SCIENCE AND WONDER 4/23/23

By Evan Hadingham

So, let's start with some big questions....in fact, the biggest questions of all, which both science and religion have been trying to answer for centuries: Why are we here? How did the universe begin and how will it end? And why is the world the way it is?

Back in the Middle Ages, philosophy and religion both put humanity in the center of creation. Perhaps the biggest influence was Aristotle's theory that the universe is made up of ten crystal spheres, with the Earth at the center and the other spheres nested around it in a concentric pattern. Another concept was the Great Chain of Being, pictured as a ladder, with rocks and plants at the bottom of the rungs and rising up though animals, humans, then angels, and finally God, the source of all creation.

But in the Renaissance, scientific discoveries began demoting the earth and us from that central place in nature, a process that has continued ever since. The starting point was the publication of Copernicus's book *De Revolutionibus* in 1543, which laid out the essentials of today's solar system and placed the sun at the center of the universe. This literally earth-shattering conclusion was, Copernicus said, "suggested by the systematic process of events in the harmony of the whole universe, if only we face the facts, as they say, with both eyes open." The church begged to disagree, and disagreeing with the Church could get you into serious hot water, or rather, fire: in 1600, Giordano Bruno was burnt at the stake, partly for supporting Copernicus' theory.

Over the last century, astronomy has continued to shrink our sense of cosmic self-importance. Thanks to pioneers like Henrietta Leavitt and Edwin Hubble, and more recent observations made by the space telescope named after Hubble, we now know that the sun is one of over 100 billion stars in the Milky Way, and the Milky Way is just an average-sized galaxy among the roughly 100 billion galaxies

in the observable universe. To sum up this drastic shift in perspective since the Middle Ages, I can do no better than read you my favorite quote from The Hitchhikers Guide to the Galaxy by Douglas Adams: "Far out in the uncharted backwaters of the unfashionable end of the Western Spiral arm of the Galaxy lies a small unregarded yellow sun. Orbiting this at roughly ninety-two million miles is an utterly insignificant little blue-green planet whose ape-descended life forms are so amazingly primitive that they still think digital watches are a pretty neat idea."

Along with this growing grasp of the vastness of space has come an equally huge shift in our perspective on time. Back in 1654, Archbishop James Ussher, a leading Biblical scholar, famously calculated that God had created Adam and the Garden of Eden on October 23rd 4004 BC at 9 AM....conveniently in time for morning church services.

Today, thanks to advances in geology and cosmology, we now view the whole of humanity's existence as a mere blip in the 4.5-billion-year history of earth. Let's revisit the famous timeline of astronomer and TV celebrity Carl Sagan, which squeezes the entire history of the universe into a single year, beginning with the Big Bang on January 1st. In this drastically shrunken timeline, the Milky Way forms in March, Earth forms on September 1st, and the dinosaurs go extinct on December 26th. All human history since the invention of stone tools takes place in the final hour of New Year's Eve, while all recorded civilization lasts just 22 seconds during the final minute of December 31st.

That's enough to make anyone feel humble, but there's another way of looking at all this: While we're not nature's main feature attraction, we're fantastically lucky to be here at all. Let's take one obvious example: without the six-mile-wide asteroid that wiped out the dinosaurs 66 million years ago, it's unlikely that the tiny shrew-like mammals that existed back then would ever have had a chance to evolve into the huge diversity of primates that eventually gave rise to us. The chances of such a gigantic asteroid impact were incredibly unlikely—a similar collision is predicted to happen only once every 100 to 200 million years.

Taking an even bigger perspective, physicists have for decades been arguing about the so-called fine-tuning problem, which makes not only humanity's existence but also the entire universe seem wildly improbable. The problem is that the fundamental laws of physics and the initial conditions at the time of the Big Bang seem to have been exquisitely finely tuned for the existence of life. Roughly 30 different items—such as the masses of elementary particles and the strengths of fundamental forces—had to be "just so" to make the universe possible. To give just one example, if gravity had been stronger or weaker by just one part in ten to the minus 40–that's ten with 40 zeroes after it!—then life-sustaining stars like the sun could not exist. Is this just dumb luck, or is it because, as physicist Freeman Dyson put it, "it's as if the universe knew we were coming?" Steven Hawking wrote that, "The odds against a universe like ours emerging out of something like the Big Bang are enormous. I think there are clearly religious implications." Unfortunately, he didn't go on to say anything more beyond that vague statement.

It's equally improbable that our fragile species on an "utterly insignificant blue-green planet" should have been able to discover so much about the history of the universe and the hidden mathematical laws that underlie all of nature. As the physicist Paul Davies has written, "Somehow the universe has engineered not just its own awareness, but also its own comprehension. The evolving cosmos has spawned beings who were able not merely to watch the show, but to unravel the plot.... The more we discover about the intricacy and delicacy of the balance in the cosmos, the more reason we have found to be amazed that we are alive."

So, while the perspective of science is a humbling one, it can also instill in all of us a sense of wonder and gratitude, enriched by an understanding of the extraordinary luck that we're here at all.