The Artificialization of Life

Designing Self-Organization[*]

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1. The Ethical Aporia

In her masterly study of the frailties of human action, *The Human Condition*[1], Hannah Arendt brought out the fundamental paradox of our time: as human powers increase through technological progress, we are less and less equipped to control the consequences of our actions. A long excerpt is worth quoting here, as its relevance for our topic cannot be overstated – and we should bear in mind that this was written in 1958:

> [...] the attempt to eliminate action because of its uncertainty and to save human affairs from their frailty by dealing with them as though they were or could become the planned products of human making has first of all resulted in channeling the human capacity for action, for beginning new and spontaneous processes which without men never would come into existence, into an attitude toward nature which up to the latest stage of the modern age had been one of exploring natural laws and fabricating objects out of natural material. To what extent we have begun to *act into nature*, in the literal sense of the word, is perhaps best illustrated by a recent casual remark of a scientist who quite seriously suggested that "*basic research is when I am doing what I don't know what I am doing*." [Wernher von Braun, December 1957].
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> This started harmlessly enough with the experiment in which men were no longer content to observe, to register, and contemplate whatever nature was willing to yield in her own appearance, but began to prescribe conditions and to provoke natural processes. What then developed into an

[1] The University of Chicago Press, 1958.

ever-increasing skill in *unchaining elemental processes*, which, without the interference of men, would have lain dormant and perhaps never have come to pass, has finally ended in a veritable art of *'making' nature*, that is, of creating 'natural' processes which without men would never exist and which earthly nature by herself seems incapable of accomplishing [...].

The very fact that natural sciences have become exclusively sciences of process and, in their last stage, *sciences of potentially irreversible, irremediable 'processes of no return'* is a clear indication that, whatever the brain power necessary to start them, *the actual underlying human capacity which alone could bring about this development is no 'theoretical' capacity, neither contemplation nor reason, but the human ability to act* – to start new unprecedented processes whose outcome remains uncertain and unpredictable whether they are let loose in the human or the natural realm.

In this aspect of action [...] processes are started whose outcome is unpredictable, so that *uncertainty rather than frailty becomes the decisive character of human affairs*[2].

Our capacity to act is no longer limited to the human sphere. We are now able to tamper with, and set off, *complex natural* phenomena. As a consequence we have to confront a new kind of *uncertainty*. From a practical point of view the key issue is to develop new concepts of prudence that are suited to this novel situation. A long time ago Aristotle's *phronesis* was dislodged from its prominent place and replaced with the modern tools of the probability calculus, decision theory, the theory of expected utility, cost-benefit analysis, etc. More qualitative methods, such as futures studies, "Prospective", the scenario method were then developed to assist decision-making. More recently, the precautionary principle emerged on the international scene with the ambition to rule those cases in which uncertainty is mainly due to the insufficient state of our scientific and technological knowledge. I believe that none of these tools is appropriate to tackling the situation we are facing now.

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[2] P. 230-232. My emphasis.

German philosopher Hans Jonas, in his fundamental book, *The Imperative of Responsibility*[3], cogently explained why we need a radically new ethics to rule our relation to the future in the "technological age". His starting point was a philosophical aporia. Given the magnitude of the possible consequences of our technological choices, it is an absolute obligation for us to try and anticipate those consequences, assess them, and ground our choices on this assessment. Couched in philosophical parlance, this is tantamount to saying that when the stakes are high, we cannot but choose consequentialism, rather than a form of deontology, as our guiding moral doctrine. Consequentialism as moral doctrine says that what counts in evaluating an action is its *consequences* for all agents concerned. By contrast, deontological doctrines evaluate the rightness of an action in terms of its conformity to a norm or a rule, for example the Kantian categorical imperative.

Something akin to the Kantian categorical imperative cannot do. The latter enjoins each of us to consider what would happen if the maxim of our present action were made the principle of a universal legislation: the self-consistency or inconsistency of such a *hypothetical* universalization is made the test for our private choices. "But real consequences are not considered at all, and the principle is one not of objective responsibility but of the subjective quality of our self-determination. We are in need of a different consistency: not that of the act *with itself*, but that of its eventual *effects* over time, and not in the abstraction of logic. What the *actual* future will be as a consequence of our actions is what matters."

