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Nanoarchitectures: The Synthetic Design of Extensions and Thoughts

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0 nanoprograming

> An ideal architecture is one that you can plant as a seed having programmed it with all the information it needs to grow itself in an environment where it can organically seek out and connect with the resources it needs. […] The architecture would be able to reproduce by cloning itself using a germline structure that offers humans an opportunity to make necessary genetic adjustments. […] The end of the lifecycle of the architecture would come when it is no longer responsive to human activity … possibly decaying in the ecosystem to be recycled by its progeny.
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> (Armstrong, 2008).

The architecture of the future will not simply substitute the natural properties of the environment with a software modelling of matter, but, more radically, will strive to reprogram space as a synthetic environment growing anew from the nanoscale of matter. In 1959, the physicist Richard Feynman already envisaged that material stuff could be redesigned starting from its atomic architecture (Feynman, 1959). In his famous talk entitled 'There's Plenty of Room at the Bottom', he stated that there was no principle in physics that could prevent the rearrangement of atoms. Much later, in *The Engines of Creation*, Drexler (1986) explained that with the atom-by-atom structuring of matter, it was possible to design molecular machines that could reproduce themselves at incrementally smaller scale.

These principles of atomic engineering led to the establishment of the new techno-scientific field of nanotechnology, aiming to reprogram atoms and molecules ranging from 0.1 to 100 nanometers (a nanometer is one millionth of a millimeter). As atoms aggregate into larger compounds or molecules, their interaction is the motor by which inorganic and organic compounds can likewise be cultivated to grow. As a result of more than 15 years of research into this field, companies, such as Intel, IBM, Bayer and Merck, are now designing real nanoproducts (from atomic computers to smart drugs and from intelligent buildings to smart clothing),[1] by using assemblers to modulate the chemical behaviour of atoms. As Drexler envisioned, nanomachines such as '[c]ell repair machines could reassemble the misarranged patterns of atoms […] and build bodies from scratch' (ibid., 98).

Since nanotechnologies may appear to define another level of mechanization of matter, where atoms are programmed to assemble together to generate certain forms and functions, the question of affect, as a qualitative measure for the capacity of feeling change may seem irrelevant here. However, this chapter suggests that extending the notion of affect toward the atomic level of matter may contribute to point at another, less obvious, significance of affect as a way of revealing inhuman modes of feelings and registering material change. At the same time, however nanotechnologies are computing machines, able to calculate and perform all possible combinations of atoms. In other words, nanotechnologies are not simulations and contribute to the wider field of ubiquitous computing not by adding a more detailed visualization of molecular data, but by directly hacking atomic structures to design new ones. From this standpoint, nanotechnologies are weapons of affect. On the one hand, nanotechnologies add another measure to the quality of feeling, since they intervene in matter to tease out unexploited potentialities of organic reproduction and design of forms and functions. On the other hand, instead, these technologies reveal that affect, as a mode of feeling, is not bounded to organic bodies and on the contrary defines an architecture of feeling, a machinic registering of change that occurs at all levels of matter. Contrary to the assumption that nanotechnologies are but another example of mechanization of matter, this chapter will suggest that the cultural and aesthetic significance of nanotechologies, and in particular, nanoarchitecture need to be rearticulated according to an abstract notion of affect. This is meant to argue for the autonomous machine of affect, or as Brian Massumi put it, 'the autonomy of affect' from emotion and from the cognitive structures of meaning. Rather than showing how this autonomy works at the level of the body, this chapter points at the workings of affect at the level of nanoparticles. In particular, however, the example of nanoarchitecture serves here to highlight how the synthetic design of spatial extension also involves a synthetic design of thought. It is this artificiality of feeling and thought in what is assumed to be the most natural of habitats for our species that interests me here. Nanoarchitecture in fact is a fictional attempt at pushing forward what is already technologically implemented in the design of smart molecules that make it *natural* for clothes to respond to temperature variations and for drugs to switch neurons on and off, to simulate the feeling of happiness, or to warn you that your heartbeat is suddenly increasing. As a form of computation, smartness (as applied to clothes, weapons or drugs) is a way to precisely design responsive effects. This design however now relies on network systems of interaction and particularly on non-linear dynamics of connection, whereby the relation between terms has become more important than the terms themselves. What happens in relations precisely concerns the deployment of affect as a field of forces defined by the uncertainty of contingencies.

