

Astronomy, God and the Search for Elegance

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Do faith and science operate in completely separate, non-overlapping realms? In the first of a series of articles for *Thinking Faith*, Vatican Astronomer, Guy Consolmagno SJ, explores how science works, how scientists work, and the place that faith has in science – simply because scientists are people.

It's something of a cliché to say that science and religion each have their own realm of applicability – as Steven Jay Gould put it, their own “non-overlapping magisteria.” We've learned, the hard way, that you can't substitute one for the other. It is an abuse of the Bible to treat it like some twentieth-century science textbook, and vice versa. (I've written a science textbook; trust me, it's no Bible!)

Yet those who would put up a watertight barrier between science and religion miss a very important point. Science and religion do intersect without doubt in at least one point: in the human being who is the scientist, in the human being whose ultimate motivations and yearnings are, overtly or not, religious.

If you're a scientist, you might be someone like Buzz Aldrin; he was an elder of the Webster, Texas, Presbyterian Church, just up the road from the Johnson Space Center on NASA Road One, and he brought their communion bread and wine to the Moon. Or you could be a self-proclaimed agnostic like Carl Sagan, who nonetheless spent his life worrying about human goals and ultimate meanings, and who as a scientist worshipped at least at the altar of truth. But every human being who becomes a scientist has chosen to be a scientist for reasons of the heart, which has “reasons that reason does not know.”

You know, when you're a scientist there's no time clock to punch. If you show up late to the lab, odds are that no one will notice. If you stay working late at the lab, no one will notice. So what gets you up in the morning? What gets you into work, and keeps you at



the lab late at night? What motivates your efforts; what turns your crank?

That desire might be fame and glory, or riches and wealth (but if it is, boy have you made a mistake!) Maybe you've forgotten why you ever wanted to do this, and it's become just another job. Or maybe you're still in love with the dream. Wherever it is, that's where your God is.

And it affects the way we go about doing our science. We've all been taught about the scientific method: notice a problem, devise a hypothesis, test it with experiment. Sure. But how do you choose your problem? Where does that hypothesis come from? Fact is, you may be able to think up half a dozen hypotheses; how do you decide which one is worth spending the next couple of years of your life chasing down? And how do you convince anyone to pay for it?

But it goes even deeper. Those human urges influence not only what we decide to do, but how we go about doing it, and how we interpret what we see.

Take an example... Is there life on Mars? We know that Percival Lowell's arguments don't work (he thought he could discern evidence of 'non-natural features' such as canals on its surface) but that by itself doesn't rule out the possibility of some sort of life on that planet. Is there now, or has there ever been, card-carrying life on the Red Planet?

How do we go about looking for an answer to that question? One way is to go to Mars. We have spectacular images of the surface, of a place that at

least fairly recently was active enough to make giant volcanoes; one is the size of Great Britain. And looking more closely, we can even see places where some fluid has been flowing out of the side of a cliff and down a slope. Is it water? Is it carbon dioxide? They're still arguing about that one. But in any event, it's got air, heat, fluids; nothing lacking that we need for life.

But we haven't gotten close enough to see for sure if it is there.

There's another way to attack the problem. Thanks to the space probes we know the composition of the Martian atmosphere, and it's a weird one; odd isotopes, unusual abundances of some gases. But it turns out, there is a rare class of meteorite that has trapped inside it exactly those gases, those isotopes. And for a lot of other reasons involving their ages and chemistry, we're confident that these were rocks blasted off the surface of Mars, that traveled around in space for another fifteen million years or so, and wound up finally falling onto the surface of the Earth.

One meteorite was found in 1984 in an area of Antarctica known as the Allen Hills. Inside this particular rock they found something that looks like a fossil bug. Associated with it, they found organic chemicals, called polycyclic-aromatic hydrocarbons; sulphur in sulphide grains of a type like those commonly associated with bacteria on Earth; and tiny magnetite grains of a shape and purity that indicate they too were formed inside bacteria.

Indeed, these magnetite grains are like little magnetic compasses inside Earth bacteria; these compasses help them figure out which way to swim to get at food. But Mars has no magnetic field today; why would Martian bugs need compasses? Further work, however, says that the surface of Mars does contain evidence of a magnetic field in its past... consistent with the thought that maybe these magnetite crystals really could be compasses for Martian bacteria.

