Molecules That Matter: Nanomedicine & the Advent of Programmable Matter
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1. Music in the Blood

I'd like to start talking about the large-scale effects of the very small, and I'd like to begin with science fiction. In Greg Bear's 1983 short story "Blood Music," Virgil Ulam, a nerdy biochemist working on engineered protein-silicon biochips, takes his research to the extremes of self-experimentation, injecting the "intelligent" biochips into his white blood cells. The biochips begin to integrate themselves into his biological system, improving everything from his metabolism, to his skeletal structure, even to his sexual performance. As Ulam confides to a friend, "I'm being rebuilt from the inside out."

However, the biochips' ability to adapt and improve their own complexity leads to some horrifying results. Ulam continues: "then one night my skin started to crawl...I wondered what they'd do when they crossed the blood-brain barrier and found out about me - about the brain's real function."

In the biochips' programmed endeavor to improve and complexify themselves, Ulam's body shifts from being an improved human anatomy to something very nonhuman. As the narrator puts it at the story's end:

"In hours, our legs expanded and spread out. Then extensions grew to the windows to take sunlight, and to the kitchen to take water from the sink. Filaments soon reached to all corners of the room...I suspect we resemble cells." The story closes with a giant question mark as to the fate of "the human" as it is subjected to highly sophisticated biomolecular technologies.

I wanted to bring up "Blood Music" because it expresses several anxieties surrounding the ways in which our bodies may be transformed by fields such as nanotechnology. On one level, the very idea of technically integrating DNA or proteins with silicon microchips represents an uneasy fusion of bodies and technologies, flesh and machine, a discomfort concerning the unpredictability of these novel hybrids: unstable media. In addition, these modifications of the body-technology relationship are predicated on the ability to program and control life at the molecular level - something that has been a technical mainstay of molecular biology for some time.

Nanotechnology - the control of matter at the atomic level - is, like biotechnology, a research field which promises a disease-free, biologically-upgraded, posthuman future. But it is also a set of practices which may transform our notions of what it means to have a body, and to be a body. Nanotechnology works towards what one researcher has called the "general capability for molecular engineering to structure matter atom by atom."

2. Nanomedicine / Nanotechnology
In 1959, physicist and Nobel laureate Richard Feynman presented a talk at CalTech entitled "There's Plenty of Room at the Bottom." In this talk Feynman speculated that, with the technological drive towards miniaturization, it was possible to build machines which would construct replicas of themselves at incrementally smaller scales, eventually reaching the level at which individual atoms could be controlled.

However, it wasn't until the early 1980s that a defined discipline around this vision of engineering at the atomic level was formed. Eric Drexler's book The Engines of Creation, put forth an ambitious program for what he variously called "molecular engineering" or nanotechnology. Put briefly, a nano-meter is one billionth of a meter, or six carbon atoms wide. In contrast to what Drexler called "bulk technology," or modes of technological production which handled matter en masse, a nanotechnology would work in a "bottom-up" fashion, focusing on the precision control of the individual atoms that compose matter. Nanotechnology broadly aims to be able to control, engineer, and design matter at this level - the very building blocks of the material world, as it were. As Drexler points out, "molecules matter because matter is made of molecules, and everything from air to flesh to spacecraft is made of matter."

In his book, Drexler outlined the types of nano-scale devices - or "nanomachines" - that would have to be constructed. As we know, atoms interact with each other with varying forces and stabilities, composing larger aggregates, or molecules, which then function in diverse ways as organic or non-organic matter. The technologies needed for design and engineering at this level would themselves operate at this level, somewhat like a tiny Tinker-Toy constructions. These include "assemblers," or nanomachines whose primary function is to assemble atoms into molecules, "replicators," or nanosystems whose goal is to make copies of themselves, and "nanocomputers," or basic computational devices constructed out of molecules and atoms. Drexler also outlined the basis for a medical application of nanotechnology, what Robert Freitas has termed "nanomedicine." As a specialized field within nanotechnology, nanomedicine works toward bodily repair and even enhancement through the use of engineered, in vivo probes and sensors that would operate, in a semi-permanent fashion, within the body. Freitas has published the first technical paper in nanomedicine for the "respirocyte," or artificial red blood cells that are capable of advanced filtering and diagnostics.

In the past 5 to 8 years, nanotechnology research has produced some significant results, many of them within the domain of nanomedicine. This is partly due to the development of new instruments for positioning and visualizing atoms, and it is also due to an influx of research funding. For instance, in 1990 researchers at IBM succeeded in spelling out the company's name by positioning 35 xenon atoms; in the early 1990s, researchers at Japan's NEC constructed nano-scale wires out of carbon atoms, which were shown to successfully conduct electricity; and, just this past summer, a team at Bell Labs in New Jersey was able to construct a molecular "motor" out of DNA.

As Drexler and other proponents are aware, the implications of nanotechnology are far-reaching. If it's possible to obtain precision
control over matter at the atomic level, then it's possible, quite literally, to make almost anything. Drexler has prophesized a coming era of global abundance, affecting manufacturing, information technologies, health and medicine, the environment, and defense. Such grandiose claims were undoubtedly part of what sparked the government's interest as well. This past year, President Clinton publicly endorsed a $500 million National Nanotechnology Initiative. The Initiative's report is subtitled, "leading the way to the next industrial revolution."

3. From Proteins to Nanomachines

A curious thing to note however, is that, despite nanotechnology's pervasive rhetoric of industrialism, the actual inspiration for the field comes not from electronics or information technologies, but from molecular biology.