However, the very same reasons that make consequentialism compelling, and therefore oblige us to anticipate the future, make it impossible for us to do so. Unleashing complex processes is a very perilous activity that both demands certain foreknowledge and prohibits it. To take just an illustration:

> The unpredictable behaviour of nanoscale objects means that engineers will not know how to make nanomachines until they actually start building them[4].

Now, one of the very few unassailably universal ethical principles is that *ought* implies *can*. There is no obligation to do that which one can not do. However, we, who live in the "technological age", do have an ardent

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[3] Hans Jonas, *The Imperative of Responsibility. In Search of an Ethics for the Technological Age*, University of Chicago Press, 1985.
[4] *The Economist*, March 2003.

obligation that we *cannot* fulfil: anticipating the future. That is the ethical aporia. Jonas tried to circumvent it by working out what he called an "Ethics of the Future" [*Ethik* für *die Zukunft*] - meaning not a future ethics, but an ethics *for* the future, for the sake of the future: the preservation of a future for humankind must become the major object of our concerns. Most of our risky technology was invented to improve or enhance what already exists (i.e. for *progress*), not to alleviate the unbearable. This does not justify gambling all people's interests. *Meliorism* – that is, the doctrine that the world tends to improve and that humans can aid its betterment – does not justify total stakes. This is the updated version of Pascal's wager: humanity's nonexistence stands in for Hell, the infinite loss that must not be risked for the brief, doubtful gain of earthly pleasure (Pascal's original version) or meliorism (our version).

Jonas's credo, which I share, is that there is no ethics without metaphysics. It is only if we venture into metaphysics that we'll have a chance to escape from the ethical aporia. My topic is the NBIC convergence: I've tried to show in my work of the last 10 years that the most important ethical issues raised by it are inseparable from the metaphysical assumptions that govern the field. I will focus here on the metaphysics of *acting into nature*, including our nature, to take up Arendt's phrase.

2. The Metaphysics of the NBIC convergence

2.1. Making the World Over

The positivist philosophy that drives most of modern science and technology (and much of contemporary philosophy) takes "metaphysics" to be a meaningless quest for answers to unanswerable questions, but Karl Popper, following the lead of Emile Meyerson, showed that there is no scientific (or, for that matter, technological) research program that does not rest on a set of general presuppositions about the structure of the world. To be sure, those metaphysical views are not empirically testable and they are not amenable to "falsification". However, that does not imply that they are not interesting, substantial, and that they do not play a fundamental role in the advancement of science. Those who deny metaphysics simply render it invisible, and it is very likely that their hidden metaphysics is bad or inconsistent. To the amazement of those who mistook him for a positivist, Karl Popper claimed that the philosopher or historian of science's task was twofold: first, unearth and make visible the metaphysical ideas that lie underneath scientific programs in order to make them amenable to criticism; secondly, proceed

to a critical examination of those metaphysical theories, in a way that is different from the criticism of scientific theories, since no empirical testing is here possible, but nevertheless rational.

Two major philosophers from the seventeenth-eighteenth centuries can be said to have fleshed out the metaphysics underlying the new science the budding of which they were witnessing and of which we are the inheritors: René Descartes and Giambattista Vico. Descartes saw science and technology as aiming at making man master and possessor of nature and of himself. More subtly, Vico gave the postulate of the "new science" (1725) a celebrated formulation: *Verum et factum convertuntur* ("The true and the made are convertible"). This means that we can have rational knowledge only about that of which we are the cause, about that which we ourselves have made. The principle of *verum factum* was originally understood as implying a want or lack on the part of human beings: we can never know nature in the way that God does, for God created what we can only observe. Quickly, however, the principle acquired a positive sense more in keeping with the growing affirmation of modern subjectivism: what human beings make can be rationally---that is, demonstratively and deductively---known despite the finiteness of human understanding. Among the branches of knowledge, ranked in descending order according to their degree of perfection, mathematics by this criterion of course comes first, followed, however, not by the natural sciences but by the moral and political sciences, supposed to be more scientific because they deal with the products of human activity.

As regards the science of nature, however, its first principle, according to Hannah Arendt, had to be that one can know only in making, or rather in remaking. Despite his human limitations, the scientist "nevertheless from the outset approached it [nature] from the standpoint of the One who made it."[5] This explains not only the scientist's emphasis on the "how" of physical processes rather than on the being of things, but also the considerable role assigned by science to experiment.