From this standpoint, the question of whether nanoarchitecture already exists or not or whether we are close to such implementation is in this chapter less important than what nanoarchitecture also envisions to be the built space in the age of nanotechnology. This space will no longer be simply artificial or natural, but will be synthetically designed to grow and evolve according to planetary changing circumstances and thus become the body that registers variations and anticipates actions. In other words, the nanoarchitectural space will be an autonomous body of affects impinging upon and more subtly governing modes of thought and feeling as we know them. The nanoprogramming of matter is not just a thing of the future, but is here an instance of how the present is defined by futurity: the potentiality of matter to be infinitely autonomous from what it is intended to be.

This chapter is concerned with how automata or machines, or any kind of mechanization of matter, instead, can be said to deploy an oblique notion of affect. This means that the quality of affective power is not only defined by the feeling of change in a system of interaction between bodies (human–machine, organic–inorganic, natural–artificial). The feeling of change instead importantly points to the power of the relation before the terms. As an index of qualitative change or intensity, affect therefore implies that quality and quantity are inseparable states having singular modes of thought and extension, which can coexist in different modes of aggregation (mathematical, physical, chemical, biological, technical) constituting actual machines of feeling-thought. In short, this chapter asks: what kind of automated feeling occurs in synthetically constructed, and in particular, nanoengineeringly designed, extension and thought?

To insist on the oblique character of affect here coincides with a speculative attempt at pushing this notion outside the realm of biological and physical immediacy so to argue that affective power extends to synthetically designed bodies and thoughts. At stake here is the necessity of disincarnating affect from a bio-physical body and a thinking mind in what is a culture of data programming and data explosion, of which nanotechnology and nanoarchitecture are examples. However, it could be argued that nanotechnologies are in the end not a technology at all, but expose what atoms and molecules already do in the physical world and that mathematical algorithms are just the language of programming that can be applied to any physical matter. From this standpoint, matter's capacity to affect and be affected is already intrinsic to atomic behaviour as explained by particle physics. Here technological machines are but another expression of the engineering of a never been natural nature described by the language of mathematics. If we were to follow this thread of thoughts, it would be quickly realised that repetition rather than change dominate both the laws of physics, which can be metamathematically described by finite sets of algorithms. Instead, the point of bringing the notion of affect into the realm of nanotechnology precisely implies that nothing remains the same. The nanodesign of atoms instead acts as an affective trigger for new forms and functions that indirectly impinge upon the physical realm itself. Similarly, the mathematical algorithms used to describe this changing realm are not merely simulations of what already exists.

The computational power at play in nanotechnology instead reveals that the programming of matter itself is no longer summoned into a universal language but rather exposes indeterminacy in calculation itself. Gregory Chaitin's theoretical articulation of uncomputable algorithms within information science challenges a universal view of computation and instead suggests that there can be no program, no theory, no universal logic, that can synthesize or incorporate all processes of computation. The significance of the uncomputable for this chapter is that even the algorithmic system of measure is tainted with the power of affect, the abstract machinery of registering change in feeling/thought. Far from being physical entities relying on the universal language of mathematics, nanotechnology and nanoarchitecture here serve to suggest that a new kind of physical entity is instead advancing underneath the natural strata in the same way as computational processing has broken from universal logic as uncomputable algorithms have entered the core of programming. It would be misleading however to assume that nanotechnologies are just another example of the arrival of pure chaos as a counter-actualization of pure control, or control without control. What is at stake here is the realization that pure chaos or patternless structures are not simply beyond order or logic, mathematical universals and physical laws. The question, which remains unresolved here, is of a speculative order, because it takes the tension between control and chaos to be a symptom of a real futurity programming the present by redesigning matter and thought. In other words, if control is investing in chaos, it is because it is working to grasp the randomness – or uncompressible nature – of affective power, whose order, structure or pattern are yet to be universalized and rather remain scattered, discontinuous, infinite instances of a multiplicity of modes of thought and extension.

1 nanodesign

It may be clearer now that nanodesign is here used not as an instance of nanotechnology that simply programs matter in a specific way, but to suggest that it is working to build synthetic feeling and thought all together. Contrary to interactive architecture for example, where buildings are designed to respond to changes of states defined by bodies moving in space or by atmospheric variations, nanoarchitecture relies on the nanodesign of matter as found in the field of nanotechnology.

By redesigning atomic patterns, nanotechnology captures their chaotic behaviour into new actualizations; by neutralizing chemical reactions in the nanofabrication of new compounds nanotech intervenes in the emergence of new molecular architectures incorporating the quantic behaviour of atoms.[2] Yet this implies no predetermination of molecular patterns. A capture also entails the reversal activity of being captured. Capture is here intended as a capacity to actualize new compounds, the transformation of molecular indeterminacy into new determinations. Hence with nanotech, matter has become programmable only to the extent that nanosystems actualize new atomic functions whose future potentials remain unpredictable.

