The Case for Living a Very, Very, Very Long Time
Danny Floyd, 2020

> *A chemist comes to us and says, "Look, I want a molecule that has the atoms arranged thus and so; make me that molecule." The chemist does a mysterious thing when he wants to make a molecule. He sees that it has got that ring, so he mixes this and that, and he shakes it, and he fiddles around. And, at the end of a difficult process, he usually does succeed in synthesizing what he wants. By the time I get my devices working, so that we can do it by physics, he will have figured out how to synthesize absolutely anything, so that this will really be useless.*
> – Richard P. Feynman, "There's Plenty of Room at the Bottom" 1959

> *Death is real / Someone's there and then they're not / And it's not for singing about / It's not for making into art*
> – Mount Eerie, *Real Death*

I like testing provocative ideas out on my students, and I admit I get a devious pleasure out of it. I love watching them get wide-eyed over the surprisingly plausible prospect, for example, that we live in not just one simulation but simulations within simulations. To my surprise, almost all of them are utterly repulsed by the idea of living into their 200s, but evidence shows they very possibly, perhaps likely will. Trying these ideas out on them seemed fun at the time when we could take for granted the now very charged idea of standing in front of each other in the same room. I sincerely hope they are now rethinking their stance.

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In his amazing ten-part documentary podcast on existential risk and the (hopefully) long-term future of humanity, *End of the World with Josh Clark*, Clark posits, for the sake of "round numbers," by the year 2050 we will have all taken a pill. He can tell it more poetically than I:

> *The moment you pop that capsule into your mouth, your healthy life expectancy increased by 100 years. As the enzymes in your gut began to dissolve the capsule, your digestive fluids poured into it, and the sudden change in temperature and pH activated the first generation of nanobots inside. They came online connected to their shared WiFi network, activated their propulsion systems and passed through your gut wall and into your bloodstream, fanning out throughout your body. [...] They search for pathogens to destroy; they prune cells that show signs of growing into tumors and repair the DNA inside to make sure they won't turn cancerous again; they clear plaque from the interior of your blood vessels; they assist insulin in removing sugars, fats, and protein from your bloodstream after you eat for storage later on; they assist in clearing neurotransmitters from your*

> *synapses after you've had a thought; they target fats to burn in areas of your body that you select through their app.*[1]

As distasteful as it sounds to sculpt your body fat with an app, it is clear that well within a generation, the two infamous cures that have long eluded us, ever evoked in public consciousness, those of cancer and AIDS, will be at our grasp. But that's just the beginning; this will mean the end of disease altogether, and age will be slowed tremendously if not virtually halted.

I turn to K. Eric Drexler the often called "Father of Nanotechnology" who was the first to hold a PhD in Nanotechnology from MIT. Drexler has been writing on the subject for about 40 years. Someone familiar with the last few decades of nanotechnology development and the realm of science fiction it birthed probably recognizes his theories as those which almost killed the field, ironically. But we will get to that later.

I am getting ahead of myself. Let's step back for a minute and clear up what nanotechnology is. The prefix nano- refers to the scale of atoms, the tiniest scale that we have been able to work with so far. It follows that nanotechnology is the ability to compute on that scale and to make computer-guided manipulations of matter on that scale. We currently can compute on the micro- scale, one millionth of a meter, but the nano- scale is one 1000th of that. Drexler writes, "Advances in the technologies of medicine, space, computation, and production – and warfare – all depend on our ability to arrange atoms."[2]

Drexler doesn't often refer to what popular culture likes to call "nanobots" as such. Apart from being over sensationalized, reasonably it is better to think of them as something akin to enzymes or hormones (especially if you want to imagine them in your body) which essentially do the same things to proteins on the molecular level as would nanomachines on any molecule.[3] It is an extension of what biochemistry has been studying for a long time.[4] He calls nanomachines with the enzyme-like ability to arrange atoms and molecules in a specific way *assemblers*.

> *Because assemblers will let us place atoms in almost any reasonable arrangement… they will let us build almost anything that the laws of nature allow to exist. In particular, they will let us build almost anything we can design – including more assemblers. The consequences of this will be profound, because our crude tools have let us explore only a*

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[1] Clark, Josh. "Embracing Catastrophe." Podcast audio. *End of the World with Josh Clark.* (iHeartMedia. November 28, 2018.) Accessed July 26, 2020. https://www.iheart.com/podcast/105-the-end-of-the-world-with-30006093/episode/ep08-embracing-catastrophe-30215320/

[2] Drexler, K Eric. *Engines of Creation 2.0: The coming Era of Nanotechnology*, (WOWIO, 2006.) p. 76

[3] He does however refer to what we might call nanobots as "machines" partly because he highlights the mechanical properties of enzymes, hormones, and proteins. In fact, he often uses the phrase *molecular machines* in reference to both bodily chemistry *and* nanotechnology. He writes of proteins, "Some push and pull, some act as cords or struts, and parts of some molecules make excellent bearings. The machinery of muscle, for instance, has gangs of proteins that reach, grab a 'rope' (also made of protein), pull it, then reach out again for a fresh grip; whenever you move, you use these machines." Ibid., p. 65