With the looming advanced technologies, we will be one big step further. The NBIC convergence presents itself as the ultimate culmination of the *verum factum*. It is no longer merely by doing experiments on it, it is no longer merely by modeling it, that men will now come to know nature. It is by *remaking* it. But, by the same token, it is no longer nature that they will come to know, but what they have made. Or rather, it is the very idea of nature, and thus of a given that is exterior to the self, which will appear

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[5] Hannah Arendt, *The Human Condition*, op. cit., p. 295.

outmoded. The very distinction between knowing and making will lose all meaning with the NBIC convergence, as will the distinction that still exists today between the scientist and the engineer. Already today, in the case of biotechnologies, the distinction between discovery and invention, on which patent law rests, is proving increasingly tricky to maintain, as the debates about the patentability of life forms demonstrate.

Under this general heading, we can include what some philosophers call "the artificialization of Nature" and, in particular, of Life and the Mind. The metaphysical program that drives the NBIC convergence, a Promethean project if ever there was one, is to turn man into a demiurge or, scarcely more modestly, the "engineer of evolutionary processes." Biological evolution, with its clumsy tinkering, has often botched the job, and it cannot be especially proud of its latest handiwork, man. It is up to man himself, then, to try to do better. This puts him in the position of being the divine maker of the world, the demiurge, while at the same time condemning him to see himself as out of date. We are dealing here with an extraordinary paradox of the coincidence of opposites, which such philosophers as Hannah Arendt or Günther Anders have brought out: the overweening ambition and pride of a certain scientific humanism leads straight to the obsolescence of man. It is in this broad perspective that we must always set the specific questions which are termed "ethical" and which touch on the engineering of man by man.

The human condition is an inextricable mixture of things given and things made. This means that man, to a great extent, can shape that which shapes him, condition that which conditions him, while still respecting the fragile equilibrium between the given and the made. Now, already in the 1950s, Arendt prophesied a human rebellion against the given. She wrote: "For some time now, a great many scientific endeavors have been directed toward making life also 'artificial', toward cutting the last tie through which even man belongs among the children of nature (…)This future man, whom the scientists tell us they will produce in no more than a hundred years, seems to be possessed by *a rebellion against human existence as it has been given*, a free gift from nowhere (secularly speaking), which he wishes to exchange, as it were, for something he has made himself.[6]" Indeed, the metaphysics of the NBIC convergence dreams of overcoming once and for all every given that is a part of the human condition, especially the finiteness of a human life - its mortality and its beginning in birth. If immortality has always had a place in man's thoughts or dreams, it is only very recently that death has come to be

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[6] Ibid., p.2-3.

considered a "problem" which science and technology can solve by eliminating it. As for birth, the fact that we are born into the world without our having had anything to do with it has become a source of shame [Günther Anders]. We discover that we have been *thrown* (the Heideggerian *Geworfenheit*) into the world and we feel abandoned. We experience forlornness when we realize that we are not the foundation of our own being. Technology fantasmatically promises a remedy for this feeling of nausea: (re)designing ourselves, partially or totally, as if we were our own machines.

At the heart of the metaphysical research program that drives much of contemporary technology, there is an enormous paradox. The metaphysics in question clearly wants to be *monist*: one would no longer say today that everything in the universe proceeds from the same *substance*, but one will say that everything is subject to the same *principles of organization*: nature, life, and the mind. The watchword of cognitive science is: "*naturalizing* the mind." It is a matter of fully restoring the mind (and life) to their proper place within the natural world. Now, it happens that the principles of organization supposed to be common to everything that exists in the universe are mechanistic principles. A device that processes information according to fixed rules, that is, the algorithm, constitutes the sole model of everything that exists. Chronologically, and despite what certain preconceptions might suggest, the mind was first to be assimilated to an algorithm (or Turing machine: McCulloch and Pitts' model, 1943); next was the turn of life, with the birth of molecular biology (Max Delbrück and the "phage group," 1949); and only later came the thesis that the laws of physics are recursive (or *Turing computable*). The naturalization of the mind thus merges with the mechanization of the mind.