At the core of nanotechnology is not so much the artificial manipulation of molecules, but the production of molecular-designing machines: nanomachines are thus able to direct quantum patterns towards new actualizations. At the nanoscale, particles can become 'probability waves', which leap across impenetrable barriers, occupy two places at the same time, and anticipate future states. In particular, programmable matter is based on the design of artificial atoms or quantum dots. Will McCarthy first used the term 'Programmable Matter (TM)' in connection with quantum dots to propose a mechanism for the precise 3D control of large numbers of quantum dots inside a bulk material.[3] According to McCarthy, a building, a suit of clothing or an implantable prosthetic skeleton could be entirely devised with programmable matter. In particular, programmable matter would not just provide access to impossible physical states; but would allow the building material to *change* states simply by shuffling electrons around. In this sense, programmable matter aims at reconfiguring physical properties in real time through the application of light, voltage, electric or magnetic fields, etc. It aims to neutralize the distinction between the physical composition of materials – atoms, photons, protons, electrons – and their properties, such as colour, shape, smoothness, brightness, and so on. In other words, it aims at extractive the affective power of materials before they become qualified in a specific form or function.

For instance, the nanodesign of artificial atoms goes beyond the real potential of atoms' natural shapes. A programmed atom can be square, pyramidal, two-dimensional, highly transuranic, and composed of charged particles other than electrons (e.g. 'holes'), and can even be asymmetrical. Their size, energy and shape have now become variable quantities without specific quality. Atoms exhibit optical, electrical, thermal, magnetic, mechanical, and (to some extent) chemical behaviours, which do not occur in natural materials. Even their structure is not determined by electrons' attraction to a positively charged nucleus, but by an electrostatic repulsion and a geometric asset called P-N-P junctions. Whilst stable natural elements are limited to 92 electron states, artificial atoms can have hundreds, even thousands, unleashing a virtual chemistry where atoms bond with one another, interacting to create new atomic compositions. For programmable matter aims for materials to change their substance instantaneously like the design and debugging of software. By entering the realm of pure potentials – of colour, shape, roughness, electricity, vectoriality, etc. – programmable matter promises an architecture of instantaneous realization of potentialities.

Gilles Deleuze (1995) warned us against the supple sprawling of algorithmic architecture coming to govern all aspects of thought and extensions by smoothing all asymmetries of connection into one flat space of continual modulation. The ever-changing dynamics of form dictated by the inexactitude of temporal sequences, defined control as the operations of collapse between the past and the future in a ceaseless reprogrammable present. With nanotechnology, matter is atomically programmed to grow and evolve, nano-ergonomically adapted to respond like a living body and an intelligent creature, ultimately overcoming the trials and errors of natural evolution. The nanodesign of the spatial matrix indeed is set to pulverize all contingencies of the bio-physical ground, by building a synthetic architecture, which is able to anticipate uncertainties by including fuzzy states in the programming of matter and thus construct modes of thought and extension that are ontologically autonomous, and irreducible to forms of living and thought as we know them. At work here no longer is control intended as the calculation of the future by means of prediction, or the calculation of the unknown through pre-set probabilities. The disappearance of bio-physical contingencies instead is directly proportional to the nano-programming of uncertainties as the inclusion of fuzzy states in the design of thought and extension. And yet, in 1986, Drexler had already warned us against the double face of the nanotech coin, the dark side stemming from the unintentional consequences haunting the ideal architecture of matter, and named it the 'grey-goo scenario': when non-biotic machines start to grow autonomous characters, behaviours, intelligences, mobility that surpass the ability of existing devices of control. In other words, the 'grey-goo scenario' refers to when synthetic machines, nanobots or artificially grown intelligent systems take on a life of their own. In 2000, Bill Joy, the co-founder of Sun Microsystems, announced a public warning against the unforeseeable dangers of nanobots in the strange new combination of genomics and robotics. 'Our most powerful 21st-century technologies –robotics, genetic engineering, and nanotech – are threatening to make humans an endangered species' (Joy, 2000). The imminent threat of nanorobots to the nature of the human species however corresponds to a deeper a threat to the biotic ground of bodies and thoughts (organic bodies and brains) in the form of automatic self-replicating devices spreading disastrously beyond control.

