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Case Study of the Manga Ganmu (Battle Angel Alita)
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Nanotechnology through the Lenses of Science Fiction

Case Study of the Manga *Ganmu (Battle Angel Alita)* by Kishiro Yukito.

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Introduction

Since Richard Feynman's famous speech "There's plenty of room at the bottom" and Taniguchi Norio's coining of the term in 1974, nanotechnology has emerged as a rapidly growing field whose dynamics and prospects pose many challenges to scientists and society at large. Most of the articles dealing with nanotechnology stress out the fascinating progress made by those who work at the nanoscale. *Nanophilic* perspectives range from the next industrial revolution to a quasi-religious vision of a "post human" future freed from any restriction.

However, in the same speculative way, insofar as Drexler's "nano robots" are yet to appear and the industrial "nano revolution" has not happened, a *nanophobic* rhetoric has come to light, emphatically pointing to the potential harms of nanotechnology.

It is therefore of interest to note that even though (or precisely because) nanotechnology is still in its infancy, its rhetoric revolves around two radically opposed views. As C. Milburn or J. Lopez point out, such a hyperbolic way of presenting a future where the world is recreated atom-by-atom relates on the use of Science Fiction rhetoric, thus blurring the boundaries between "real" science and SF. Basing his reflection on Baudrillard's hyper reality concept, Milburn goes as far as to say that nanotechnology is a "science fiction" (112). Such an analysis, beyond its post-modern perspective, draws the attention to the close connections between the imaginary and Science.

Science does shape our every-day life and influence our imaginary, but, and this seems of less concern, the opposite also holds: scientific activity and its technical corollary borrow much from the imaginary, which SF is a part of. SF has always explored the possible consequences of technological innovation, attempting to give meaning to the social transformation related to science and technology. Avoiding to fall into an apologia for scientific progress, it is a literary genre which presents an imaginary world where the use of fictitious technology urges the reader to question the principles upon which society order rests.

Japan is a wonderful example inasmuch as manga and animation, as a modern medium for SF, have dealt a lot with the political, economical, social and ethical impact of nanotechnology. Among others, works like *Ganmu (Battle Angel Alita)* by Kishiro Yukito, or *Ghost in the Shell* by Shirō Masamune provide an interesting base to consider the way Japanese science fiction apprehends a nanotechnologically modified future. This is what I propose to further analyse in this modest article by focusing on the former only for the sake of time and space.

A Historical perspective

Before embarking on the analysis of how Kishiro depicts nanotechnological development and its interactions with society, it is necessary, first, to consider his work on a historical perspective. This will help us understand the scientific base upon which the mangaka built his reflection and allow a quick overview on nanotechnology itself: its definition (as reported by the main actors in the field: the US, Japan and Europe), a brief chronology of events and the most prominent features of the scientific debate about its development.

Ganmu was originally published in Shūeisha's monthly *Business Jump Magazine* from 1990 to 1996 and released in the form of 9 volumes (Tankōbon) at the same period. Kishiō later designed some other works based on a similar dystopic world¹ and eventually decided, in 2000, to carry on the *Ganmu* cycle with *Ganmu: Last Order*, in which he created an alternative ending to the first opus and resumed anew with a story whose conclusion he was not satisfied with². However, and even though *Ganmu: Last Order* provides a new reading of nanotechnology social implications, as Bounthavy Suvilay points out in her very interesting article about nanotechnological representations in Manga, I will focus only on the first series, arguing that its ending (which Suvilay chose to overlook) unveils the metaphysical and epistemological foundation of nanotechnology in the 80's and 90's and offers an ethical conception of its development.

Nanotechnology, a synopsis

We need thus to sketch a succinct outline of what nanotechnology is. There is still some debate around the exact definition, but the American NNI³ (National Nanotechnology Initiative), the European Commission⁴ and the Japanese MEXT⁵ share a similar interpretation. The prefix "nano" derives from the Greek word "nannos" meaning "dwarf" and is used in mathematics to signify one billionth of a meter (10^{-9}). Conceptually, nanotechnology refers to science and technology at dimensions between 1 and 100 nanometers and to the new properties that can be understood and mastered at that level. As Senior Advisor for the NNI Mihail C. Roco points out: "The nanoscale is not just another step toward miniaturization, but a qualitatively new scale with unique properties, phenomena and processes" (2003, 1). One of the examples usually given to illustrate this point is that of gold: whereas 1 ton, 1 kilogram or 1 gram of gold possess the same physical properties, it is not true when reduced to the nano scale. Its color, melting point and chemical characteristics change as a result of the quantum interactions that prevail in small structures: "Nano gold doesn't act like bulk gold" (1).