2.2. Heidegger's Error

Is the ambition to (re)make the world tantamount to *controlling* it, in keeping with Descartes' metaphysics? Therein lies Heidegger's fundamental error. The author of *Sein und Zeit* thought he had found in technoscience in general, and in cybernetics in particular, the culmination of what he called "Western metaphysics". For Heidegger, metaphysics is the search for an ultimate foundation for all reality, for a "primary being" in relation to which all other beings find their place and purpose. Where traditional metaphysics ("onto-theology") had placed God, modern metaphysics substituted man. This is why modern metaphysics is fundamentally humanist, and humanism fundamentally metaphysical. Man is a subject endowed with consciousness and will: his features were

described at the dawn of modernity in the philosophy of Descartes and Leibniz. As a conscious being, he is present and transparent to himself; as a willing being, he causes things to happen as he intends. Subjectivity, both as theoretical presence to oneself and as practical mastery over the world, occupies center stage in this scheme—whence the Cartesian promise to make man "master and possessor of nature." In the metaphysical conception of the world, Heidegger holds, everything that exists is a slave to the purposes of man; everything becomes an object of his will, fashionable as a function of his ends and desires. The value of things depends solely on their capacity to help man realize his essence, which is to achieve mastery over being. It thus becomes clear why technoscience, and cybernetics in particular, may be said to represent the completion of metaphysics. To contemplative thought—thought that poses the question of meaning and of Being, understood as the sudden appearance of things, which escapes all attempts at grasping it— Heidegger opposes "calculating" thought. This latter type is characteristic of all forms of planning that seek to attain ends by taking circumstances into account. Technoscience, insofar as it constructs mathematical models to better establish its mastery over the causal organization of the world, knows only calculating thought. Cybernetics is precisely that which calculates—computes—in order to govern, in the nautical sense (Wiener coined the term from the Greek xvbepvntns, meaning "steersman" and defined it as "the Control and Communication in the Animal and the Machine"): it seem indeed to be the height of western metaphysics.

Thinking so Heidegger remained blind to a fundamental shift in the metaphysics of contemporary technology. It is often the case that the philosophy implicit to a new field is given away, admittedly in a crude way, by its visionaries and ideologues. On this score it is difficult to be more explicit than Kevin Kelly when he writes: "It took us a long time to realize that the power of a technology is proportional to its inherent *out-of-controlness*, its inherent ability to surprise and be generative. In fact, unless we can worry about a technology, it is not revolutionary enough.[7]"

I will illustrate this assertion with the case of synthetic biology.

2.3. The Metaphysics of Making Life From Scratch

In recent years, the enterprise of "making life from scratch" has been organized as a formal scientific discipline under the seemingly innocuous

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[7] Kevin Kelly, "Will Spiritual Robots Replace Humanity by 2100?" in *The Technium*, a book in progress, http://www.kk.org/thetechnium/

name of synthetic biology. In June 2007, the occasion of the first Kavli Futures Symposium at the University of Greenland in Ilulissat, leading researchers from around the world gathered to announce the convergence of work in synthetic biology and nanotechnology and to take stock of the most recent advances in the manufacture of artificial cells. Their call for a global effort to promote "the construction or redesign of biological systems components that do not naturally exist" evoked memories of the statement that was issued in Asilomar, California more than thirty years earlier, in 1975, by the pioneers of biotechnology. Like their predecessors, the founders of synthetic biology insisted not only on the splendid things they were poised to achieve, but also on the dangers that might flow from them. Accordingly, they invited society to prepare itself for the consequences, while laying down rules of ethical conduct for themselves.[10] We know what became of the charter drawn up at Asilomar. A few years later, this attempt by scientists to regulate their own research lay shattered in pieces. The dynamics of technological advance and the greed of the marketplace refused to suffer any limitation.

Only a week before the symposium in Ilulissat, a spokesman for the ETC Group, an environmental lobby based in Ottawa that has expanded its campaign against genetically modified foods to include emerging nanotechnologies, greeted the announcement of a feat of genetic engineering by the J. Craig Venter Institute in Rockville, Maryland with the memorable words, "For the first time, God has competition." In the event, ETC had misinterpreted the nature of the achievement.[11] But if the Ilulissat Statement is to be believed, the actual synthesis of an organism equipped with an artificial genome ("a free-living organism that can grow and replicate") will become a reality in the next few years. Whatever the actual timetable may turn out to be, the process of fabricating DNA is now better understood with every passing day, and the moment when it will be possible to create an artificial cell using artificial DNA is surely not far off.

