

THE END

Thou by thy dyals shady progress maist know,
Times thievish progresse to eternitie.

William Shakespeare (1609)

This is the way the world ends
Not with a bang but a whimper.

Thomas Eliot (1925)

Their characters lived in a world in which, long before the atom bomb,
civilization had created the machinery for its own destruction.

Raymond Chandler (1950)

In such perfection, all things move toward death.

Frank Herbert (1965)

And so ended my voyage of discovery.

Alan Pakula (1982)

“Meaning?” Vic looked at Marty. ... “We’re fresh out of meaning. All
we got left is chaos and random disorder.”

James Hall (2003)

To this day, scientists haven’t yet determined to anyone’s
satisfaction whether the universe will continue to evolve forever, or
whether it will eventually settle into a placid state of equilibrium.

Sean Carroll (2010)

All good things (come to an end), Nelly Furtado sings. Even the universe? I’m hoping to discover this. But certainly this job—I’m uncertain even now if it’s a good thing—will come to an end and it will happen soon. If she were here, what would she say? If I told her all about it, that is. Would it blow her mind as it blows mine? Would she even care? Would she ask questions? Likely she would zero in on the black holes: You say there *are* no zeroes? Can you run that by me, please? Polite. And always checking.

At least, that’s what I hear in my mind’s ear. In my mind’s eye she is already dimming. In fact I cannot seem to picture her at all, as if she’s gone, not merely to Genève, just gone. Of Frank my picture’s clear enough, although of course I never see him. He I now can’t hear. Not even with my mind’s well-practiced ear. Did I say he? That should be him whom I can’t hear.

It stuns me, the simplicity of his creation. He doesn’t start with 10-D space

and curl up six dimensions as is done in search of strings. He starts with no space and a single 6-D Manifold with volume and he has all else unfold. It's not easy to explain how big this difference is. It's big because his universe *has* a Beginning. Big because as it unfolds all else makes sense. He does this with a handful of parameters. Not only *not* a Problem, not just less than 32, it's beautiful! And that must rate an optimistic check. Too bad he isn't here to see his score.

Looking back at Problems he has tackled since we did the dog and pony show I see a dozen checks and now he adds Parameters. Grand total 45 of 47! The two loose ends? Superposition and the Missing Monopoles. Whatever. He can answer four of Smolin's five great questions. It's a coup. No other answer can come close. Indeed there *is* no other answer. Will there ever be? The test laid down by Ockham says a better answer explains more or assumes less. Who'll take up the challenge? Not for years has anyone possessed his foolish courage. I wish he could come back at least to take a bow. Of course he can't. I've come to realize his ceasing to exist may be a price he has to pay for going where he went. This leaves me feeling guilt. In some ways he's the author; I just couldn't let him take control. And it wouldn't do for him to stick around to work the claim. Everyone would say he's crazy; they still may. Or maybe they will say I'm crazy in his stead.

So why do I still plug away? It's oddly apt to once more ask myself that question as I try to think what his Beginning has to say about the end. *Will* it end? And, if so, when? And why, I wonder, do I wonder? Why think what will happen to the universe a trillion years from now? Can mankind ever really know? And anyway, who cares? Well, many are—like Asimov—inspired by the concept that the universe began—as he once said—exactly fifteen point two billion years ago. Some such number. Since then guessing has improved. Today a good guess would be 13,714,057,109 years. Give or take say forty million. The thing is: We know that there *is* a number. Thanks to recent data we can guess it like we can how many beans are in a bottle. But our curiosity's not sated by a better number. Few heed signs that say THE END IS NIGH but many wonder what's in store not just for us but for the cosmos. Motives much like Asimov's—I am curious, I can—turn my thoughts forward. Can I see the end?

Well, as Smolin says, in one way one might say the end *is* nigh, though only in a cosmo-geographic sense:

According to general relativity every bit of the collapsed star and every particle that falls afterwards into the black hole will end up at a last moment of time, at which the density of matter and strength of the gravitational field become infinite.

In other words the boundary of each black hole demarks an end of time. GR says time ends close by—astronomically speaking—at the center of our galaxy. This somehow seems to bring the concept of time ending close to home. Most

significantly, time, according to GR, does have an end. Or rather, many of them. And, in its version of reality, the cosmos may be heading for one now. Or, if this universe is crunchless, may continue without end.

