechanics. "A hundred years ago it seemed we could measure nature more and more precisely, and that there were no limits on our knowledge," says physicist Piet Hut of the Institute for Advanced Study in Princeton, N.J.

But the last century also brought the first hints of fundamental, inherent limits on the knowable. Kurt Gödel discovered, to everyone's shock, that some statements in mathematics can be neither proved nor disproved. And physicists showed that the laws of quantum mechanics prevent us from knowing simultaneously both the position and the momentum of a subatomic particle. Will the world continue to yield to man's curiosity, or will we encounter evermore Gödelian limits?

"We grow up thinking more is known than actually is," says Ralph Gomory, president of the Alfred P. Sloan Foundation. Because that belief can trigger misconceptions about the natural world, Mr. Gomory launched the foundation's program in Limits to Knowledge.

"It's hard to get researchers interested in the question of what's unknowable, since they are much more oriented to pushing the frontiers of knowledge," he says. Nevertheless, quite a few are taking the puzzle seriously.

In genetics, for instance, it's becoming clear that knowing the entire genome of an organism will still not tell you all of the creature's physical traits. "I am asking where the rest of the information is," says Prof. David Thaler of Rockefeller University in New York City. "For now, we don't have any way even to quantify what fraction of all you'd like to know about an organism is in its genome."

Knowing someone's future health, let alone personality or intelligence, based on a genetic readout may be impossible—in a fundamental, inherent sense, not because we're stupid.

**IN COSMOLOGY**, one seemingly unanswerable question is whether our little universe is embedded in a "multiverse," a frothing sea of universes bobbing like bubbles in the sea. In principle, contact between universes is impossible. "But who knows?" asks Prof. Hut. "Just as wormholes might allow you to go from one point in the universe to another more quickly than light [by taking a shortcut, not by breaking the universal speed limit] maybe we'll come up with a way to communicate with other universes."

For now, how to do that is unknown, but maybe not unknowable.

Prof. Hut is less sanguine about another cosmic puzzle: whether the universe has to be the way it is because the laws of nature can exist only in their current form, or if other physics are possible. Einstein called this the question of whether God had any choice in how he created the world.

Without another world to show us different laws of nature, "I think we can never know for sure if the universe had to be the way it is, or if other laws of physics would allow other kinds of universes," says Prof. Hut.

In more down-to-earth fields, scholars suspect that where and when an earthquake will strike is knowable even though it's currently unknown. "The problem may be that we have the wrong theory," says Sloan's Jesse Ausubel, who is also a professor at Rockefeller. The future of markets may be unknowable. "That depends on what's in other people's minds," he says, "and unless I can read your mind I won't know what's going to happen on Wall Street except probabilistically."

"It really changes the way you deal with the world when you realize there is some ineluctable uncertainty," says ecologist Simon Levin of Princeton University, whose research examines whether knowing about large-scale phenomena (forests, for instance) tells you all you want to know about small-scale ones (trees), and vice versa.

It doesn't. As for making those stalactites talk? A definite maybe.

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