From this standpoint, the nanocontrol of atomic patterns reintroduces the threat of non-living extensions and thoughts to the dominance of biotic life: the split of inorganic thought and bodies from the organic strata. The grey-goo scenario envisages nanodesigned systems taking over and re-engineering living systems. To put it in another way, by moving beneath carbon-based life (the use of protein to generate new proteins), the nanoengineering of matter will irreversibly change the nature of the body and thought through controllable yet utterly choatic abiotic nanobots. Thus, the extent to which nanobots are able to control themselves in their remaking of biotic systems remains an open question. Nanobots do not abide by Asimov's laws of robotics (the human–robot distinction according to which the robot follows the rules of the master) or the bioinformatic command line of the cyborg (according to which the human accepts to become hybridized with the machine). Nanobots accept no compromise and initiate the process of inorganic reprogramming of the organic nature of matter all together. Moving beyond the uncertainties of genetic engineering, nanobots force biotic life to confront the far-from equilibrium dynamics of its quantum condition.

From this standpoint, nanoarchitecture is proactively designing the futurity of the future by substituting bio-physical materialities with the nanoprogram of matter and thought. Such proactivity is determined by the nanodesign of atomic and molecular particles able to program an architectural structure from within its indeterminate or fuzzy conditions. Here programmed algorithms have entered the nanostrata of matter, to the extent that computational programming here corresponds to synthetic biology.[4]

2 hacking the bio-ground

Recently, synthetic biologist Chris Voigt has pre-programmed bacterial organisms to detect information changes in the cellular environment and to secrete spider silk proteins in order to build a stronger elastic biomaterial. Similarly, Massachusetts Institute of Technology (MIT) researcher, Angela Belcher, has used viruses to build tiny wires for environmentally friendly microelectronic circuits, avoiding the use of toxic material or high temperatures (see http://belcher10.mit.edu). Similarly, according to Belcher, the synthetic design of a biological counter for instance is not meant not replace laptop computers, but will serve to evolve biological computing through the inserting of memory and logic into cells.[5]

These two brief examples already reveal to us that synthetic biology goes beyond what is already bio-technically possible and does not intend to simply imitate nature. Synthetic biology promises to computize or to mathematically decode biology and the bio-physical strata of evolution, adaptation and change with a monstrous engineering of new molecules, bacteria and viruses that have never and would never exist otherwise. In other words, synthetic biology implies a quantification of the biological ground realized by the extension of mathematical coding or programming beyond the generative use of algorithms to design endlessly evolving forms. The biological ground is thus computed to perform evolution beyond its biological possibilities. By reprogramming cells and environments, the auto-evolving and adaptive spatiality created by software modelling will veritably be built with synthetic bioparts. These parts are also known as 'biobricks',[6] nanotechnical devices which are equivalent to electrical engineers' transistors, capacitors and resistors, used to reprogram cells. Each biobrick is made of a standard biological part containing information of a piece of DNA and of its encoded functions, adding an extra layer of information according to which cells can be reprogrammed beyond their original rules.

According to Endy Drew, co-founder of the BioBricks Foundation, biobricks are concrete devices that break down all genetic, structural and functional biological components in real time, which can then be architecturally re-engineered anew, without simply simulating the original natural model. He argues that BioBrick™ standard biological parts allow us to program living organisms in the same way a computer scientist can program a computer. Because synthetic biology does not require a close knowledge and understanding of fundamental DNA sequencing, Drew has devised a series of open source genetic objects to expand the production of biobricks outside the lab doors into the public domain.[7] For instance, at the International Genetically Engineered Machine competition (iGEM), students have been invited to build biobricks in a DIY fashion, showing how the synthetic production of biological components is attuned to the culture of open information, access and participation in software programming. Drew has advocated for a sort of open laboratory where participatory learning methods define an empirical computational practice, devoted not to the implementation of mathematical models of simulation, but to the extension of mathematical rules to the programming of biology. Synthetic biology is then becoming a cultural practice of hacking biology,[8] reprogramming the molecular order beyond its own bio-physical capacities. This reprogramming is central to the construction of unnatural atomic architectures or nanoarchitectures subtending the design of new kinds of buildings and cities, able to adapt, recycle, evolve and die out, set to idealistically overcome the problems of accumulation, excess and waste of industrial and post-industrial cultures.

