

It's Elementary?: An Advent Journey into the Atom
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UCV

For seven years now, on the first Sunday of the Advent season we've been responding to the challenges identified by Thomas Berry and Chet Raymo. Raymo speaks of the failure to bring scientific discovery into our spiritual and ritual life; the outcome he fears is a dwindling sense of the sacred. For Thomas Berry, it's about the stories we tell of how the world came to be, the evolution of the cosmos, life upon this earth, and of our crucial role as stewards of that knowledge.

If we walk away from the challenge of telling a new story informed by science and spirituality, we surrender the field to traditional religious and purely market approaches which, in spite of their differences, share the egotistical view that the world is a storehouse of riches for us to plunder with little consequence.

The stories we tell matter. The quality of attention we pay to this life, to the truth about this world, has outcomes, for good or ill.

So, on the first Sunday of Advent, since 2002, we've looked at one awe inspiring explanation of the advent of life after another. In 2002, it was the austere beauty of evolution, our origins, and the development of life from a simple common ancestor; as well as the teeming diversity and interconnection of all living things. Next (2003), we celebrated the "birth" of the moon and how its orbit around the earth steadies us in our cosmic flight and thus makes conditions for life down here possible. We looked next (2004) at how organic life may have arisen from the toxic, chaotic waters, and awesome tides of the earth's oceans some 4 billion years ago.

On Advent Sunday 2005, we journeyed along the earth's tectonic plates and how their restless movement regenerates and makes new our planet through processes of convection, drift and subduction. In 2006, we journeyed through the stars to reckon the size of the universe; flew on migratory wings with shorebirds, and considered the miracle of it all! Finally, last year (2007), we journeyed into the cell, the smallest unit of living matter, and with wonder and appreciation, marveled at their speed, function, and complexity.

Last year we journeyed into the smallest *living* thing. This year I want to invite you to join with me and dive deeply down into...

Atomnaut: *Here I am, ready for take off!*

SE: Excuse me, I'm trying to give a sermon here...

Atomnaut: *Precisely, and I am your woman.*

SE: For what?

A: *The journey into the atom and the realm of the subatomic. I am an atomnaut, she who travels not to the stars, but deep into matter itself.*

SE: Well, that's what I am going to talk about.

A: *Words, words. What you need is an explorer, an eye witness about the very nature of matter. What are we made of? What is the world made of? Think about it! The sweet air we breathe, the cool water we drink, the thoughts whizzing in our heads, the pews you're sitting on, the stars and yonder galaxies! Is there one thing that ties everything together?*

Democritus: *I knew the answer to that question 2500 years ago!*

SE: Oh my! And who are you? (This is getting quite out of hand.)

D: *My name is Democritus. I lived in ancient Greece. The answer is "atoms": they are solid, hard and compact; so small and hard that they cannot be cut up into anything smaller. Atoms swirl in empty space; they collide and attach and arrange themselves into different compounds. And thus they form all things, consciousness itself. But only a few believed me.*

SE: (to Atomnaut: you might as well sit down for a minute) And why didn't anyone believe you Democritus?

Aristotle: Because *that* madman is from Thrace! A barbarian land and people. *Atoms?* What nonsense! Have you ever seen an atom? Mere speculation.

SE: Excuse me! This is a worship service. I was trying to give a sermon. And now this! *Who are you?*

AR: *I am Aristotle, teacher of Alexander the Great. There are four basic elements: earth, air, fire and water. These we can see, test and observe. And my theory of the elementary forms of existence held sway throughout the civilized world for 2200 years.*

John Dalton: *Yes, until I came along, and in 1808 I began to show that Democritus was almost right and Aristotle wrong. My name is John Dalton. I was a Quaker, and son of a poor weaver in England. I took the work of Boyle, Bernoulli, Newton, Lavoisier, and others—their experiments proved that Aristotle's four basic substances—earth, air, fire and water—were not the indivisible elements he thought they were.*

SE: And what was your contribution to this story?

JD: The root of all matter is exceedingly tiny particles and their connections. There are lots of elements—like carbon, sulfur, hydrogen and they can't be broken down into simpler things by chemical means. But what makes them different? Each element has different atoms; but within each discrete element all the atoms are alike, sharing the same weight; and atoms of different elements have different weights. I started with hydrogen; it's the lightest element, and assigned it an atomic weight of one; and went on from there. The "principle was sound and formed the basis for all modern chemistry and much the rest of modern science." (Bryson, 137) I also believed they could neither be created nor destroyed; and they're incredibly compact and hard like billiard balls (or so I thought).

Ernest Rutherford. Ernest Rutherford, born on a sheep farm in New Zealand; later of Cavendish Laboratory, Cambridge. (addresses SE): May I?

SE: (giving up) by all means.

