THE PROBLEM OF THE SECOND LAW

Chorus: What, never?

Captain: No, never!

Chorus: What, never?

Captain: Hardly ever!

William Gilbert (1878)

"Travis, I've mentioned to you the second law of thermodynamics."

"Which is?"

"That all organized systems tend to slide into chaos and disorder. Energy tends to run down. The universe itself heads inevitably toward darkness and stasis."

"Cheering thought."

John D. MacDonald (1978)

Whereas most physicists regard the second law of thermodynamics as a reflection of the improbability of certain types of initial conditions, there are others who regard it as a far more fundamental idea that is prior to the laws of nature themselves.

John Barrow (2007)

There are many ways to pose the Second Law. Which should I tell him? An over-simple version says heat always flows from hot to cold as time goes by. A better one is: Things look messy now but they are going to get worse.

It seems self-evident. Heat flows downhill like water as it were. Why wouldn't it? It never flows uphill unless it's pushed. Well, hardly ever; Gilbert's onto something but it is obscure. Eddington says, 'Strictly speaking … for a small-ish system the chances [that heat would flow from cold to hot] are, say 10^{20} to 1.' In other words he gives uphill a tiny chance.

The Second Law's at odds with all the other laws of physics. It alone is unsymmetrical in time. So does the Second Law give time an Arrow? Well, yes and no—and after lots more reading, mostly no it seems. It merely summarizes what is seen with many molecules. Heat is an expression of motion at a molecular level. A statistical expression. That is, it expresses average behavior. A check of any single molecule will show that it *does not* obey the Second Law. It goes hot and cold, fast and slow, in a random way. Yet Reichenbach leans on this fuzzy law to find a

fuzzy definition of time's Arrow: 'The direction in which most thermodynamic processes in isolated systems occur is the direction of positive time.' Thus heat may point the way for time but only mostly.

Through the latter 1800s Boltzmann tries to prove the Second Law. By the 1890s he concludes it can't be done. Others follow in his failing footsteps. It turns out that it is *not* a law like other laws of physics. So if it's not a law what is it? Well, it's just an observation. Long observation coded in the Second Law is all we have to validate our sense that time unfolds one way. Otherwise the time dimension has a lot in common with the space dimensions. This makes it easy for Minkowski to pack all four into Spacetime. SR places moving in space on a par with moving in time. It suggests we only think they're different. It has no space for the Second Law.

One way to view the Problem of the Second Law is: It's unlikely that a universe would have this law. Outrageously unlikely. Penrose considers different possibilities for the kinds of universe that could exist and calculates the odds in favor of the Second Law, a humungous number—far more than the atoms in the universe—to one against. Of course it's not a poker game and these are not odds. No one gets to bet against the universe. But this is a problem for cosmology.

It's a problem too for my detective. Not the odds but the behavior. When does the universe begin to play this way? Is it in the rules the universe begins with? If so, why isn't it a law? If not, where does it come from?

So, does the Problem of the Second Law offer insight into the Beginning? Barrow says some see it as a kind of super-law. But could it be a super-clue?