Nanoarchitecture was architect John M. Johansen's vision of the future of built environments inspired by the nano-synthesis of material proposed by the Foresight Institute.[9] His speculative design resulted in a series of nano-buildings developed from a mathematically programmed genetic code planted and then grown on site, aiming to respond to the potential variations of the environment. For Johansen (2002), nanoarchitecture proclaimed the end of architecture as we know it.[10]

According to this view, nanoarchitecture is not simply defined by the physical implementation of synthetic atoms into buildings, but determines the advances of a new species of buildings, which are smart organisms ready to sustain one another, self-organising, self-regulating and self-diagnosing their own malfunctions so as to reconstruct and replace their damaged tissue of connection. Nanoarchitecture radically announces the neo-construction or neo-stratification of a synthetic ecosystem of communication, transportation and energization. Here the computational growing of form is actively programmed in the nanodesign of materials containing virtual instructions for the growing and modifying of each and any building on site. Far from reiterating the gap between computer models (or the algorithmic architecture of generative form) and the physical realization of buildings, the neotectonics of built environments–nanoarchitecture exposes the concreteness of abstract architectures offering a precise diagram of unknown atomic complexities building the most unforeseeable of forms.

Johansen's project, the 'molecular-engineered house' is described in a diary of its day-by-day growing (ibid., 24–30). Set in the year 2200, the molecular-engineered house is planned to grow in nine days out of a nanodesigned set of DNA codes – pre-programmed germinal seed – which have ultimately substituted traditional forms of planning, such as drawings, with mathematical speculative calculations. Synthetic DNA defines how the surplus value or the potential of genetic code will veritably substitute the entire computational machine of building or the meta-machine of architectural coding – e.g. axiomatic formal systems governing the political, economical, cultural and communicational organization of the built environment – with a virtual architecture of pro-programmed control able to transversally pass through distinct arrangements of order in rule-specific habitats.

Here DNA codes are nanotechnologically designed, but are also able to articulate their feature on site through sets of selected chemicals and bulk materials in liquid form used to harvest the molecular growth of the house. The nanohouse, for Johansen, simply starts in the form of a vascular system, with roots originating from chemical composites. Such roots will then form grade beams, extending horizontally to the edge of the house, where they curve upward to support the superstructure. Johansen envisions the ground floor of the house as formed by cross ribs that connect the grade beams. These are the starting levels of growth of the structure, which the following day develop into a superstructure, equipped with exterior and interior vertical ribs. Between these connecting ribs, Johansen includes a varied density of lattice, which begins to fill the gaps. To this he adds the formation of a neural network, which is not pre-programmed, but designed to pro-develop step by step in accordance with changes in the vascular system.

The following day, the spinal cord of the house starts to grow into a sprouting central staircase connecting with the upper floor. Meanwhile, the exterior of the house folds inwards into a protective membrane of the interior deployed by an unbroken fabric, infused with electric current by a manual selector that induces the molecules to discharge and form openings. Other molecules are designed to act as muscles at the opening edges, bending to open the membranes and allowing access inside the house. Once inside, light glowing through translucent membranes affords the experience of an enveloped ambience, varying from opaque to transparent tonalities.

Johansen insists that this is a self-sufficient nano-house because it is autonomous from public services, such as the distribution of heat, the collection of waste, and the provision of water. Hence, solar power activates heat, but also the cooling, recycling and purification of water, while nano-molecules sustain and repair the material composition of the house. In this nano-engineered house of the near future human social codependence vanishes in favour of a society of molecules defined by each and any building-entity disentangled from the imperative of biological cooperation for survival. This nanoengineered ambience rather seems to install a new regime of synthetic cooperation, based on the auto-immunity of each and any component of a building, onto the causal chain of physical interaction. Hence, a synthetic cooperation between the intrinsic potential of parts is here able to pro-program their forms and functions accordingly. Not simply a self-enclosed, solipsistic architecture, but rather a potentiation or a surplus valuation of architectural codes. Not the governance of meta-axioms of exact instructions, but rather the weird calculation of surplus values intersecting the potential potentialities of codes across distinct levels of computational architecture.

Johansen's nanoengineered house continues to grow. The interior design evolves out of walls and floors making furniture a potential extension of the entire structure itself. The floor in particular is engineered with a resilient, spongy substance able to respond to tactility by changing its texture, colour and consistency according to circumstances. On day eight, the house will have become a protective cocoon synthetically equipped with opaque, iridescent and gossamer membranes that respond to the immediate environment. Finally, on day nine, the last day of molecular growth, the space becomes habitable, and the nano-engineered structure is ready to become infected with new hosts.