ER: *Not at all like billiard balls; nor pudding, nor crumpets with raisins.*

SE: I'm sorry what are you talking about?

ER: *The landscape of the atom my dear man, its particles and internal structure! Do you realize that in 1900, fewer than half of all scientists believed in atoms? Well! They changed their minds and in a hurry.*

SE: How did that happen?

ER: *In 1905, Einstein had proved their existence theoretically; by this point, I, and others, knew that atoms were made up of particles, but we needed experimental proof; something tested in a lab that would be incontrovertible. And that's what we accomplished at Cambridge in 1910.*

SE: How did you do that?

ER: *We fired alpha particles at a sheet of gold foil; some flew clear through, but to our astonishment, others bounced back. I'll tell you, it was as if I'd shot a 15 inch artillery shell at a piece of paper and it rebounded back into my lap! That was it! We knew then two things: an atom is made up mostly of empty space, with a very dense nucleus at the center.*

Atomnaut: That's my cue!

SE: your cue for...?

A: *The journey into the atom! Rutherford located it; it is time now for me to explore and report. Assistants please! (They bring out the "curtain") Behind this subatomic reducing curtain, a strange world awaits! I will now shrink down to subatomic size. The journey begins! Piano please! (roll from the piano. Atomnaut steps behind the curtain ... from behind the curtain) Fantastic! Amazing! Unbelievable! Not at all what I thought: like a tiny spoonful of cloud. And such numbers! So small! So old! And practically indestructible! (Re-emerges) The miracles I have seen are explainable; "it is the explanations that are miraculous." Here is my report. It's been quite a trip. Farewell! (exit)*

So what have we learned? 14.5 billion years ago, our universe leapt into being from a singular blinding flash; a "genesis moment" that heralded the beginning of all things, obscured in a cloud of mystery that we are still groping to understand. Fine. I can live and revel in this mystery. For over 2500 years, using our minds, with the combination of intuitive imagination, experiment, observation, mathematical calculation, and increasing technical sophistication, we have arrived at a Standard Model of the very constitutive elements, a picture, an understanding of atoms that are the foundations of matter. Here's just a sketch of what we have learned:

First of all: that great Canadian cosmologist, Joni Mitchell, was right. "We *are stardust*, we are golden; we are billion year old carbon." We are made of material created and ejected into the cosmos by the violence of early stars and the tremendous journeys through interstellar space of those particles of stardust that have now come together to incarnate us and all matter. "The two simplest atoms: hydrogen and helium emerged in the first few minutes of the Big Bang, and are the parents, in a mythic sense of all other atoms"; parents, because the others are all formed through fantastic processes of compression, fusion, and explosion of these two, producing all atoms in their various configurations. We and our planet are inextricably linked to the stars, from them we are made. "Fifty times a second, a supernova occurs in some galaxy in the visible universe, spewing out into space enormous quantities of heavy elements that travel millions of light years before falling into the gravitational fields of some newly forming solar system like our own; elements made up of atoms, that join together to create, in that solar system, a planet that billions of years later will pulse with life." "Our bodies literally hold the entire history of the universe, witnessed and enacted by our atoms." (see Primack and Abrams, *The View from the Center of the Universe...*, 94-99)

Atoms are mind benderingly *durable*; practically indestructible, and they get around, and not only from distant supernovas. "Every atom you possess has almost certainly passed through several stars and been parts of

millions of organisms on its way to becoming you." It has been estimated that a billion atoms in each of us once belonged to Shakespeare. A billion more from Buddha, *and* Genghis Khan *and* Beethoven, and any historical figure you can name. We are atomically numerous and vigorously recycled at death. So in some sense we are all re-incarnations of all animate and inanimate things that went before us. Atoms go on practically forever. It is we who are short lived; and don't we know it! (sse Bill Bryson, *A short History of Nearly Everything*, 133-47. hereafter *BB*)

Atoms are also very, very *abundant*. A molecule is simply two or more atoms working together in an arrangement: combine two atoms of hydrogen to one of oxygen and you have a molecule of water. This was John Dalton's singular contribution to our story. Now imagine, picture this: At sea level, at a temperature of 0° centigrade, one cubic centimeter of air (about the size of a sugar cube) contains about 45 billion, billion molecules. And they are in every single cubic centimeter around you. Picture how many cubic centimeters there are in the world outside your window—how many sugar cube size bites it would take to build a universe. Atoms, in short, are very numerous indeed.

And they are small, unimaginably small, curiously composed and behaved.