Four different lines of evidence, all surprising, all of which can be explained by one simple hypothesis: life on ancient Mars.

Yet other scientists look at the same images, the same evidence, and they see a completely different story.

The worm-like things also look like what happens when rock gets weathered by water and carbon dioxide. There are plenty of other places where the rock may have picked up the polycyclic-aromatic hydrocarbons — including on the surface of Antarctica, where this rock had been sitting for a few thousand years before it was picked up. There are lots of natural ways to make sulphate compounds and magnetite compounds; and are the ones seen in these rock really, exactly, the kind that are made by bacteria or do they have a subtly different crystallographic shape? The arguments are continuing, and won't end soon.

We are taught that, given many different ways to explain a set of data, the simplest explanation is to be preferred. So which is simpler — hypothesizing one mechanism, ancient life forms, that will explain everything? Or is it “simpler” to take four different processes, all of them we know already to happen, to explain these four different lines of evidence? Which is the more elegant explanation?

There's no consensus.

The year after this work was first published in 1996, a friend of mine, Tim Swindle, went around and asked his fellow scientists what they thought of it. Half of them said it was nonsense — one chance in ten that it really showed life. The other half said it was interesting, worth a second look, tantalizing, intriguing... there was a good chance that it might actually be something. Maybe as much as one chance in ten.

Both sides looked at the same data. And in fact, both gave the same odds, they drew the same conclusions. But then they went in completely different directions. How did that happen?

Science is done by scientists. Scientists are people. People make choices... choices about what to do with their lives, what careers to follow, what questions to ask, what experiments to perform, what theoretical models to construct. The philosophers of science tell us that every piece of scientific data is “theory-laden”; they mean that, every time you do an experiment, you already have in the back of your mind an idea of what you're likely to see; how else do you know it when you've seen it? And that colours the way you take your

data, and how you interpret your results.

Think of a pendulum, a weight on a swing, moving slowly back and forth. If you're Aristotle, you see that eventually it comes to rest, hanging straight up and down, and you conclude that all things in nature seek a natural resting place. If you're Galileo, you notice that the period of the pendulum stays constant, even as it swings less and less. If you're Newton, you see that there are outside forces, friction in the string or in the air, that slow down the pendulum; without those external forces, there'd be nothing to stop the pendulum from swinging forever. Same pendulum: three completely different interpretations.

Does that mean that science is not objectively true? Well... yes, to some degree. Does it mean that science is invalid? Absolutely not. For one thing, it works — if not perfectly, then good enough. You can use Newton's laws to design a clock, regulated by Galileo's pendulum, while Aristotle's common sense reminds you that you'll have to wind it on occasion. And even now that we know Aristotle, Galileo, and Newton have all been superseded by relativity and quantum physics, the clock still keeps good time. And Aristotle, Galileo, Newton all did something that a perfectly accurate, perfectly objective video tape of the pendulum could never do: they were able to pull out, abstract, the pendulum from all the things around it; and once they could think of a pendulum in the abstract, they tried to make sense out of what they could see.

There's a wonderful story about Einstein that served as the title for Abraham Pais's biography of him. It seems that Einstein was lecturing in Germany in the 1920's when word came of an experiment in Cambridge that appeared to disprove his General Theory of Relativity. What do you think of that, Mr. Einstein?

Einstein shrugged. "The experimenters made a mistake, that's all."

Well, we all know how we've been taught, you make a hypothesis, you test it with experiment? So here was the experiment, and the hypothesis failed the test. How could Einstein be so sure it was the experimenters, and not the theory. His answer was a classic. He knew how well his theory fitted together; he knew

that it was airtight, and more, he knew that it was elegant; so beautiful; such a theory couldn't be false. "God is subtle," he said, "but He is not malicious."