While the ubiquitous computing of interactive architecture smoothens channels of input and output communication between stimuli and response, by prototyping super compatible machines of transmission, the nano-computed house rather works to anticipate potential changes through a series of proto-models ready to mutate the arrangement of the space – the kitchen becomes a bedroom, a study becomes a playroom, and so on. From this standpoint, the nano-computed house does not wait for external input to become activated, but it is itself able to anticipate the potentialities of the environment, pro-adapting to the incipience of changes according to its interior levels of relational sensitivity. The changing shapes of the house interiors indeed are parallel to the molecular pro-sensitivity for external variations, which allows the house to recycle itself, but also to destroy itself and thus provide the seeds for the growth of a new building.

3 coda on nano-pre-emption

> The atom is only explicable as a society of activities involving rhythms with their definite periods. … the quanta are, themselves, in their own nature, somehow vibratory; but they emanate from the protons and electrons. Thus […] rhythmic periods cannot be disassociated from the protonic and electronic entities.
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> (Whitehead, 1970: 87–9)

At a deeper level, this mathematical extension of computation into the realm of the living is immediately actuating a deterritorialization of the biophysical strata (the algorithmic order of evolution), which is becoming the locus of secretion for new territories, new articulations of power intrinsic within the synthetic and nanobuilding of the bio-logical. The fast-growing culture of synthetic biology announces the impending effects of a neo-stratification of matter, whose layered architectures are enfolding together into a new, utterly unnatural, skin. This culture is but a symptom of a neo-articulation of power in the regime of pre-emption, no longer operating on existing bio-social, techno-cultural, economico-political sediments, but speculatively embracing the reality of unlived worlds, which anticipate the habitats of the future. Synthetic biology promises to program nature beyond the natural, to activate the architecture of the biological strata of matter. As a specific instance of the nanoarchitecture of extension and thought, synthetic biology is but a small symptom of the reconfiguration of that level of power called pre-emption, which is now moving beyond the prehension of the future, and towards the synthetic building of new bodies and minds. If, according to Massumi (1993: 10), the ecology of fear implied that the uncertainty of future – or the unknown potentiality of futurity – actively worked to foreclose potentials into the actual present, in the age of synthetic matter, the power of pre-emption means that futurity is fully engineered in the present as a way to redesign the past (or the bio-physical strata as we know it). In other words, for nanotechnology there is no future, because all potential futurity, all contingent indetermination has been programmed to be so. Here potentialities become the auto-modulator of new potentialities of extension and thought. In other words, nanoarchitectures expose the power of pre-emption to deliver the biological substance of bodies and thought to non-organic bodies and non-human forms of intelligence. The nanodesign of matter only confirms that there is a realm of extension and thought at the inanimate level, that there are conceptual and physically prehensions at the atomic scale, whose potential capacities to be more than biological being and rational thought, far from being already prescribed, are now unleashed. But what does it mean that atoms can physically and perceptually prehend? According to Alfred N. Whitehead, prehensions define the non-cognitive grasping of a concrete fact conceived in itself and for itself experienced by any actual entity. All actual entities – no matter how small and how inorganic – can prehend or feel data from the environment and other actual entities (1970: 69–72). In other words, prehensions are activities of feeling, somehow affective states that register changes in the environment of data. Contrary to affect however, prehensions are not just physical modes of feeling. They are also conceptual modes of feeling realities that do not actually exist yet. In other words, prehensions are also speculative activities grasping uncomputable probabilities from the realm of potentialities. Whitehead's notion of prehension may indeed contribute to redefine the notion of affect as a mode of feeling-thinking, which coincides neither with emotion nor with cognition. This notion contributes to highlight that the autonomy of affect implies a-conscious activities or activities that occur at an imperceptible level of thought. For Whitehead, conceptual prehensions define the ingression of eternal objects, or pure ideas, in actual occasions, or the selection of these pure potentials in the process of formation of an actual entity (ibid., 291). With the nanodesign of the bio-logical strata of matter, what is a stake is not simply the physical registering of data but also, and significantly for us, the conceptual pre-hension or pre-emption of pure potentials, the speculative bet on the power of pure abstractions, coinciding with the speculative computation of the living and of thought.

For mathematics, according to Guattari, defines the 'extension of [the] operational possibilities' of the sign, coinciding with the productive character of the code and code extension (2006: 232). In particular, the mathematization of physics, Guattari suggests, has led to a deterritorialization of the signifier's linearity, order and continuity, which implies '[t]he loss of "metrical" in favor of general topological spaces, with re-axiomatization at every step of the way, underscoring the "return" – an eternal return – to polyvocality. At every stage, there is "a supplementary coefficient of polyvocality", or the "enrichment of the field of operational possibilities"' (ibid.).