The question arises, however, whether such an achievement will really amount to *creating life*. In order to assert this much, one must suppose that between life and non-life there is an absolute distinction, a critical threshold, so that whoever crosses it will have shattered a taboo, like the prophet Jeremiah and like Rabbi Löw of Prague in the Jewish tradition, who dared to create an artificial man, a *golem*. In the view of its promoters and some of its admirers, notably the English physicist and science writer Philip Ball,[12] synthetic biology has succeeded in demonstrating that no threshold of this type exists: between the dust of the earth and the creature that God formed from it, there is no break in

continuity that permits us to say (quoting *Genesis* 2:7) that He breathed into man's nostrils the breath of life. And even in the event that synthetic biology should turn out to be incapable of fabricating an artificial cell, these researchers contend, it would still have had the virtue of depriving the prescientific notion of life of all consistency.

It is here that nanotechnology plays an important symbolic role. It is typically defined by the scale of the phenomena over which it promises to exert control--a scale that is described in very vague terms, since it extends from a tenth of a nanometer[13] to a tenth of a micron. Nevertheless, over this entire gamut, the essential distinction between life and non-life loses all meaning. It is meaningless to say, for example, that a DNA molecule is a living thing. At the symbolic level, a lack of precision in defining nanotechnology does not matter; what matters is the deliberate and surreptitious attempt to blur a fundamental distinction that until now has enabled human beings to steer a course through the world that was given to them.

Once again, we find that science oscillates between two opposed attitudes: on the one hand, vainglory, an excessive and often indecent pride; and on the other, when it becomes necessary to silence critics, a false humility that consists in denying that one has done anything out of the ordinary, anything that departs from the usual business of normal science. As a philosopher, I am more troubled by the false humility, for in truth it is this, and not the vainglory, that constitutes the height of pride. I am less disturbed by a science that claims to be the equal of God than by a science that drains of all meaning one of the most essential distinctions known to humanity since the moment it first came into existence: the distinction between that which lives and that which does not; or, to speak more bluntly, between life and death.

Let me propose an analogy that is more profound, I believe, than one may at first be inclined to suspect. With the rise of terrorism in recent years, specifically in the form of suicide attacks, violence on a global scale has taken a radically new turn. There was a time when even the most brutal persecutor expressed his attachment to life, because he killed in order to affirm and assert the primacy of his own way of living. But when the persecutor assumes the role of victim, killing himself in order to maximize the number of people killed around him, all distinctions are blurred, all possibility of reasoned dissuasion is lost, all control of violence is doomed to impotence. If science is allowed, in its turn, to continue along this same path in denying the crucial difference that life

introduces in the world, it will, I predict, prove itself to be capable of a violence that is no less horrifying.

If they were interested in Heidegger's "deconstruction of Western Metaphysics", the proponents of synthetic biology would dismiss the "onto-theological" imputation that their implicit metaphysics is the substitution of Man for God, and they would be right! Theirs is a much more devastating project and – another huge paradox – much more akin to the ambition pursued by Heidegger himself and his followers, structuralists, post-structuralists, deconstructionists and the like: namely, the debunking of Man and of all the distinctions he has introduced in the world to navigate his way in it. In other terms, theirs is an anti-humanist metaphysics.

3. Designing Self-Organization

All the paradoxes that I have brought out so far are epitomized in the paradox involved in the project of *designing self-organization*.

With the NanoBioConvergence, a novel conception of engineering has indeed been introduced. The engineer, far from seeking mastery over nature, is now meant to feel that his enterprise will be crowned by success only to the extent that the system he has created is capable of surprising him. For whoever wishes ultimately to create a self-organizing system--foremost life--is bound to attempt to reproduce its essential property, namely, the ability to make something that is radically new.

3.1. Natural versus Artificial Machines

One of the most outstanding conceptual breakthroughs of the second half of the twentieth century was the emergence and the development of the notion of *natural machine*. The current dynamics of technoscience thrives on the corruption and decomposition of that idea. The ethical and political implications are momentous.

