LOOKING FAR

Let us begin, then, at once, with that merest of words, "Infinity." … It stands for the possible attempt at an impossible conception.

Edgar Allan Poe (1848)

The universe according to Newton is finite, although it may possess an infinitely great total mass.

Albert Einstein (1917)

The nightmare of infinity still arises in regard to time. The world is closed in its space dimensions like a sphere, but it is open at both ends in the time dimension.

Arthur Eddington (1928)

What is the universe? Is it infinite, or finite?

Lee Smolin (1997)

The number of grains of sand on all the Earth's beaches is only about 10^{20}.

Sean Carroll (2010)

It's been a slow start but that's good, she says to me this morning. She wants Frank to get the basics. Now she wants me to introduce him to the universe. Big picture first, she says.

She's keeping up the pretense that he's studying this stuff. She must know he's learning nothing at the library. If he's there at all, that is. For all she knows he spends his days at Venice Beach. She wants me writing even when he isn't reading. My hidden premise is the project's changing. It's not for him anymore; it's for the book.

The big picture, she says. Well, as Adams tells the world in *The Hitchhiker's Guide*: 'Space is big. Really big. You just won't believe how vastly hugely mindbogglingly big it is.' But is it *infinitely* big? He needs to know. Why? Well, because if it is infinitely big today then it was infinitely big 13.75 billion years ago. And if that is so, then what he's looking for was never small. Its beginning must be big. Indeed, infinite. Infinity's a word that doesn't have a lot to do with people's daily lives. (Physicists aren't widely seen as people.) But it's a word that one must deal with when one's looking for the way the universe begins. So here I am, like Buffy Summers, going through the motions. Is this really me? Or should I say, although it doesn't sound right: Is it I?

For many years philosophers and physicists assume the universe is infinite.

Most see no need to understand it. As Conway says, 'Becoming sufficiently familiar with something is a substitute for understanding it.' If they were right, about its being infinite that is, we have a problem that we cannot solve. But perhaps the most astounding idea about the universe is that it may be finite. Two hundred years ago a guy called Olbert says that if the universe were infinite the night sky would be white. Why? Because it would have infinitely many stars. Everywhere one looked there'd be one. Soon opinion starts to tilt toward the finite. Stargazers ask themselves: Is there an end out there? But it turns out that's a different question. The universe can be finite yet have no end. How can this be? It`s easier to see this in 2-D: The surface of the Earth is big but we know that it's finite—about 200 million square miles. Some 12,000 miles away's the farthest destination but one doesn't need to *stop* there. One never finds an end because it curves back on itself. Just so, some say the universe may have no end.

When Frank arrives I'll put the question of the day to him: How big is it? He will likely be surprised that there could be an answer. I bet he too assumes it's infinite but never thought too much about what *that* means. If so, to help him get a taste of it I'll hand him Poe. As Poe asserts, infinity must boggle the imagination. The largest number anyone can think of is no nearer to infinity than zero is.

He's already seen how Einstein deals with this. He thinks first of a universe whose boundary in space is at infinity. He doesn't worry whether he is able to imagine it. He figures out that every part of such a universe would have to be quite different from what we see. So he puts his money on a universe that's finite. He says it has no spatial edge. Frank may say this sounds confusing but it's what he needs.

Finity is not a word. Perhaps it should be. Finiteness is, but it's not tough enough. Finitude is the *condition* of being finite, a noun that dangles from its adjective; it sounds tame and not up to the task at hand. The notion that the universe is finite from the first is central to a search for the Beginning. He and I will need a red-meat word for it. How's finity? It's not opposite infinity. Infinity's the opposite of it. And like infinity, it isn't the condition; it's the thing itself. So if we go with Einstein the domain of space is finity. And too it's the domain of atoms in the universe. Their number could be written on a single sheet of paper. If we knew the number. But we know it's big.

Finity can mean big numbers. I figure he will need a better way to write them down: It's 'scientific notation.' It avoids long boring strings of zeros; saves paper too. For 500 he can write 5×10^2. And 0.005 is 5×10^{-3}. Of course these numbers don't save paper, but we could trim the US budget: $\$3.7\times10^{12}$ instead of $\$3,700,000,000,000.00$. It makes big math look simpler: Divide $\$3.7\times10^{12}$ by 1.37×10^{10} to find that $\$2.7\times10^2$ gets spent for each year since the universe began.

$270.00. Less than six bits a day. If anybody needs to know.

My favorite is the googol: it's 10^{100}. What's so hot about it? Well, it gives the world my favorite verb: to google. Those guys can't spell but serious ambition they do show. The reason why I aim to bend his ear with this is he'll soon handle numbers that are up there with the googols and beyond.

Given not much choice I figure he is bound to follow Einstein; he'll go for finity. The bad news is there's no way to be sure that the Beginning can be found in finity until he finds it. The good news is that finity is something he can faintly hope to find.

Where is it? Well, those stargazers had the right idea. It's out there. It's anywhere one cares to look. Except where one's line of sight bumps into real estate. The Earth itself cuts off half of the view. But as the eye moves past the Moon and Sun the odds are good its gaze aims at empty space. Of course the real estate is also finity. Just not the finity he's setting out to find.

He's looking for the whole shebang. He'll want to think of a big boundary, a sphere, say, round it all. But his finity—and Einstein's—doesn't work that way. Here's the deal, I'll tell him. Think of a sphere in space. Blow it up like a balloon until exactly half the universe is caught inside. Freeze frame. Consider what will happen if you blow it up to twice that size: Will it hold the entire universe? Well, no: It will hold none of it.

Here's why: Freeze-frame still frozen, he should leave me inside and step out. Now he's in the other half of the universe, the half that is outside the sphere. Looking round, he'll see that he's *inside* a sphere containing his half of the universe. As I expand my sphere, he'll see his getting smaller. As mine reaches twice its halfway size his shrinks to zero so it disappears. That's what he sees; so do I. In Einstein's universe a sphere can't really have an inside and an outside; it only has two sides.