Like the people arguing over life in the Mars rock, in many cases the argument comes down to an aesthetic one: which is the most elegant theory? Which one matches the subtlety of the Creator? And that depends on what your idea of elegant is; what your idea of the Creator is. It takes time, experience and training to learn what elegance looks like. If you can't tell the difference between an elegant theory and a theory that's the science equivalent of Elvis on Black Velvet, you're not going to go very far. It's that sense of elegance that is your compass when you decide which hits to follow, which flashes of intuition are likely to lead to the mother lode, and which ones are best left untouched. Ultimately, the successful scientist is the one with the best scientific taste.

Robert Millikan added to modern physics a bit of insight that in many ways has the most important lesson of all for our philosophies. Classical physics, from Newton onwards, used mathematics as its metaphor for the workings of the world. A falling rock, an orbiting Moon, a frictionless pendulum all behave like the solutions to a very simple equation. The equations Newton used came from his Calculus, they were easy to handle (relatively speaking), they were single-valued, they could be integrated or differentiated, they were continuous.

And so the metaphor of Newton's mathematics suggested that the universe itself was smooth, simple, and continuous. Everything was fields and forces.

Millikan proved that, on the scale of an atom, it wasn't so. By balancing oil drops in an electric field, he showed that charge — electrons — existed as individuals. Always the same amount. Exactly. Very minute, yes; but at that minute scale, the universe is grainy, not smooth.

I hear in that an echo of what in theology has been called the "scandal of particularity"; it is all well and good to speak of trends and conditions, and make general statements of good and evil. But ultimately we live lives of immediacy, this moment, this position, this situation; and as individuals we finally meet our

maker, the Christ who chose a particular time and place and manner to enter into creation, intending not to save humanity, but to save you and me and each of us individuals, one by one. I see the same familiar workman's hand at work, creating individual electrons and individual souls.

That's one of the joys I get from doing science as a Jesuit; by playing with the Universe I play with God, and thus I get to know God, I get to see his quirks and his personality, His way of doing things; his special brand of subtlety, that is His sense of humour. That's my aesthetic; that is what has trained my sense of the elegant.

But just as every scientist must bring their personal aesthetic, personal philosophy, personal religion to bear on how they choose what they will study and how they judge one experiment or another to be in better taste, and thus their religion shapes their science; so likewise, every religious believer must believe their faith in the context of the particular universe their God has created. That particular God, incarnate in a particular time and place, demands that we encounter him in this particular time and place. If we close our eyes to the people and the culture and the knowledge of the universe around us, we are closing our eyes to God.

The universe whose creation was described in Genesis was the universe of the Babylonians; it was the best science of its day, three thousand years ago. And it said that bigger than the dome of the sky and the mountains holding up that dome and the waters above and below that dome, bigger than it all and before it all was the Creator who was there before the beginning, caused it to be, and saw that it was Good.

That's a pretty big God.

But if today we can see across vast distances of space to the birth and death of stars, how much bigger must we recognize that God is!

And it is not only in seeing further; it is also seeing deeper, being able to take the light that God made by fiat, and pouring it through a prism to sort it out, colour by colour, and come to a deeper understanding of what it is all made from — here, the star radiating in all colours, surrounded by the gas ring shining in the

red of hydrogen and the green of oxygen. Not only is the Universe good, and beautiful; so are the laws that control it and explain it. And most beautiful of all is that we have been given, undeserved, the ability to understand those laws, to share in God's glory and get God's jokes.

Like Einstein said, the most incomprehensible part about the universe is that it can be comprehended.

I conclude with this reminder: that beauty controls both our spiritual and our intellectual lives. But the beauty derives, in part, from our own humble understanding of ourselves in relation to that Sun and those mountains and clouds. We are not masters of all we survey, in full and complete knowledge of how it all works. We know our scientific theories are always incomplete. We know our religious understanding of God is also always incomplete.

But God gives us any number of roadmaps to help us find the way. One is the ability to know what it is we don't know; to realize that we always have more to be learned. That is the key and the essence of true science. Another is the confidence that, with God's gifts and God's help, we actually can learn. And another, most surprising aid we get, the compass that directs our intuition, is this yearning for truth, for beauty, for elegance, that directs our souls and needs to be nourished in every aspect of our human lives.

The equations that describe the colours of a sunrise are remarkable for being, in their own way, every bit as beautiful as the sunrise themselves. God wants to share the sunrise with us; that's why He gave us eyes.

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