The reader of Descartes may react here to what she may take as an anachronism. Obviously there was no need to wait for the twentieth century to treat nature and life as if they were machines. But one should avoid a confusion at all cost. One must not confuse the metaphysics that treats nature and life as artificial machines, on the one hand, that is, machines that have been designed by an artificer – in which case we remain caught in a form of finalism or teleology; and the metaphysics
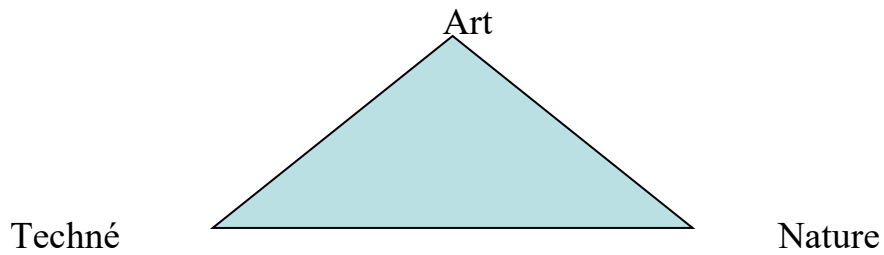
that treats them as natural machines, on the other hand, that is, that dispenses altogether with a conscious designer, be it God, the gods, or Nature itself. The theory of complex, self-organizing systems that emerged in the wake of cybernetics and in reaction to it permits us to give full consistency to the concept of a complex machinery such as life without a designer.

An impressive series of scientific and mathematical discoveries made during the second half of the twentieth century has completely changed the way in which we conceive of dynamics, the branch of mechanics that concerns the trajectory of a material system subject to purely causal physical laws. It is well known today that complex systems, made up of many elements interacting in nonlinear ways, possess remarkable properties—so-called emergent properties—that justify their description in terms that one should have thought had been forever banished from science in the wake of the Galilean-Newtonian revolution. Thus it is said of these systems that they are endowed with "autonomy," that they are "self-organizing," that their paths "tend" toward "attractors," that they are "path-dependent", that they have "intentionality" and "directionality"—as if their paths were guided by an end that gives meaning and direction to them even though it has not yet been reached; as if, to borrow Aristotelian categories, purely efficient causes were capable of producing effects that mimic the effects of a final cause.

In a sense, we are not far here from Kant's conception of nature in the second part of his third Critique, the *Kritik der Urteilskraft*, entitled "Critique of Teleological Judgment." Only explanations that ultimately appeal to causal mechanisms are considered adequate. Nonetheless, faced with the most surprising manifestations of complexity in nature (life for Kant), recourse to another "maxim of judgment"—teleological judgment—becomes inevitable. Concepts such as "internal finality" are indispensable, and perfectly legitimate, so long as one keeps in mind that they have only heuristic and descriptive relevance. Teleological judgment consists in treating them as though—the Kantian *als ob*—they have objective value.

3.2. Dangerous Metaphors

It is striking, to say the least, to observe how unstable this notion of natural machine has been in the ecology of scientific concepts.

Art

Techné   Nature

In this golden triangle whose vertices are Art (construed as human workmanship), Nature (including Life), and Technique (construed as the science of the mechanical) and whose center is the concept of complex, self-organizing system, the Art-Nature side represents Kant's *Critique of Judgment* with its two legs: aesthetic judgment and teleological judgment; the Art-Techné side, the concept of artificial (man-made) machine; and the Techné-Nature side, the concept of natural machine. It is the Kantian side that keeps the natural and the artificial apart. When it collapses – that is, when the concept of immanent finality is lost track of -, the semantic proximity between machine and artifact causes the concept of natural machine to disappear.

Confronted with the complexities of natural and biological systems, theistic philosophy inferred the existence of God via the notorious argument from Design. Thus, David Hume, in his *Dialogues Concerning Natural Religion* [II, 1776]:

> Look round the world: contemplate the whole and every part of it: You will find it to be nothing but one great machine, subdivided into an infinite number of lesser machines, which again admit of subdivisions to a degree beyond what human senses and faculties can trace and explain. All these various machines, and even their most minute parts, are adjusted to each other with an accuracy which ravishes into admiration all men who have ever contemplated them. The curious adapting of means to ends, throughout all nature, resembles exactly, though it much exceeds, the productions of human contrivance; of human designs, thought, wisdom, and intelligence. Since, therefore, the effects resemble each other, we are led to infer, by all the rules of analogy, that the causes also resemble; and that the Author of Nature is somewhat similar to the mind of man, though possessed of much larger faculties, proportioned to the grandeur of the work which he has executed. By this argument a posteriori, and by this argument

alone, do we prove at once the existence of a Deity, and his similarity to human mind and intelligence.