Nanoarchitectures substitute the approximate calculation of infinitesimal variations, with a computational model able to precisely give us the measure of infinity through discrete processing. This substitution makes all the difference in the pre-emptive activities of control. Nano-ergonomic control indeed leaves nothing to approximation and yet its precise design remains infinitely open. It is thus not based on a vague cause, but on a precise unknown, almost designed to remain exact albeit uncertain. Nanoarchitecture builds synthetic machines as specific forms of potential information processing (from smart materials to nanobots) running beneath the bio-physical order of cognition and sensing and at once revealing the reality of non-human, non-organic and non-animate orders of thought and extension. Synthetic thought and sensing are emptied of any empirical given, but also of *a priori* instructions. Relieved of all signifiers, atomic thoughts and bodies have become effective hosts of nanomachines of control. From the standpoint of nanoengineering, thought is as real as a thing, and yet each nanodesigned object cannot but disentangle from human intelligence and expose another kind of thought that cannot be kept in the hands of the controller. If nanoarchitecture marks the deterritorialization of thought and feeling from the biological substrate, then it may indicate the end of the teleological dream of reason's synthesis of human and world. Perhaps nanoarchitecture may help to unbound thought and extension from the anthropomorphic bounds of idealism and empiricism. 'If we regard a human modified with technology as no longer human, where would we draw the defining line? Is a human with a bionic ear still human? How about someone with neurological implants? How about someone with ten nanobots in his brain?' (Kurzweil, 2006: 374).

Nevertheless, it will be limiting to understand the significance of nanoarchitecture as simply a techno-progressive promise for a new form of disincarnated thought, or a further level of dematerialization of bodies. More importantly, instead, nanotechnology marks a new deterritorialization from the bio-logic imperative of life and thought no matter how bare this can be. This is not simply achieved through the substitution of the organic bio-logic with an inorganic mechano-logic. When the inorganic is designed for the mimesis of the organic, as it occurs for some instantiations of synthetic architecture, nanoarchitecture simply remains caught within the idealist framework of empirical functionalism. On the contrary, a novel processing of thought and extension is here granted not by the efficiency of operational functioning. This new level of nanodesign deploys the trans-machine operationality of quantic worlds, which questions the double dominance of an ideal model of pre-programming and an empirical construction of forms. Nano-control operates not purely through certainty or entirely through uncertainty, but confronts the reality of uncompressible data, which is found at the atomic and subatomic levels of prehension. Nanocomputation does not simply allow for the axis of command and control to stir real-time responses. Here it is not a question of measuring variations in patterns of stimuli–response. It is not a question of profiting from the fluctuating universes of emotional cognition to generate new axiomatic parameters. The problem that nano-control has to face is instead the uncompressible nature of algorithm itself. This is why nanocomputation operates at the level of numerical infinities or uncomputable quantities. According to Chaitin, uncomputability is the maximally complex unit within any mathematical system of measure. It determines not simply the interruption of logic by some external contingent factor. On the contrary, it this is about the primacy of surplus value of codes (the primacy of quantic complexity in logos) whose prehensive power challenges both the dominance of human cognition and biological extension.

These are not the workings of cognitive or immaterial capitalism operating on the activities of communicating and thinking brains. Similarly, these are not even the workings of affective capitalism here intended as the return of the living body resuming from the symbolic structure of collective intelligence. If, as Whitehead argues, conceptual prehensions entail the vector transmission of quantitative variables from there to here, such prehensions are activities of any actual object and are not specific to an entity equipped with a brain. This is not simply to say that conceptual prehension can be defined by a hybrid state of human–machine intelligence or by the extended mind – the prosthetic infomorphism of a central brain. On the contrary, there is no brain at stake here, but only uncomputable activities, unsynthesizable quantities, vibrations and electrons characterizing actual occasions of whichever kind. Here to conceptually prehend eternal objects is to become infected with an abstract thought, or pure potential of matter irreducible to any specific thinking or material form of thought and yet constituting the objectness of thought at all, infinite scale. In other words, pre-emptive/prehensive power exceeds the onto-logic of a techno-economic system extracting value from the material force or the living brain. This system instead has exhausted all modes of prediction of potentialities, and is now operating on a futurity outside time and space, or, as Whitehead (1978) calls it, the abstract mathematical relations of the 'extensive continuum'. If this means that pre-hensive control is directly constituted by the realm of *SCIFI* capitalism (Fisher, 2009), it is because we have entered the field of pure speculation where experience does not need to be lived in order to be real and where thought does not need to be embodied in order to be real. Experience indeed occurs at every level of matter, where bio-physical, cognitive, affective, aesthetic capacities are undergoing a deep reprogramming. This means that the experience of atomic reprogramming is not confined to atoms themselves. If atoms prehend their transmutation in colour, shape, dimension, electrical power, it is because they prehend eternal objects ingressing their actuality. Yet these atomic prehensions are but appetites for more potentialities, for pure power to become new forms of space and time, new skins and new cognitive architectures. The nanoprogramming of matter therefore indirectly allows atomic appetites to become data for the coming of new actual occasions of experience. The nano-manipulation of atoms indeed is not without consequences for all levels of actual occasions. If atoms change colour and shape in real time this cannot but bring unforeseeable consequences for the experience of space and time of a body, a thought, an affect, a perception. Pre-emptive/hensive power thus works to nanobuild the realities of alien forms of thoughts and of monstrous kinds of extensions, which are invisibly restratifying the biological grounds of human-bound bodies and thoughts.

