THE PROBLEM OF ANTIMATTER

It is natural to ask whether distant objects may be made of antimatter; one might even hope the answer will teach us something about the way … the other forms of matter were created.

Jim Peebles (1993)

When in contact, matter and antimatter can annihilate one another to produce pure energy—that's why there is extremely little naturally occurring antimatter in the world around us.

Brian Greene (1999)

Physics sits on a foundation of some simple laws. That's what I learned in school. One of them—maybe the most important—is that mass must be conserved. I remember it as sacrosanct.

So when I first heard of antimatter I was disappointed. Today I look it up and find Carl Anderson discovered it in 1932. Science news can travel slowly on its way to school. My disappointment was the fact that positrons destroy electrons, and vice versa. Their masses vanish in a blast of photons. But then Einstein said that mass is energy. Physics patched its laws accordingly. This news also took its time.

Mass is made of certain kinds of particles. The Standard Model lists them all. In its scheme each particle is paired up with an antiparticle. One way to think about an antiparticle is that it *is* the particle but travels back in time. Another is its charge is opposite. When a particle meets its antiparticle they annihilate immediately. They make two photons whose energies are equal to the masses in accordance with: $E = mc^2$.

He saunters in. It's after ten. I give him my CliffsNotes on antimatter. I summon back the Big Flash picture. I ask him to imagine half its atoms are composed of whatsits—such as protons and electrons—and the other half of anti-whatsits. As they bump and grind there would be, sings Jerry Lee, a whole lotta shakin' goin' on in the short-term picture-future and nothing but photons in the long term.

So the Problem of Antimatter's not: Why is so little of it left? It's: Why is there *any* matter left? Which is to say: It seems that the original proportion *wasn't* half and half. How come? Physics has a symmetry it calls CP. It says exactly 50-50 is the way it has to be.

It takes two steps to get from particle to anti: Step one, reverse its charge (that's C). Step two, look at it in the mirror (this is P; it stands for parity). The image shows the antiparticle. No one says it quite as well as Penrose: 'We see that CP sends a particle's zig into its antiparticle's zag.' *CP Symmetry* says this double operation doesn't change the physics. For a while this is the rule. Key forces—electromagnetism, strong force, gravity—all follow it. Particle or anti seems the same. Nobody thinks to check the weak force.

Physical cosmology contrives an answer to the 50-50 question. Well, an answer of a kind. It says CP Symmetry was violated when particles were born in the Big Bang. There are some suggestions as to how this could have happened. They look like little more than stirring up the same old problem. It's like the beat cop saying to the beach bum: Move along.

But then it turns out that the weak force *doesn't* follow CP Symmetry; well, not exactly. At last, there is a way to favor particles and so explain the stuff we see. The celebration is a short one. There's a Nobel Prize or two. CP violation, as it's called, explains why more than half was matter. But it covers just a trillionth of the matter that we see. Which brings the matter back to square one: Why were there more particles than antiparticles?

This Problem's huge. Or seems it should be. Like beauty, huge is in the eye of the beholder. What, I ask, could cause asymmetry that saves the universe from being blown away before it's born? His answer as he stands up is a barely stifled yawn.

To me it looks like a Beginning kind of problem. Missing opportunities like this could get me down. Once again I want to whistle up a fictional detective. One who will stick around. One who will with Milton trip the light fantastic. One who can detect a cosmic clue.