Darwin's Simuniverses

A wild guess on the origin of the Church-Turing-Deutsch principle

Charles Alexandre Bédard

bedarc@usi.ch

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The laws of physics are awesome. They really are. They permit the existence and stability of matter, atoms of which diversify in stars before being unleashed violently. Gravity gathers the leftovers into more stars, or, incidentally, into nearby planets like our own. Atoms can be arranged in countless ways in chemical reactions, some of which are facilitated by *catalysts* — molecules needed but retrieved intact after the process. When a molecule is both a catalyst and a product of a reaction, it is replicated. The very existence of molecular-based replicators, *genes*, is the origin of life, of which we, like any other organism, are but the complex means by which genes self-replicate. The take-off of life on a sterile planet follows from the co-existence of non-self-replicating things with self-replicating ones: The replicators take over and soon enough the planet's crust is called a *biosphere*, filled by *replicators*.

What happens if replicators not so efficient at self-replicating coexist with some that are really good at it? Well... the good ones take over! But how can they become good in the first place? Randomly. Completely randomly. If, in the process of getting passed on, genes or combinations thereof are somehow altered, then the child organism may be better, or more likely, worse. Worse variations go extinct, un-replicated, but so long as better ones are possible, better ones take over. *Darwinian evolution*, like physics, cannot predict future species, but it can, unlike physics, predict that they will be awesome; awesome enough to entail their replication in a competitive environment. Indeed, architected by highly selected genes, our bodies and our minds are stunning: While we unconsciously deploy complex nanotechnology to fight invaders like viruses, we wonder about which problem, human or abstract, to solve. We build ideas about how the world works, we err and we make progress and nothing seems to be fundamentally in the way of our comprehension. The laws of physics are awesome enough to permit all of this: they are rich enough for entities like us to arise, yet, parsimonious enough to warrant their own comprehensibility.

The attempt of this essay is to share a possible, yet science-fictional, explanation to:

Why are the laws of physics awesome?

The *Church-Turing-Deutsch (CTD) principle* states that:

1) Any physical system can be simulated with arbitrary accuracy...

2) by a universal computer, which can be built within the universe.

The first part of the CTD principle alone, doesn't say much about the universe. In fact, it's completely empty. "The universe is a computer...Wooo" should leave one unimpressed: OK, we can think of our physics as being run on some meta-computer, outside the universe, but what does it change? In fact, whatever the laws of physics would be, we could think of them in this way, since the computing properties of the meta-computer are left open, unruled by our own physics. The second part brings the essential meaning. Laptops and brains, built here from the inside, are *universal computers*. They can simulate any part of the universe to any desirable accuracy, given the right instructions, and given enough memory and time.

Our computing power increases yearly: We simulate phenomena of ever greater complexity. Our computer games embedded in virtual reality are becoming close to indistinguishable from reality. If we choose that it is right to do so, one day we shall be able to simulate beings like us; after all, we too are physical systems. These beings will arise in the world we would design, their physics will be the fruit of our inspiration. They shall be able to crack (simulated) rocks, look at (simulated) fossils and wonder about their origins. Of course, in the (simulated) being's local time, the (simulated) universe — or *simuniverse* — could be as young as 6000 years old, while the rocks and fossils could trick them into believing that their universe is in fact 14 billion years old. However, this precocious strategy would cost us immensely more computing resources, for we would have to input all the complexity up front, rather than letting it slowly emerge from simple rules. We shall then prefer the latter. This, by the way, is the programmer's (or God's) perspective on Bennett's *logical depth*.

One day, our children could decide to launch their own simulations. We would be grandparents. How nice! And the simulations can recursively go on, in principle, *ad vitam æternam*, with *us*, of course, at the base of this recursion. After all, we feel well rooted in base reality, no? Of course, this appearance of intimacy with base reality can be "Copernicused" away, and it shall be proposed that we sit in fact somewhere in this recursion. By the boring part of the CTD principle, it is obvious that we can indeed be the product of our "parent's" simulation. Well, then, pressure is on us, or rather on our cosmos, for the legacy that it leaves as offspring simuniverses.

Here again comes Darwinian evolution, with the molecular outfit traded for a cosmic one. *Programmers* — more generally understood as entities able of launching their own simulation — are both inspired and constrained by how their own reality works in order to choose what to simulate. They can attempt to improve it; they can introduce random variations. Not all simulation will lead to programmers. It doesn't matter. Not all organisms replicate. So long as some simuniverses generate offspring, the process of cosmic evolution goes on. The laws of physics, from simuniverse to simuniverse is then subject to variation and selection, and in the long run, can become more and more awesome. In fact, I argued that our (sim)universe is awesome because it gives rise to us — us who understand our own universe and even launch simulations. In other words, the "awesomeness" of our laws of physics that I advocated can instead be thought of as *adaptability*, namely, their ability to cause their own replication, up to some variation. In the ecosystem of simuniverses, competition is tough, although indirect. Unlike different genes that directly compete for the resources in their environment, simuniverses compete for the computing resources of their parents: We may choose to shut down uninteresting simuniverses, and allocate the computing resources to a different one.

In life as we know it, the replicators are the genes, and not the organisms as it can be mistakenly thought. Indeed, organisms do not replicate, rather, they are the vessel enabling gene replication. In the cosmic evolutionary process, what is the replicator? Not the simuniverses, not the programmers. The laws of physics are. They are selected by their simplicity, namely, by the modesty of the computational resources required on the parent's computing device. They are also selected by their interestingness: their ability to generate worlds in which other worlds can be born. Like ideas in memetics, laws of physics in this cosmological evolution should not be thought of as perfect replicators, for they too are not identically replicated. Except one, perhaps. One physical principle is very hard not to transmit from generation to generation...

The Church-Turing-Deutsch principle! In fact, the first part of the principle is impossible not to transmit. Not only do we know that the laws of physics in a given simuniverse can be thought to be executed on some meta-computer, outside that simuniverse, but we know precisely that this computer sits in the parent's simuniverse. How about the second part of the principle? Is it necessary that it be transmitted? Well, if it is not even possible to build a computer in the child simuniverse, then this child is *sterile*. Ruling out this option, it remains possible that some non-universal computers can be built within the simuniverse. There would then exist, in that simuniverse, some phenomena that cannot be grasped — simulated to increasing accuracy — by such computers. Those ghost phenomena have then no chance of being transmitted to offspring simuniverses. They either die out by lack of transmission, or even better, the parents realize that they should not allocate computing resources to dead ends and retroactively adjust their simulation. Thus, the Church-Turing-Deutsch principle arises as a token to a fertile progeny in the grand cosmological web of simulations, with the side effect that when we stare at our world, we find no superfluous, inexplicable, non-transmittable physics.