Notes

1. On commercial developments in nanotech, see 'nanobusiness', www.nanobusiness.org. On nanocomputers, see Brown (2001) and Goho (2004).
2. In particular, the specific novelty of nanotechnology is to be found in the way nanomachines can rearrange the very position of every atom. Each atom

can then be placed in a selected position to become an active or structural component of a living system that is to be redesigned. In particular, this new capacity of controlling the position of atoms suggests that the high-speed oscillation and fuzziness of molecules, which was central to the discoveries of quantum physics, no longer involves an absolute indeterminacy, defined by atomic superposition between particles and waves. On the contrary, this *relative* indeterminacy of atomic fuzziness has been fundamental to develop conditions for nanoengineering. In other words, with nanotechnology, the chaotic instability of molecules is turned into a weird dynamic productivity. The quantum fluctuation of atoms implies that atoms occupy a series of discrete positions in space. This position therefore does not correspond to a permanence of the same atom, but to the permanence of a *pattern* that repeats itself through vibrating energy in far-from equilibrium conditions. On far-from equilibrium and quantum physics, see Prigogine (1997).

3. The most interesting forms of this device or substance – known as 'quantum dot fiber', 'programmable dopant fiber', or 'Wellstone(TM)' – are under development at The Programmable Matter(TM) Corporation. Wellstone was a hypothetical form of smart material first proposed by Will McCarthy in his novella 'Once Upon a Matter Crushed', (*Science Fiction Age*, 1999), consisting of nanoscopic semiconductor threads covered with quantum dots. These threads can be woven together to form a bulk solid with real-time adjustable properties. In this sense, electronic devices built of Wellstone could use the quantum dot arrays themselves as computing elements, bringing a whole new meaning to the term 'smart materials' (McCarthy, 2004: 78).
4. Carl R. Woese (2004) has argued that 'a new biology for a new century' no longer needs to be concerned with the study of genes and molecules. The twenty-first century's synthetic biology shows us that the future of science is to project new natures rather than simply studying what exists in nature.
5. From this standpoint, one can imagine building a biological counter into a liver cell triggered every time the cell divides. At the same time, another biological device is set to monitor the counter so that if the cell has divided more than 200 times, it is killed. According to synthetic biologists, this could be a very effective way – a fully automated technique – to beat cancer avoiding chemotherapy and surgery.
6. MIT computer scientist Tim Knight coined the term *biobrick* in 2001. In general, biobricks are composed of *parts*, which encode basic biological functions and of *devices*, which are made from a collection of *parts* to encode some human-defined functions (such as logic gates in electronic circuits), and of *systems* to perform certain tasks (such as counting). See http://biobricks.org (accessed 20 September 2010).
7. Endy reminds us that DNA sequence information and other characteristics of BioBrick™ standard biological parts are made available to the public free of charge currently via MIT's Registry of Standard Biological Parts. See also Drew Endy podcast on open source biology (2010).
8. See for instance, Luhn (2007).
9. For further information on the Foresight Institute, see www.foresight.org.
10. Johansen claims, 'Composition is gone, because the thing continually recomposes itself within an almost infinite range of possibilities. Function

is gone, because it is unknown in advance. Structure ... is gone, because it is entirely fluid-dynamic, nonlinear, even mathematically chaotic. All that remains is an initiate and unpredictable interaction between the inhabitant and the architecture' (Johansen 2002: 19).

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