But Smolin isn't stating *his* view; he is telling GR's tale. GR says black holes are pointy. I now know that they are not. This gives black-hole math a new gestation. Let me guess: True calculation could show that a clock that falls into a black hole would take time but not forever to hit bottom. Clock arrives, Krrrunch, tops up the black-hole mass-gas-tank. Over time the mass of the disintegrated clock will make more space. My travel clock's about four ounces. Converting it to space creates a whole new arbitrary constant: 2.5 quadrillion cubic miles per clock. But Frank says GR's black-hole ends of time will need new quantum calculations.

And what about the still-expanding and accelerating universe? Does his tale foretell its end? Well, it surely says its movie has no noisy ending. None of the scripts that could be written as the universe's biggest mass falls from the universe's highest height in a Big Crunch will make it to the biggest of the big screens. Reason is: Flecks have fixed volume and do not decay; space can curve but can't contract.

Next I can project: In time black holes eat everything but space. As Carroll says, the black hole at the center of the Milky Way 'might be a few million times as massive as the Sun—big compared to any individual star, but still small compared to the galaxy. But it will continue to grow, sweeping up whatever unfortunate stars happen to fall into it.'

Given time, still spewing space, it must run out of solar snacks. Its lifestyle's unsustainable. Maybe by going cannibal it can postpone the evil day. But that day comes and slowly, oh so slowly, it must disappear. Carroll says, 'If we wait long enough—and now we're talking 10^{100} years or so—even the supermassive black holes at the centers of galaxies will evaporate.' Carroll is relying here on Hawking and his frigid radiation to get rid of them. Space-manufacture will evaporate them faster than cold photons can. Some 10^{88} times faster. Until they're small; and then their hotter photon fizzle affords Hawking—who has earned it—the last word.

Since the matter mass is finite, space-creation must eventually end. Space is so big, so inconceivably vast, that this may be what Dickinson means when she says,

Soul admitted to itself -- Finite infinity.

And yet there comes a Move when the last Fleck is manufactured. The universe then does what Einstein found—to his dismay—his version of it wouldn't: It stays static.

The final irony is this: In the end Einstein's fudge factor, the one that he invents to stabilize his universe, then terms his greatest blunder, and then does his utmost to abolish, *it's* the only thing that's left. One might say that the universe turns into fudge.

As expansion slows towards this end, the disappearing universe stops disappearing and then slowly—but eventually at the speed of light—comes into view again, if view has any meaning when there are no viewers left and all there is to see is black holes that cannot be seen. As it heaves back in view in my imagination it's as if it never left. I feel that I have always been a part of all of it. And all of it's a part of me. I think of him. Is this his parting benediction?

It's creating space that starts the Cosmic Clock. Does ending space-creation bring an end to time? Does the CC itself run out of gas when there is no more matter to make space? I think of it this way: I set up two new counters in Times Square. One tracks the volume of the universe in Flecks. How many digits will it need? I wouldn't want to make the same mistake as Durst who never dreamed the US national debt would pass \$10,000,000,000,000. How about four hundred? Lots of left-hand digits don't light up. I can read maybe sixteen digits; many right-hand digits change so fast they can't be seen. But far into the future if it somehow keeps on working even the right-hand-most digit of *my* Times-Square counter stops. (For Durst's I venture no forecast.) My other counter follows time in Tocks; it's a much smaller number. As of now it needs 61 digits but with Durst in mind I make an even hundred of which forty-two are just a blur. The question is: When my Fleck counter stops, what happens to the Tocks? Does their counter also stop? Does that last Fleck mark the End of Time? I wonder: What would that mean?

Would it mean the Cosmic Clock's a kind of wind-up gadget driven by the entropy of the Beginning, one that's wound up once and can't be wound again? Sounds like a question to ask Dr. Who; it seems the sort of thing a Time Lord ought to know. But the idea of a universe that's stopped seems to me as unthinkable as one that's not begun. Yet it seems inescapable that if the Cosmic Clock itself is powered by the entropy machine it must tick a last Tock. The UC dealer will have dealt the last card in Tumulka's foliation. Thus, in this scenario, there *is* a day without tomorrow—a moment we might call the end of time although it wouldn't be a moment. It would return the universe to doing nothing.