The best evidence that Vico's *Verum Factum* has carried the day is that a full-blown scientist today, confronted with the same complexities, will reverse the argument from design and conclude that "there are too many things that just don't make sense if they were designed. If they were designed then we should fire the designer." In other terms, if It were a designer, Nature would have botched the job. But we are on a very slippery slope. The design metaphor is so strong – and the concepts of natural machine, immanent finality, self-organization, etc. are so elusive – that the metaphor of the artificial machine eventually wins the day. Instead of saying "there is no design" one says "the design is bad". Witness the conversation between American journalist Michael Krasny and evolutionary biologist Neil Shubin, author of the fascinating book *Your Inner Fish*, in which he traces back most of the human anatomy to our fish ancestors:

> NS: We are not designed very intelligently. We're designed historically […] When you look at the human body, … you find bizarre detours and loops and turns and twists that make no sense. Nobody in their right mind would have designed a body like this.
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> MK: You mean, God wasn't in His right mind?
> [Laughters]
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> NS: The fish were in their right mind. […] The spermatic cord in human males makes a weird loop around the pelvis: a really bad design![8]

One further step and it is inevitable to ask questions such as "Can nanostructuring improve on *Nature's design*?"[9] Or, like Damien Broderick, "Is it likely that nanosystems, designed by human minds, will bypass all this *Darwinian wandering*, and leap straight to *design success*?"[10] One can hardly fail to note the irony that science, which in America has had to engage in an epic struggle to root out every trace of

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[8] NPR/KQED San Francisco,

[9] Hongyou Fan, et al. "Modulus density scaling behaviour and framework architecture of nanoporous self-assembled silicas" *Nature Material* 6, (May 21, 2007). 418-423, 1.

[10] Damien Broderick, *The Spike: How Our Lives Are Being Transformed by Rapidly Advancing Technologies* (New York: Forge, 2001), 118.

creationism (including its most recent avatar, "intelligent design") from public education, should now revert to a logic of design in the form of the NBIC convergence—the only difference being that now it is mankind that assumes the role of the demiurge.

The important point here is not the mimetic rivalry between mankind and Nature – one admires the weight of contempt carried by this "all this Darwinian wandering": French Nobel laureate François Jacob spoke of "bricolage" - , but what the stakes are: it is a matter of being the better designer! But, of course, all the critiques that have been leveled at the "Intelligent Design" paradigm, leading to the concept of self-organization, are even more pertinent in the case of human design. There is way too much information, in the form of complexity, in the organizations presented us by Nature for a single mind, even if it is God's, to have been able to design them. If mankind strives to emulate a feat that God himself could not have achieved, doesn't it run the risk of playing the sorcerer's apprentice? Furthermore, human beings do those things for a purpose – e.g. meliorate their well-being. However, as French poet Paul Valery once wrote, « *Artificial* means, that which tends toward a definite goal. Artificial is then the opposite of living […] If Life had a goal, it would no longer be Life.[11] » The notion of "artificial life" is a sheer oxymoron.

Last but not least, let's not forget our starting point: we are able to act into nature and our ambition is to design complex processes that escape our control. Traditionally, the notions of design and control belonged together. The new metaphysics associates design and out-of-controlness, a marriage that Heidegger could never envisage. In 1948, John von Neumann, in a famous lecture, defined a complex machine (which he called an automaton) as one capable of bringing about something more complex than itself: its own behavior. Soon, he went on to prophesy, the builder of automata would find himself as helpless before his creations as we feel ourselves to be in the presence of complex natural phenomena. With the NanoBio convergence, we may be nearing that moment. The sorcerer's apprentice myth will then have to be updated: it is neither by error nor by terror that Man will be dispossessed of his own creations but *by design*.

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[11] *Cahier B*, 1910.

4. Setting limits: technology and religion

With all its paradoxes, the metaphysics of the NBIC convergence is purely secular. We shouldn't pay too much attention to the accusation that mankind is "playing God", given that the exchanges it leads to are mainly rhetorical. I would like to conclude, nevertheless, by broaching the issue of the relationship between technology and religion.

Those who make the claim that mankind is "playing God" and that that is a forbidden game have something in common with those who shrug that claim off: both camps assert that this taboo is specifically "Judeo-Christian." In one of his most insightful reflections on his responsibility in the bombings of Hiroshima and Nagasaki, Oppenheimer said in 1965, echoing in a way this imputation:

> Long ago, I said once that in a crude sense … the physicists had known sin. I didn't mean by that the deaths that were caused as a result of our work. I meant that we had known the *sin of pride*. We had turned to effect in what proved to be a majority way the course of man's history. We had the pride of thinking we knew what was good for man […] This is not the natural business of a scientist[12].