[4] Ibid., pp. 68-73

> *small part of the range of possibilities that natural law permits. Assemblers will open a world of new technologies.*[5]

"A world of new technologies" is putting it lightly. We could arrange any matter into any other matter, ending the idea of global scarcity altogether. Why not reassemble all of the trash we are polluting into oceans and the tons of carbon emissions in the air into atomically precise diamond fiber as a building material or better yet, as extremely inexpensive solar panels? Assemblers would of course work in tandem with *disassemblers*. Together with nanocomputer analytics, they could take an object apart and replicate an exact copy to the atom.[6]

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While medicine as we know it can take place on the molecular level, as in the case of drugs, it relies on the cell's ability to repair itself. What Drexler calls *repair machines* "will be able to build molecules and cells from scratch, they will be able to repair even cells damaged to the point of complete inactivity. Thus, cell repair machines will bring a fundamental breakthrough: they will free medicine from reliance on self-repair as the only path to healing."[7] The idea is to, instead of focusing on the function of the body, focus on its structure. Medicine would no longer be reactive but rather maintinative and preventative.

In the case of DNA repair, the artificial intelligence (AI) used by repair machines in your body will be a descendant of an AI you already use, autocorrect. In your body, the machines will have billions upon billions of amino acid molecules to analyze as "correct." When it proofreads (so to speak) one that is damaged, it can fix it based upon a dataset so enormous that "a device that compares many strands will make the chance of an uncorrectable error effectively nil."[8]

He identifies five functions that the nanotechnology would perform, all of which happen biologically already: access, recognition, disassembly, reassembly, and rebuilding. White blood cells already access other cells, and viruses do the same. The body already recognizes foreign pathogens either chemically or by touch. We have already discussed that enzymes and hormones disassemble and reassemble molecules throughout the body, and again, viruses also do this naturally. Finally, cells rebuild from the molecular level up.[9]

Even simpler will be the most common application, destruction of dangerous replicators such as cancers or pathogens. Dissaesseblers will work in tandem with the repair machines to not only cure the disease but also resolve the disorder. "Selective destruction will also cure diseases such as herpes in which a virus splices its genes into the DNA of a host cell. A repair device will enter the cell, read its DNA, and remove the addition that spells 'herpes.'"[10] Needless to say, *if* (and that's a big if) a virus lasted long enough in your body to replicate to any degree, you would never feel the effects.

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[5] Ibid., p. 76
[6] Ibid., p. 86
[7] Ibid., p. 239
[8] Ibid., p. 242
[9] Ibid., p. 237
[10] Ibid., P 244

At this point, some readers around my age may be thinking back to season six episode nine of *The X-Files*. The episode opens on Assistant Director Walter Skinner in the emergency room. He is barely conscious and his veins are purple and bulging. We flash back to Skinner fainting during a boxing match, which lands him in the hospital the first time. When he comes to, he has little recollection of what has happened but is discharged with a nasty bruise. Agents Dana Skully and Fox Mulder can tell he isn't feeling well at work, so they investigate. Subsequent flashbacks and surveillance camera footage reveal that Skinner was accosted briefly by a famous physicist in the lobby. Mulder investigates this while Skully goes to the hospital to enquire; she is a doctor after all. When Skully looks at a blood sample she sees something she can't explain, tiny carbon objects clogging up the space between Skinner's blood cells and replicating alarmingly quickly.

Meanwhile, Mulder reveals that this renowned physicist is somehow associated with a Senator who is working to get a foreign aid and transport bill passed. Amid all this, Skinner begins to remember a shadowy figure present at every scene and whose trails Mulder is close behind. This shadowy figure is seen in the mezzanine of an abandoned warehouse where, under auspices unknown, the Senator finds the physicist strapped to a gurney with the same condition as Skinner. With a stylus, the shadowy figure operates a handheld device displaying the physicist's name on a screen much to his torture. After some sleuthing, Mulder finds the building the next day and confronts the Senator who is inexplicably still there. It is revealed that buried in the bill he is trying to pass is a provision about the export of new technology.

"Technology that the world believes is purely theoretical," says the Senator.

"Nanotechnology!" Mulder exclaims dramatically, "Microscopic, atom-sized machines!?"

Skinner is back in the hospital and not doing well. Just after he is pronounced dead, the shadowy figure appears in the distance. With his stylus, he dials down the screen on his handheld device, and Skinner jolts back to life. Days later, the shadowy figure is waiting for Skinner in the back seat of his car. He flips the handheld device shut. He is revealed to be the insidious Alex Krycek. Skinner asks what he wants, and he simply replies, "All in good time."

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Drexler released his major work on nanotechnology's potential in 1986 as a book titled *Engines of Creation*. Though an attempt to tout the remarkable possibilities of the technology, it was fodder for science fiction dystopian visions in pop culture such as above. He is credited with what is called the "grey goo" hypothesis, in which the AI in nanobots achieves superintelligence with the directive to replicate. To do so, they eventually disassemble all available matter reducing the world to a seething colloid of endless microscopic machines. He has since denounced this theory, because it sowed so much mistrust in the field as to set it back decades and because the technology would never go that far without built-in safeguards.[11] "The ideas that spread fastest simplified, transmogrified, and sensationalized. Soon, 'nanotechnology' was all about making so-called 'nanobots' – self-replicating bug-like things that could work miracles, but would

[11] Clark

inevitably run amok, eat the world, and turn it into 'gray goo.' And these monster nanobugs were, of course, said to be my idea,"[12] he writes.