It is the famous physicist Richard P. Feynman who is generally credited with having symbolically given birth to nanotechnology in his speech at the American Physical Society annual conference in 1959, when he asserted: "The principles of physics, as far as I can see, do not speak against the possibility of maneuvering things atom by atom" (29). But it is later in the 80's that Eric K. Drexler, an engineer at the MIT, building upon Feynman's assumption that "we can make a thing very small which does what we want" (35), popularized the word of nanotechnology. In his book *Engines of Creation*, he theorized the notion of a nanoscale assembler, a tiny machine operating through a built-in program that would be able to build a copy of itself and of other items by manipulating atoms directly. As Drexler himself puts it:

The resulting nanotechnology can help life spread beyond Earth - a step without parallel since life spread beyond the seas. It can help mind emerge in machines - a step without parallel since mind emerged in primates. And it can let our minds renew and remake our bodies - a step without any parallel at all. (21)

Drexler's vision of Nanotechnology, as "a very tall and slender tower of reasoning"⁶ it may look, did spark a lot of attention and participated in laying the path to the launching in 2001 of the American National Nanotechnology Initiative (NNI) with a \$ 465 million budget. A collaborative model largely followed by Japan and the European Union. Thus, even though Drexler's ideas have been later dismissed as being science fictional and not applicable⁷, the opponents to his molecular manufacture scenario do acknowledge his tremendous effect on the field of nanotechnology. Besides, critics of Drexler's nano-assemblers feasibility have more or less arisen quite late in the 90's (and more vehemently from 2000), and probably

largely because of the issues about nanotechnology ethical and social implications raised by *Engines of Creation*.

The controversy around Drexler's nano assemblers does not actually call into question the control of nanophenomena, but rather rejects its mechanical conception (the very idea of engineering nano robots that would manipulate atoms according to a program), emphasizing instead a chemical approach. As B. Bensaude-Vincent has pointed out, the machine metaphor is "all-pervading" (2006, 9) and can also be found in biology and chemistry. However, as she skillfully illustrates, the bottom-up process (building up single components into more complex assemblies) advocated by chemists rests upon self-assembly: an organized structure is formed as a consequence of specific, local interactions among the components themselves, without external direction. Now, such a process implies that chemistry's use of the machine metaphor offers at the same time an "anti-mechanistic" view that "do not deprive matter of spontaneity, of dynamis" (2006, 21).

This is of course an oversimplified account of the development of Nanotechnology, and I have skipped many of the interesting and intricate debates or issues associated with the multiplicity and variety of the scientific works in the field. But the scope of this article is not a scientific journey into the nano world, it rather attempts at probing the connections between nanotechnology and science fiction, so that a quick survey should prove sufficient to frame the analysis. The very fact that most of the social studies related to nanotechnology have arisen in the late 90's underlines the significance of works of science fiction that were published before, insofar as their author were precisely concerned with the same issues. It is therefore quite interesting to have a look at the way nanotechnology was depicted in a popular medium such as manga between the mid 80's (when Drexler published his book) and the mid 90's, at a time when it emerged as a prospectively revolutionary field. In this respect, *Ganmu* provides a compelling narrative that draws the reader into a technologically modified world, urging him to ponder over the interplay between society and science and the way it is modified by nano applications.

Kishiro's vision on nanotechnology, the "tech-notes"

When looking at the commentaries and technical notes inserted at the end of each volume, and in particular those of Volume 5, Kishiro's understanding of nanotechnology is clearly based upon Eric Drexler's *Engines of Creation*, published a few years earlier in 1986. Besides, it is worth noting that in the little chronology he gives of nanotechnology "genesis", he does not mention the fact that the very word of nanotechnology was coined by Japanese scientist Taniguchi Norio, professor of Tokyo Science University, in a paper published in 1974 (some 12 years before *Engines of Creation*). He does refer, as all chronological accounts on the origin of nanotechnology start with, to the seminal speech by Richard Feynman, but interestingly points to a narrative preceding it: the science fiction novel *Waldo* by Robert A. Heinlein. For Kishiro, nanotechnology "Ur-text"⁸ is thus not a scientific work but a narrative fiction depicting a scientist who designed mechanical hands (the "waldoes") of decreasing size, controlled by an operator and enabling him to manipulate matter at a microscopic level. Some social scientists have already underlined the fact that Heinlein ideas were deeply interwoven in Feynman's speech and his vision of tiny tools, but, again, most of them published their paper after 2000 (Toumey, 2006 and Milburn, 2004). Kishiro had already worked out this connection quite early and it is therefore not surprising that his picturing of nanotechnology bears close relation to the futuristic writings of Drexler, notably his vision of nano assemblers (also referred as "nano machine", "nano robot" or "nanobot"). For Kishiro, the possibilities envisioned by Drexler provide a fertile ground to reflect upon a technology of

“creation”, “abundance”, “healing” and... “destruction” (as *Engines of Creation*’s chapter title shows).

However futuristic Drexler’s molecular engineering may sound, the invention in 1981 of the Scanning Tunneling Microscope (STM), enabling the imaging of atomic surfaces by using a tip which scans the electric field at the surface of the sample, strengthened its stance. As luck would have it, it was later discovered that the STM made the individual manipulation of atoms and molecules possible. This led to the drawing of the IBM logo with single atoms of Xenon in 1990, the latest “achievement” Kishiro refers to in his chronology but not the least because it added plausibility to Drexler’s theory and happened exactly when Kishiro started *Ganmu*.