The question is arcane, except for one thing: It is tied up with the workings of the Cosmic Clock. Someday physics might provide an answer. The boundary that he calls the Beginning might lead to another. In the end—no pun—here's my two-bits' worth: I don't buy this story. It seems to me the Cosmic Clock is more than just a fancy clockwork. What it does it does because of what it is. It seems to me this should be in the Rules.

Does the UC keep computing? Could space go on forever with ‘forever’ having no ongoing meaning? Should the sign say FOR SALE EMPTY UNIVERSE? Since nothing else can happen to it I suppose it will. Holmes says, ‘Eliminate all other factors, and the one which remains must be the truth.’ Does this—will this—have a meaning? Well, the answer to this is, it seems to me: This is the question of the falling tree.

To this speculation it might be objected that the rate at which Flecks get created may be—likely is—what physicists call asymptotic. This means that the rate gets slower at an ever-slower rate so that it never gets to zero, just like Zeno’s paradox. If so it might seem that the universe will never end. But this asymptotic argument works only in a space that is continuous. Thus there *will* be a last Fleck much sooner than the googol years that Goldsmith says black holes need to evaporate. It will be made in a specific Move; don’t hold your breath.

It’s time to set up my last list, his story of the cosmos. Of two vast expansions, the first one is fast; it’s driven by the orderly Beginning. But the second one is slow; it’s driven by a zillion replicas sequestered in black holes. Each can be seen to have three eras. We are entering the Back-Slope Era, second of the new expansion, or perhaps leaving the first, when black holes grow apace and making space is in its heyday, though it’s nothing like the heady days of the Big Fizz. Here’s his Space Story:

Space Era	Scale (Years)	Manufacture Action	Expansion
Big Fizz Era	1 gazillionth	Doubling every Tock	Accelerating
Big Bang Era	1 million	Few fat Flecks left	Slowing down
Big Snooze Era	100 million	Matter aggregates	Almost stopping
Black Hole Era	10 billion	Black holes grow	Accelerates again
Back Slope Era	1 trillion	Black holes starve	Slowing down
Long Goodbye	1 quadrillion	Matter is exhausted	Comes to an end

The Big Flash picture’s from the Big Bang Era. Sure, it’s hot and, sure, it’s still expanding. Notwithstanding that it has an action-oriented name, it is a boring era; if you’re looking for expansion little of it’s going on. It’s perfect for a portrait. But the finest feature of his whole Space Story’s surely this: It follows from such simple Rules. It is, you might say, almost effortless. That single tendency to Fizzion manufactures space that twists and braids the mass that warps space into gravity, which

packs mass into black holes, which give space a new go-round of Fizzion. The whole thing is a space machine.

Six eras make fine fodder for a figure with a heading like: The Evolution of the Universe. I can see it when I close my eyes. It doesn't look much different from diagrams derived from far more complex premises, but it is different. Lockwood sums up current wisdom: 'On the face of it, the universe, according to the picture that has now emerged, is destined to expand for all eternity.' That universe is heading for infinity. My guy says not.

He says it will end with finite size. He says it will end in absolute disorder. For those who yearn for normal this is heaven, everything is average, deviance is finally put down. But forget Zorba's; *this* will be the full catastrophe.

It's too bad that these prognostications don't count as predictions. It will take too long to check them out. Here is another: The Beginning says the end will sort out Descartes (wrong) and Newton (right) because, when the last matter's gone, space will remain.

Writing these words has me looking back through what I wrote on time and space so many days—it seems like half a life—ago. Those words look different today. Is it that I see this now less as a diary, more as a book? Or is it that we, he and I, have come so far since she turned my life in this new direction? Our lives, I should say, though his life may not be his own. I guess that in a way he owes his life to her. What can I do to clean this messy story up? Write *her* out of it? Simpler. But I'd have to bury Flatfoot Frank as well. Then what could I do with *my* detective? Without *them*, who is *he*? I can't write him out of it; it is more his than mine. I sit back and ponder all the bits in the computer. Do they explain it all? I wonder. I can almost hear him.

"It is only a beginning."

Of course he would be right. He *is* right. There is more, much more, that needs exploring.