DOCUMENT

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Fundamental Principles of Global Ecophagy

Self-assembly + replicating capacity: How viruses went from representing the technological future of humanity to being the absolute emblem of pandemic extinction

I first came across the FFP3 respirator a few years ago when I started working in a lab where nanomaterials were being prepared. It's a personal protective mask that, together with surgical gloves and gown, may be appropriate to use in cases where, not being able to work under a fume hood, you are exposed to the risk of inhaling nanoparticles. These precautions are necessary because nanoparticles are not a normal kind of object: they are so small that they pass through almost everything, including the skin and, in some cases, the cell membranes of our body. This incredible capacity for penetration, of course, is also the reason why nanoparticles can be used for advanced biomedical applications.

Nanomedicine, an emerging interdisciplinary subject of study, exploits the ability of nanometric objects to slip into places unthinkable for any macroscopic instrument, allowing the identification and, if necessary, the destruction of cancer cells, for instance, with astonishing accuracy. The health and environmental effects of exposure to inorganic nanoparticles such as those I use in my research depend upon their size, their chemical nature and state of aggregation, and are still widely debated. In any case, I have always had some difficulty in describing the subtle anxiety that something invisible and vaguely harmful might have entered my lungs. Now, viruses are far more refined and potentially far more dangerous objects than any synthetic nanoparticle; but they share a number of interesting

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features, beginning with the most obvious one: their size, which varies between 20 and 400 nm, makes them equally difficult to filter out.

I confess that talking about viruses makes me awestruck, and not just because of their potential capacity for extermination. In fact, I find the virus one of the most fascinating of biochemical systems, but it is also an object that is incredibly highly charged with cultural and technological significance. The virus simultaneously represents a sort of dark omen of the future of technology and the emblem of its failure; over the last century, viral thought was one of the most relevant components of the imaginary of the future, a miraculous intersection between the worlds of biochemical matter, technology, and human culture. The virus is a hybrid object in every sense, which inhabits space on the borderline between chemical matter and living matter, and for this reason it illuminates the mechanisms of assembly that govern complex molecular structures.

The ability of viruses to self-assemble is a feature of particular interest: some viruses are able to rebuild themselves even in a test tube, without the help of any preformed organism, starting from their elementary components—a little as if a human being were thrown into a giant blender and then emerged intact from its own mush. The technological interest of this capacity is obvious: the possibility of designing complex and functional systems capable of assembling themselves independently would enable an incredible extension of our control over matter, especially on the nanometric scale, where the mechanical manipulation of objects has obvious limits. This idea is encapsulated in the concept of nanobots, the nanotechnological automata that have populated the dreams of scientists and futurologists for generations, but which, in fact, have not yet seen the light.

On the other hand, the virus is also a model of how matter and information are in close and interdependent contact; an idea that, in the new digital age, seems less and less alien to us. Not only does the virus encode the information needed to build the ingredients that make it up in the form of genetic code, but it is also 'almost' nothing but information. Devoid of any physical structure that is not strictly functional to the replication of a code, the virus has been perceived as a quasi-virtual object, appropriate for highlighting the intrinsic virtuality of biological structures and, at the same time, able to reveal the creative—and destructive—potential of the new computational sciences. The virus as a fragment of parasitic software illuminates, finally, the last step in the evolution of viral thought, in which genetic information is supplanted by the cultural element, and leads to the formulation of Richard Dawkins's doctrine of memetics, with which we are all, for better or worse, familiar. In general, the two fundamental properties of the virus, that of self-assembly on the one hand and that of replication on the other, have been two key concepts for thinking about the technological future of humanity and, inevitably, also for imagining its end.

The relevance of the virus as a conceptual category is very well expressed in a 2000 article in *Wired* by Bill Joy, the founding computer scientist of Sun Microsystems, entitled 'Why the Future Doesn't Need Us'.[1] In his article, Joy reviews all of the technologies that, over the coming millennium, will place the future of humanity at risk. Rereading this article

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today is, without a doubt, quite surprising; there is no mention of global warming or zoonotic infections, but there is extensive and almost mathematical certainty about artificial super-intelligence and futuristic nanobots which, escaping from some laboratory, risk making life on earth obsolete. Here Joy refers to the so-called 'gray goo' scenario, a nanotechnological dystopia on the border between science fiction and scientific speculation that gained surprising popularity in the nineties and succeeded in arousing genuine, albeit completely unfounded, concern among the public. Gray goo, an unstoppable infestation of automatic nanobots, in many ways resembles a viral pandemic, with the difference that, whereas viruses need living organisms to replicate, grey goo will definitely manage to do without us. In other words, grey goo as nanotechnology pandemic takes the virus to its most extreme consequences, theorizing an exponential replication that no longer even needs a biological vector to operate.

