THE LUMPS PROBLEM

Lucy, you got a lotta 'splainin' to do.

Bart Andrews (1951)

All one can say is that if the Universe was originally uniform then the small irregularities that arise from statistical fluctuations would not develop into galaxies in the time available.

Dennis Sciama (1971)

Unfortunately, the level of random fluctuations that would be expected to exist at any time in the universe was far too low to generate the structures we see today.

John Barrow (1994)

Galaxies are not dotted randomly throughout the cosmos but are generally concentrated in groups or clusters, which are themselves connected by a multitude of filaments known as the cosmic web.

Rodrigo Ibata & Geraint Lewis (2010)

Dawn of day four of breathing fumes—if this is breathing. The air—if this is air—outside the Metro station stings my eyes. The forecast forms the headline in the paper. It says we're waiting for the Santa Ana winds. Heedless of fire danger, Santa Monica, North Hollywood and all the smog bowl in between unite in prayer. I walk upstairs to save a watt or two. The air system's groaning like its volts are flirting with the verge of brown. Though the inside air's not good its sting is down. With an excuse like this the chances are that he won't show. Okay by me; I need some time to check this out.

I find it told a dozen ways but soon I see it's all one story: It's the story of the universe's lumps. The Big Flash picture shows the early universe was smooth as butta but today it has great clusterings of galaxies with giant gaps between. Theory says it got this way with gravity. The tiny variations shown in the Big Flash picture were unstable. Anywhere that's a bit denser had a bit more gravity so there it grew.

But what makes those variations? As Sciama says—and Barrow says and so do many others—random lumps are far too tiny. In *Rabbit's Kin* Pete Puma tells Bugs he wants a whole lotta lumps; so he makes them himself. How could the cosmos make its own lumps on a cosmic scale? Computer simulations say it needs a *source* of lumping in the early universe.

This, I figure, is a thing that he can understand. Pictures make it easy. On YouTube there's a simulation called 'Formation of large scale structures'. It's

from the Max Planck Institute. I'm thinking that's where I thought she went in Potsdam some months ago when the door latch clicks behind me and to my complete confusion he says: What's up doc?

Doc is what he seems to think it's fun to call me. It's no good letting on it bugs me; he'll just do it twice as much. So I say take a look at this and start into the story of the lumps. This looks like—I say off-handedly—it might be a good clue. I can't tell him it's a doozer! The lumps must be built-in in the Beginning. He's as enthused as a mortician with a body in a cardboard box.

The Big Flash picture shows the universe's large-scale structure after only a few hundred thousand years. A cosmic eye-blink, I say, but it's lost on him. The variations in the large-scale structure, the lumpinesses of the lumps, are very small—about one part in 100,000. But sideways size-wise they're humungous. It's a message sent right after the event that he's supposed to sleuth.

Simulations say these lumps construct the cosmic neighborhood in which we live. Looking back, the picture shows exactly what was needed then to get what we see now. Without them we'd see cold, dark, almost-perfect vacuum, nothing solid in it anywhere. Solitary atoms—hydrogen and helium, a few of lithium—would wander through a space so empty that collisions would be rare. We'd see, I say, but we would not be there.

Thanks to lumpiness we see not only galaxies but clumps of thousands of them—superclusters—with vast voids between. There are millions of these superclusters in the universe that telescopes detect. How did they get there? Well, over almost fourteen billion years, gravity makes mountains from the molehills of the Big Flash lumps. At first slowly on a many-millions-of-years time-scale, then faster, the denser parts attract more matter than the parts that are less dense. Given that initial lumpiness, galaxies and superclusters are, you might say, self-fulfilling prophecies. A lump is like a slight depression. One might say that all that mass just slides downhill. As mass accumulates, its gravity turns slight depressions into deeper canyons. Time to start the YouTube movie. Twelve billion years unfold in forty winks.

I summarize for him the knee-bone-thigh-bone version of the cosmos: The universe sets out with large-scale little lumps; the lumps make superclusters; the superclusters contain galaxies; the galaxies make factories for stars; stars are gravity-fired nuclear reactors; the first stars self-destruct and their debris makes more star factories; stars in the second set do much the same; in our galaxy our third-generation star, the Sun, spins up our Solar System; it makes much—including us—from waste, the corpses of the second set of stars. It all begins with lumps.

With this in hand he can step back and see the bigger picture. The horizon problem and lump problem are Yin and Yang. Two problems or only one? As

two: Why *is* the universe so uniform? And why is it *not* quite uniform? Or as one problem: How come the early universe has large-scale little lumps? Ricky says to Lucy, 'You got alotta 'splainin' to do.' And, just so, those lumps need lots of 'splainin'. It gets worse. They give rise to what's called a fine-tuning problem. Aka the Goldilocks problem. Even if we can explain both uniformity and lumps, why is the lumpiness exactly what is needed so the Sun could come into existence and last long enough for Earth's geology to settle down and for life to evolve? It's as though some cosmic Goldilocks sits down to bowls of cosmo-porridge and finds one too lumpy and the next too smooth. This bowl is exactly right. Bad for Baby Bear but good for us. But Goldilocks—she's the Anthropic Principle in thin disguise—is not the kind of answer physics wants.

The computer models say that with a bit more lumpiness the cosmic light show should be over long ago. A bit less lumpiness and there would never be a show at all. The Big Flash picture's lumpiness is just right. Rerun the universe with a change up or down and there will be no Milky Way. No Sol. No Earth.

Physicists are not big on coincidence. Nor are detectives. So they have a Problem: Why were the lumps exactly right? Besides, where did they come from? Goldilocks is not an answer to the second question. This must be a clue: What made the lumps?

It goes to waste. He is long gone.