In a 1981 technical article presented to the National Academy of Science, Drexler shows how protein production in the cell provides a jumping-off point for the development of more sophisticated means of controlling matter at the atomic level. For Drexler, protein production in the living cell provides what is referred to as the "proof of concept" of nanotechnology: that the ribosome in the cell provides us with an example from nature that molecular-scale control and engineering is indeed possible.

Yet, what begins as an inquiry into the molecular systems of protein production, ends up as a program for a miniaturized industrial factory. Writing some ten years later in his book Unbounding the Future, Drexler's vision of nanotechnology is markedly different:

"Nanotechnology will be a technology of new molecular machines, of gears and shafts and bearings that move and work with parts shaped in accord with the wave equations at the foundations of natural law."

In this research which begins by discussing protein production in the cell, Drexler eventually moves towards a machine-view of the analogies between microbiological components and industrial technologies: thus RNA acts as a kind of conveyor belt, enzymes acts as clamps, ribosomes act as construction sites, microtubules as struts and beams, and DNA as a storage device. This is not exclusively a linguistic shift, but it is a technical shift as well, affecting the kinds research practices which are developed.

What is important to note here is that this shift from proteins to nanomachines is also a shift from living to non-living matter, from bodies to technologies. Nanotechnology researchers are explicit about their interests in the instrumental character of being able to structure matter at the atomic level. As Drexler states, "Improved molecular machinery should no more surprise us than alloy steel being ten times stronger than bone, or copper wires transmitting signals a million times faster than nerves."

In this sense nanotechnology is indeed a new type of industrialism: it adopts the conventional position of developing techniques for working upon the natural world, including the human body. Nanotechnology is not
so much interested in being able to artificially produce proteins, but it is rather invested in the production of protein-designing machines. At issue here is design, and the relationship of design to the materiality of the body.

4. Programmable Matter

What makes such a position possible for nanotechnology is a view of the material world that resembles a kind of atomistic reductionism. Speaking about the medical benefits of nanotechnology, Drexler puts it plainly:

"The ill, the old, and the injured all suffer from misarranged patterns of atoms, whether misarranged by invading viruses, passing time, or swerving cars. Devices able to rearrange atoms will be able to set them right."

What is the body in nanomedicine? The body is a particularized "arrangement of atoms" which has the macro-scale effect of being designated as healthy, normal, or diseased. The body is thus like any object - a complex aggregate of atoms that participates in the universalized composition of matter. In such an instance, bodily disease becomes an error in molecular construction, and the nanomedical use of in vivo probes and sensors becomes a three-dimensional pattern-recognition system. Writing about nanomedicine, Robert Freitas reiterates this view:

"...nanomedicine phenomenologically regards the human body as an intricately structured machine with trillions of complex, interacting parts, with each part subject to individual scrutiny, repair, and possibly replacement by artificial technological means."

Nanomedicine - and nanotechnology generally - are thus predicated on a view of the body that is open to the interventions of medical design and engineering at the molecular level. The body becomes what we might call "programmable matter"; a materiality characterized by a constructionist logic, and a total mutability induced through the intersection of molecular biology and mechanical engineering.

But is there not something highly contradictory about nanomedicine's view of matter in this instance? In other words, in the move away from living to non-living matter, from proteins to nanomachines, does not nanomedicine undermine it's claim for the universality of matter?

The challenge put to nanomedicine is this: In order for a nanomachine such as an in vivo respirocyte to operate diagnostically, researchers must have a sense of a clear difference between the in vivo nanoprobe and the blood cells whose concentration it measures. In other words, for nanotechnology to operate instrumentally, a distance must be established between technology and its object. Yet, because nanomedicine involves the use of engineered nanomachines operating inside the living body, possibly in a permanent or semi-permanent way, the nanomachines must be able to successfully integrate themselves into the body's molecular surround.

The result is that nanomedicine requires the incorporation of medical technologies into the biological body as self, so that
those technologies can operate instrumentally as not-self. This is a dual strategy of being able to precisely control matter, and also being able to absorb its benefits in vivo.

Drexler's original move from proteins to nanomachines, from the biological to the technological, seems to present us with a contradiction, or at least a tension, in how matter is defined in the medical application of nanotechnology. Either matter is a universal, effacing the macro-scale distinctions between living and non-living matter, or matter is highly differentiated and heterogeneous, in which there may even be incommensurabilities between living and non-living matter. While the former view provides us with a world that is constructed from a universal set of components, the latter view provides a distancing-effect with which to approach that world instrumentally.

5. Posthuman Bodies

In this way nanotechnology is an example of the privileging of a technological domain through the contradictory regulation of the boundary between living and non-living matter.

As proponents of nanotechnology have speculated, the applications for medicine could include everything from cell and tissue repair, to smart drugs, to cryonics and anti-aging techniques, opening the way to a posthuman future of biomolecular design.

It is in this notion of the body as programmable matter that nanotechnology will come up against some of its greatest challenges. As a still-developing field, the line dividing medical healing and biomolecular design is generally underexamined in nanotechnology. With the promises and the research pointing to a so-called new industrial revolution, nanotechnology will have to confront the tensions between a total control of the material world, and the radical transformations which such control will bring about.

References


Freitas, Robert. "A Mechanical Artificial Red Cell: Exploratory Design
in Medical Nanotechnology (Respirocytes)." Foresight Institute: <http://www.foresight.org/Nanomedicine/Respirocytes.html>.


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