The reference to the "Judeo-Christian", I am afraid, completely misconstrues the lesson of the Talmud as well as that of Christian theology. It gets them mixed up with the ancient Greek conception of the sacred: the Gods, jealous of men guilty of *hubris*, send after them the goddess of vengeance, *Nemesis*. But the Bible depicts man on the contrary as being the co-creator of the world. As the biophysicist and Talmudic scholar Henri Atlan notes when analyzing the literature about the Golem:

> One does not find [in it], at least to begin with, the kind of negative judgment one finds in the Faust legend concerning the knowledge and creative activity of men 'in God's image.' Quite to the contrary, it is in creative activity that man attains his full humanity, in a perspective of *imitatio Dei* that allows him to be associated with God, in a process of ongoing and perfectible creation.[13]

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[12] Interview on CBS News, 5 August 1965.

[13] Henri Atlan, *Les Etincelles de hasard*. Tome 1: *Connaissance spermatique*, Paris, Seuil, 1999, p. 45.

As to Christianity, a whole series of major authors, from Max Weber to Louis Dumont, from Marcel Gauchet to René Girard, have analyzed it as "the religion of the end of religion": they hold it responsible for the desacralization of the world (the famous "disenchantment"), and, consequently, for the progressive elimination of every taboo, prohibition or limit. This, moreover, is why the same authors view Christianity as the primary cause of the scientific and technical development of the West, for science and techniques depend precisely on the overcoming of every limit.

It fell to science itself to pursue this desacralization of the world set in motion by the religions of the Bible, by stripping nature of any prescriptive or normative value. It is therefore utterly futile to try to paint science as being at odds with the Judeo-Christian tradition on this point. Kantianism conferred philosophical legitimacy on this devaluation of nature by making the latter a world devoid of intentions and reasons, inhabited only by causes, and by separating it radically from the world of freedom, where the reasons for action fall under the jurisdiction of moral law.

Where then is the ethical problem located, if there is one here? It is clearly not in the transgression of who knows what taboo or limit guaranteed by the sacred, since the joint evolution of religion and science has thoroughly undermined the very concept of a moral limit, and hence of a transgression. But that is precisely the problem. For no free and autonomous human society exists which does not rest on a principle of *self*-limitation, even when it believes it has received this principle from some kind of transcendent authority. Rousseau and then Kant defined freedom or autonomy as obedience to the law one gives oneself. Rousseau wanted the laws of the political community to have the same exteriority with respect to men as the laws of nature, even though it is men who make the former and even though they know this. But in a society that dreams of shaping and molding nature to its desires and needs, it is the very idea of an exteriority or alterity which loses all meaning. The substitution of the made for the given is obviously a part of this same process. Traditionally, nature was defined as what remained exterior to the human world, with its desires, its conflicts, its various depravities. But if, in our dreams, nature becomes entirely what we make of it, it is clear that there is no longer anything exterior, so that everything in the world will sooner or later reflect what men have done or not done, sought or neglected.

How are we going to set limits? What are we going to ground them in, in the absence of any form of legitimizing authority other than our own free agreement? This is the most important challenge of our times.

I have no ready-made solution to offer. What I know for sure is that we will always keep the liberty to set limits to ourselves. In other terms, I do not advocate any form of technological determinism. It is only when some critical thresholds are crossed that everything happens *as if* we were the puppets of our own creations. We'll know that that is the case when we are no longer able to think through what we are doing.

I would like to quote one last time from *The Human Condition*, Hannah Arendt 's masterpiece, as I did in the beginning:

> The trouble concerns the fact that the 'truths' of the modern scientific world view, though they can be demonstrated in mathematical formulas and proved technologically, will no longer lend themselves to normal expression in speech and thought. […] it could be that we, who are earth-bound creatures and have begun to act as though we were the dwellers of the universe, will forever be unable to understand, that is, to think and speak about the things which nevertheless we are able to do. In this case, it would be as though our brain, which constitutes the physical, material condition of our thoughts, were unable to follow what we do, so that from now on we would indeed need artificial machines to do our thinking and speaking. *If it should turn out to be true that knowledge (in the modern sense of know-how) and thought have parted company for good*, then we would indeed become the helpless slaves, not so much of our machines as of our know-how, *thoughtless creatures* at the mercy of every gadget which is technically possible, no matter how murderous it is.[14]"

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[14] Op. cit., p. xx.