

THE PROBLEM OF THE THREE DIMENSIONS

That everywhere space ... has three dimensions, and that space cannot in general have more, is based on the proposition that not more than three lines can intersect at right angles in one point.

Immanuel Kant (1783)

It is the characteristic of three-dimensionality that *it and only it* leads to continuous causal laws for physical reality.

Hans Reichenbach (1927)

We see that if there are three large dimensions of space because of some deep principle of nature, then we are very fortunate.

John Barrow (1994)

String theory requires exactly ten dimensions to be consistent, no more and no less.

Shing-Tung Yau (2010)

First off I tell him that the topic of the day is the dimensions we can see. It's to distinguish them from those we can't that Barrow calls them 'large'. He says, offhand: Okay. Which sounds odd as, as Barrow says, it is much more than just okay. The number of space dimensions may be *the* most fundamental thing about the universe. We see three. The Problem is: Why three? Reichenbach says any other number would make this a useless place. He doesn't mean it as an explanation. He just wants to make a point.

So, why are there three? Why not four or two or seven? Why any at all? Where do they come from, so to speak? Well, nobody knows. As Barrow says, echoing Reichenbach, there are good reasons why it's a good way for things to be. But that it's good says nowt about how it comes to be so. That kind of reason is the root of the Anthropic Principle on which he knows my views.

More than two hundred years ago Kant publishes a proof that there can't be more than three dimensions. Actually, Kant's reasoning, if that is what he's reasoning, is simply wrong. If there *were* four space dimensions, then *four* lines could intersect at right angles in one point. All he shows is that there *are* three space dimensions; not a word of why. He goes on to say his proposition rests on intuition, and is apodictically true. It was Reichenbach—no friend to Kant—who introduced me to the apodictic back before I hit the wall and sought the beach; it

means indisputable. If Kant inclined to shorter words he might have just said simply: We see three.

Kant calls on gravity: The force between two bodies, Newton says, decreases with the inverse square of separation. The inverse-square law, Kant says, leads to three dimensions. Somewhere I see Barrow saying that Kant has this backwards; three dimensions lead to Newton's Law.

A hundred or so years ago a book took a satiric look at life in two dimensions; little more has surfaced since. We still see three. We still have nothing more to say about the reason. Physics plays with more dimensions. But not writ large; not out in the open where they can be seen.

I remind him that string theorists begin with nine. In addition to the three we see there are, they say, six more dimensions all curled up so tightly they're impossible to find. Physicists have reason to expect them to be there: The *Supersymmetry* that makes neat sense of different kinds of particles needs ten dimensions if it is to work. Three space, one time, six squished or Compactified.

But enough of these dimensional digressions. The Problem is in view for him to see: Why three?