If you lined a half a million of them up shoulder to shoulder, they could still hide behind the width of a human hair; each of them one ten millioneth of a millimeter in diameter. From outside, they would look like a spoonful of cloud; or a very fuzzy tennis ball. That's the outer shell of the atom's *electron* domain. Electrons hold a negative electrical charge, and so fleet are electrons as they move in space, that what we see is a mere, but real blur; a zone of statistical probability marking the area beyond which the electron only very seldom strays—so fast moving that they are at once "everywhere and nowhere;" jumping in and in out view, in and out of observable existence, in quantum leaps between now one, now another, "shell" that encircles the hidden nucleus within like a ring of concentric circles.

If we could pass through this electron cloud, and enter into the interior realm of the atom, another astonishing fact presents itself: a fantastic amount of "empty" space. In the centre of the atom we have the nucleus, composed of two elementary particles: *protons*, which have positive electrical charge and *neutrons* that have no charge. That composite nucleus is tiny—it makes up only one millioneth of a billioneth of the full volume of the atom. I know these numbers are wild; but again, try to imagine; try to picture this: if we were to magnify, to blow up the size of one atom to the size of our planet; and then place the nucleus at the center of it all, the nucleus would be only as big as the size of a classroom globe of the earth, while the closest electron shell, hovering, wizzing, circling aloft out there would be as distant as the earth's atmosphere; with everything in between—EMPTY SPACE. Atoms are mostly empty space. Everything that know, experience, observe, and think, every backdrop and foreground of our lives, consists of these discrete, hollow particles.

The solidity we experience all around us is real, but kind of spooky. For example, when two billiard balls collide, they don't actually strike each other. Rather, "the negatively charged fields" of their amassed electron clouds, repel each other. When you sit on those pews, you're actually levitating above it at the height of a hundred millioneth of a centimeter. The electrons of your backside, and the electrons comprising the elements of the pew are repelling each other; they are implacably opposed to any closer intimacy. (*BB*, 141)

Finally, and if we look closer into the structure of the atom as we know it, since the mid 1930s scientists have been breaking down, smashing up, and analyzing the constituent particles of which electrons, protons and neutrons, the forces that hold them together and other cosmic particle are made. The result of these efforts has yielded what they call the *Standard Model*, which is essentially a sort of parts kit for the subatomic world. "The arrangement essentially is that among the basic building blocks of matter are quarks; these are held together by particles called gluons; and together quarks and gluons form protons and

neutrons, the stuff of the atom's nucleus. Leptons are the source of electrons and neutrinos. Quarks and leptons together are called fermions. Bosons are particles that produce and carry forces, and include photons and gluons." (BB 166)

Vera Rubin: *Steven, aren't you forgetting something?*

SE: Vera?

VR: *Yes, Vera Rubin.*

SE: But Vera, I am running out of time.

VR: *Steven.*

SE: Higgs Bosons? Superstrings? The Large Hadron Collider in Europe?

VR: *You know what I'm talking about.*

SE: Dark matter? Dark energy?

VR: *That's right.*

SE: But I don't have time; and this has been about atoms.

VR: *Say something, then. Just a hint.*

In 1974, Vera Rubin discovered that there was something out there pulling galaxies toward their centres at rates that couldn't and cannot be explained by the amount of visible matter in the cosmos. Scientists have called it "dark matter" and are racing to figure it out and describe it. And then in 1997, Saul Perlmutter, opened another can of worms; stars and galaxies, he discovered, are not only moving away from each other in the way we thought they should, they're accelerating away from each other in ways that defy everything we thought we knew. Something, some anti-gravity energy that we didn't know about is pushing the stars to the remotest reaches of the universe. It's been called "dark energy." A mysterious, but real cosmic force we're only now beginning to encounter and explain.

It turns out that all these atoms I've been talking about, ordinary matter, makes up only 4% of the universe; with the rest being 21% dark matter and 75% dark energy. That's a lot of stuff that no one yet really understands.

Our knowledge is a finite island in a sea of inexhaustible mystery. Now...mystery can confound us, wrap us up in blankets of obfuscation and magic; it can also convoke us to attentive, inquisitive wonder, the kind that beckons both scientist and mystic to expand the shoreline of what we can explore. "We are at our human best," Chet Raymo asserts, "as creatures of the shore with one foot on the hard ground of fact and one foot in the sea of mystery...Art, science [and religion] flourish at the boundary of the known and unknown."

Of matter and atoms, of dark energy and matter, that all this happened and how it happened, that's part and parcel of the great and capacious cosmos of which we are a part—we move step by glorious step towards an increasingly clear picture with profound pleasure and awe. *Why* it happened and to *what* end; what is the *purpose* of it all? Well that's up to us to discover, explore, define and embody, one day at a time, one thought and compassionate and just act at a time.

May we move toward this holiday season with wonder for what is and where we've come from; and may we resolve that we will embrace this season with praise for that shoreline where we stand with one foot on the hard ground of fact and the other in the sea of mystery.