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Based on Drexler's writings, I would venture that Clark's estimate of 100 more years of longevity is conservative. "Aging is fundamentally no different from any other physical disorder;" Drexler wirtes, "it is no magical effect of calendar dates on a mysterious life-force. Brittle bones, wrinkled skin, low enzyme activities, slow wound healing, poor memory, and the rest all result from damaged molecular machinery, chemical imbalances, and mis-arranged structures."[13] The constant maintenance by repair machines will slow or perhaps arrest these "disorders." Drexler argues at length and convincingly that this is not in some way against the laws of nature. After all, nanomachines will essentially do what the body already does (remember the comparison to enzymes), through means the body already uses. They will just do so indefinitely.

"Who would want to live that long?!" is almost always the response I get from my undergrads. I suspect this is a coded way of saying "Who would ever want to be that old?" – a youthful disdain for age from someone too young to have ever meaningfully faced death. If I wasn't trolling for a reaction, I would probably ask, "Would you want to be youthful forever?" as opposed to "Would you want to live to 256?" I'm sure the answer would be different. But they can never answer the question "Why not?" I always say, "You say that now having never had cancer. What would you do then? Wouldn't you do anything to stop it?"

Obviously, long life poses global dilemmas. Overpopulation is one, but remember nanotechnology will have already solved the problem of pollution. "We will be able to get resources and make things without scarring the landscape with mines or cluttering it with factories," writes Drexler.[14] Again, scarcity, which is the most common (if not the only, when you really boil it down) pretext for war, is eliminated. The technology replicates itself, so it would be extremely affordable and ubiquitous. We could use the space we have so much better, but even if we really, truly run out of space, this could be our ticket to another world entirely.

The medical breakthrough of biostasis, what is more commonly known as suspended animation, is already underway. Using chemicals known as "cryoprotectants," we already have the means to preserve a human body indefinitely; we simply can't reverse it yet. These chemicals displace water with what technically fits the definition of a type of glass. Nanomachines could do the dual task of displacing the water in cells and restoring them when the time comes. There is also speculation that bodies already cryogenically frozen could be revived when this technology appears.[15] So if the world becomes too overcrowded, "a method of producing reversible biostasis could help astronauts on long space voyages to save food and avoid boredom, or it could serve as a kind of one-way time travel."[16] By "long space voyages," he means perhaps hundreds of Earth years.

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[12] This passage appears in the introduction to the 20th anniversary edition of his book dubbed *Engines of Creation 2.0*, where the majority of the source material for this paper comes. He released it for free on the internet in 2006.
[13] Drexler, p. 255
[14] Ibid., p. 270
[15] Ibid., pp. 287-291
[16] Ibid., p. 249

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I hope it is by now abundantly clear why I am writing about Drexler's work, and I hope his ideas are being read in a way they have never been before. Pardon me for invoking *The X-Files* again, but I want to believe in this technology. Maybe nanotechnology will take a disastrous turn, but from the depths of global despair, I need some shred of optimism that there is a permanent way out of this. I am not without anxieties, admittedly. For instance, it could very easily go in the direction of eugenics – enforcing bodily ideals on others as opposed to taking them on by one's own choice – though I don't believe that it *has* to go that way. It is also worth mentioning that, in various points while making his case for the medical use of nanotechnology, Drexler writes that we should leave the brain more or less alone, that alternation of the brain is too fundamental an alteration of who we are as individuals, though one can see how others may go down this dark route. My optimistic hope is that this technology will be used not on the basis of any given idea of superiority of one body over another, but along the same ethics of doing no harm and healing that medicine is already bound to.

I'm sure it has also crossed your mind already that this technology poses certain existential risks to the human race, particularly in its potential for weaponry if warfare is not indeed phased out, particularly the insidious use of nanotechnology as a sort of germ agent. However, if you believe as I do that nanotechnology is imminent, having them fortifying our bodies may prevent such an event as they may be the only protection against it. Perhaps germ warfare is more a reason to use them medically than to not. AI in general poses a threat to our future, but this is true whether or not it comes in nano- form or not. The question of whether or not these are reasons to pursue this technology is meaningless, because that die has already been cast. The only option is planning against these possibilities with applications that benefit us, and there is time for that. "People sometimes guide their actions by standards of truth and ethics, and we should be able to evolve AI systems that do likewise, but more reliably," writes Drexler. "Able to think a million times faster than us, they will have more time for second thoughts. It seems that AI systems can be made trustworthy, at least by human standards."[17]

All of my reservations about this prospect are set against the idea that the world would never, and perhaps *will* never, again go through the pain it is experiencing in this moment. In the age of COVID-19, I am finding it harder and harder to argue against the introduction of nanotechnology into our bodies.

[17] Ibid., p. 371