So my sixth point is to deconstruct the metaphors upon which artificial intelligence, life extension technology, nanotechnology, robotics, and genomics are all based—the idea that life and mind are machines that can be reverse engineered. Human engineering is pretty fantastic stuff, but I doubt whether anything that humans have ever designed approaches the biochemical complexity of a single cell. Let me quote Bill Bryson's description of a simple prokaryotic cell from his book *A Short History of Nearly Everything* (2003, 2005):

> Blown up to a scale at which atoms were about the size of peas, a cell would be a sphere roughly half a mile across, and supported by a complex framework of girders called the cytoskeleton. Within it, millions upon millions of objects—some the size of basketballs, others the size of cars—would whiz about like bullets. There wouldn't be a place you could stand without being pummeled and ripped thousands of times every second from every direction. Even for its full-time occupants the inside of a cell is a hazardous place. Each strand of DNA is on average attacked or damaged once every 8.4 seconds—ten thousand times in a day—by chemicals and other agents that whack into or carelessly slice through it, and each of these wounds must be swiftly stitched up if the cell is not to perish.
>
> The proteins are especially lively, spinning, pulsating and flying into each other up to a billion times a second. Enzymes, themselves a type of protein, dash everywhere, performing up to a thousand tasks a second. Like greatly speeded-up worker ants, they busily build and rebuild molecules, hauling a piece off this one, adding a piece to that one. Some monitor passing proteins and mark with a chemical those that are irreparably damaged or flawed. Once so selected, the doomed proteins

proceed to a structure called a proteasome, where they are stripped down and their components used to build new proteins. Some types of protein exist for less than half an hour; others survive for weeks. But all lead existences that are inconceivably frenzied.[23]

Bryson's vivid trope for describing the trillions of biochemical reactions per second in a simple prokaryotic cell does not even begin to approach the real nanotech-level, informational, and developmental complexity of this smallest unit of life. A typical such cell contains 20,000 different types of proteins, each with capacities to fold and unfold in specific context to accomplish specific tasks. A small cell contains perhaps 100 million protein molecules. The adult human body contains some 10 trillion (10^{13}) large Eukaryotic cells. All of these cells began as a single fertilized egg in your mother's womb, a single cell with 23 chromosomes, some 70,000 genes, and 3 billion base pairs, a single cell that replicated, initially exponentially, and along the way differentiated into 210 tissue types in their proper organs performing their proper function.

Can a computer model the complexity inside of a single cell, let alone the complexity of the entire brain of some hundred billion neurons (10^{11}) connected together in a tangled web of over one hundred trillion synaptic connections (10^{14}). What details are we necessarily going to exclude from these models? If we follow Bryson's lead and blow an entire human brain up to a scale where each atom would be the size of a pea, then suddenly the only human creation that might compare to the informational complexity of the brain would be the entire global economy shrunk to the size of a brain. Nobody designed and nobody controls the global economy, even though we try to influence it as best we can as differentially empowered participants with different interests, motivations, and expectations.

But wait, a disembodied brain is a useless mush of grey matter. For a human brain to realize its extraordinary abilities—for instance, in the extraordinary intelligence, creativity, and concern manifested by the speakers and conferees at the Singularity Summit—requires in its ontogeny and phylogeny an entire body and an evolved history. A brain requires a network of nerves and a metabolism. It requires vocal chords and oppositional thumbs. The brain must evolve and develop in natural environments rich in semiotic and semantic meanings. It requires the nurture of families, communities, and civilizations from which it acquires language, tools, and purpose. The brain, much like the genome, does absolutely nothing by itself. When separated from this messy matrix of embodied relationships—top down,

[23] Bill Bryson, *A Short History of Nearly Everything: Special Illustrated Edition* (New York: Broadway Books, [2003] 2005), 477-78.

bottom up, side to side—the brain really has no capacities at all, computational or otherwise.

In a profound ontological sense, the human body-brain-mind-spirit is an