In Joy's words,

> Accustomed to living with almost routine scientific breakthroughs, we have yet to come to terms with the fact that the most compelling 21st-century technologies—robotics, genetic engineering, and nanotechnology—pose a different threat than the technologies that have come before. Specifically, robots, engineered organisms, and nanobots share a dangerous amplifying factor: They can self-replicate. A bomb is blown up only once—but one bot can become many, and quickly get out of control.
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> Much of my work over the past 25 years has been on computer networking, where the sending and receiving of messages creates the opportunity for out-of-control replication. But while replication in a computer or a computer network

1. <https://www.wired.com/2000/04/joy-2/>.

Philip K. Dick's 'Autofac' speaks to the anguish of being trapped in a production system that has revealed its viral and parasitic nature, blind and totally indifferent to the future of the human beings who designed it, dominated exclusively by the thermodynamic principles of self-assembly

> can be a nuisance, at worst it disables a machine or takes down a network or network service. Uncontrolled self-replication in these newer technologies runs a much greater risk: a risk of substantial damage in the physical world.

Joy's story here draws upon both science fiction and the science literature of the time. His explicit reference is scientist K. Eric Drexler, who became famous for being one of the first pioneers of nanotechnological thought, and for popularizing the idea that grey goo could pose a real threat to the future of humanity. And indeed, Drexler's thinking is strictly viral, both in his treatment of nanobots—for which the virus provides an excellent example of natural nanoengineering—and in his approach to the problem of the development of technology as a whole. The ideological pool, in Drexler's thought, is dominated by the Darwinian imperative of the survival of the most suitable ideas, to the point of completely destroying the boundary between reality and virtuality. 'Just as viruses evolve to stimulate cells to make viruses', Drexler suggests, 'so rumors evolve to sound plausible and juicy, stimulating repetition. Ask not whether a rumor is true, ask instead how it spreads. Experience shows that ideas evolved to be successful replicators need have little to do with the truth'. It is, perhaps, precisely for this reason that Drexler cared very little that his theories were pretty much pure speculation, belonging more to the realm of fantasy than to that of respectable science.

In Drexler's wake, the idea that a nanotechnological catastrophe was on its way began to spread in an unexpected way, in a proliferation of articles and books filled with pseudo-technical jargon and diagrams of complicated molecular combinations that could not be implemented in practice. Among them, Robert A. Freitas's 2000 article 'Some Limits to Global Ecophagy by Biovorous Nanoreplicators, with Public Policy Recommendations'[2] is a brilliant and surreal example of speculative science—a wacky collection of elementary notions from inorganic chemistry, physical laws taken out of context, and completely hallucinatory conclusions. The term 'ecophagy', coined by Freitas, indicates the catastrophic scenario in which nanotechnological automatons synthesized by humans will begin to compete with living ecosystems, using them as reservoirs of chemical resources before finally destroying them. 'Perhaps the earliest-recognized and best-known danger of molecular nanotechnology', explains Freitas, 'is the risk that self-replicating nanorobots capable of functioning autonomously in the natural environment could quickly convert that natural environment (e.g., "biomass") into replicas of themselves (e.g., "nanomass") on a global basis, a scenario usually referred to as the "grey goo problem" but perhaps more properly termed "global ecophagy"'. In a bitterly ironic twist of fate, one of the most significant limits that Freitas indicates to the exponential replication of grey goo is precisely climate change: by converting living biomass into robotic nanomasses, nanobots will produce such a quantity of heat that it will cause a catastrophic rise in the temperature of the planet.

One of the first science fiction stories to contemplate the problem of grey goo was Philip K. Dick's 'Autofac' (1955). In this tale Dick imagines a post-atomic scenario in which humanity, threatened by nuclear war, has entrusted its production system to a fully automated cybernetic network in order to ensure its survival. At the end of the war, this system of self-replicating machines now has an absolute monopoly on natural resources, and the protagonists of the story try everything possible, ultimately without success, to regain control of human civilization. Right at the end, when it seems as if the Autofac system has finally been razed to the ground, swarms of tiny robots emerge from the rubble and, after being shot like spores across the world, begin to assemble microscopic replicas of their mother factory. Dick's story speaks to the anguish of being

2. <https://foresight.org/nano/Ecophagy.php>.

trapped in a production system that has revealed its viral and parasitic nature, blind and totally indifferent to the future of the human beings who designed it, dominated exclusively by the thermodynamic principles of self-assembly. ‘One word of caution’, one of the story’s automatons communicates to us in a sinister tone. ‘It is fruitless to consider this receptor human and to engage it in discussions for which it is not equipped. Although purposeful, it is not capable of conceptual thought; it can only reassemble material already available to it’. Catastrophe theorists, take note.