Thus, Kishiro’s drawing of “mad-scientist” Nova’s nano assemblers reflects Drexler’s design, with tiny dots reminding the imaged picture of the IBM logo and a round “body” resembling the fullerene (a spherical, entirely carbon-based molecule discovered in 1985). Fitting Drexler’s description, Nova’s assembler is a “molecular-sized robot, with gears, bearings and motors”⁹, it has tiny arms¹⁰ and can self-replicate (here, Kishiro’s note literally quotes a part of chapter 2 from *Engines of Creation*¹¹).

As far as the possible applications of such assemblers are concerned, Kishiro is first concerned with pushing back the frontiers of physical and biological determinism. Drawing from Drexler’s insight that “by restoring all the cells and tissues of the body to a youthful structure, repair machines will restore youthful health”¹², he alludes to brain restoration and eventually to immortality (as long as there’s no total dissolution of the body and the brain). From such a postulate of conceivable “restoration”, there’s only a nano-step to “enhancement” which Kishiro makes promptly: brain enhancement, artificial spinal column, mechanical prosthesis, and so on. As Norbert Wiener has pointed out, after having modified their own environment to better suit their condition, humans have now turned to their own nature, modifying it for the sake of their own projects¹³. The “anthropotechnic”(Goffette, 2006) process of modeling and improving the human body had begun long before with the coining of what has become a powerful trope in the 20th century, namely the cyborg¹⁴. But what has nanotechnology to do with the cyborg imagery originally associated with cybernetics and the theory of information?

It is largely because the latter have made the same attempt at reducing everything to information (the theory of communication and control applies equally to humans, animals and machines, hence the informational pathways connecting organic and synthetic components) as the former is trying to reduce everything to atoms (the fundamental bricks of matter, may it be organic or not). What’s more, promoters of nanotechnology, especially the American NNI, are advocating what they call the NBIC convergence which aims at unifying Nanotechnology with Biotechnology, Information Technology and Cognitive Sciences. As W.H. Wallace puts it:

If the *Cognitive Scientists* can think it
the *Nano* people can build it
the *Bio* people can implement it, and
the *IT* people can monitor and control it (Roco and Bainbridge, 2003, 13)

The unifying process sparked by nanotechnology supporters, by trimming down everything (information, matter, life...) to what critics like the ETC Group have nicknamed the “little BANG” (Bits of information, Atoms, Neurons and Genes), contributes to the blurring of boundaries between human and machine, matter and information, nature and artefact, organic and inert matter. But then, how does *Ganmu* tackle this new perspective? Katherine Hyles convincingly makes the point that “the literary texts often reveal, as scientific work cannot,

the complex cultural, social and representational issues tied up with conceptual shifts and technological innovations” (24), so that looking into a cyber-punk-labeled manga such as *Ganmu* should provide some insight into how the characters make sense of those blurring boundaries.

Shifting boundaries, *Ganmu* and the enabling technologies

The storyline - technological achievements

The manga takes place in a seemingly dystopic world where the reader is first brought to Kuzutetsu, literally the “scrap yard”, an urban sprawl that looks like a huge slum, host to a bunch of technologically enhanced cyborgs mingling with common humans. It is spreading under the celestial city Zalem, with which it was once linked through an orbital skyhook¹⁵ made out of carbon nanotubes. The connection was however severed and Kuzutetsu became Zalem’s dumping ground while remaining under its rule: its factories supply water, food and basic resources to the floating city via the linear tubes, their very last and unrequited relationship. The factories act also as a local government, enforcing Zalem regulation through the “deckmen”: a type of cyborg with a cylindrical body allowing them to move within the linear tubes. They were former humans who relinquished a part of their brain (along with their memories, their will and desires) so that the remaining chunk works more or less as a computational chip processing the information coming from Zalem¹⁶. The deckmen are for instance responsible for the recruiting of bounty hunters (referred to as “hunter warriors”, the only “police” of Kuzutetsu), whose glial cells¹⁷ they imprint with an identity code upon their registration. Such an identifying measure clearly reminds of the miniaturization of existing RFIDs¹⁸ and their implantation in the human body for monitoring purpose (Laurent and Petit, 260-3).

Kuzutetsu appears as an ultra-liberal world going hand in hand with a frantic technological development where a rough type of cyber technology prevails which enables the creation of hybrids out of the mastery of inert matter and microscopic engineering. Kuzutetsu’s cyber technology cannot however do without the actual biological brain which is deemed to be irreplaceable. Whereas the body is interchangeable at will (insofar as one can afford it), death of the brain signifies the actual and irreversible death of the subject. There remain also “genuine”¹⁹ humans who either don’t have the financial means to undergo a procedure of body enhancement or utterly refuse the replacement of their biological body.

Now, it is in the midst of such a composite and wild environment that a former citizen of Zalem discovers the head and the upper torso of a cyborg whose brain is still alive. He succeeds in saving her, provides her with new bodies and a name: Gally. But she has lost her memory and can only rely on her fighting technique to catch a glimpse of her past and of herself. The story therefore unfolds as a picaresque story about the initiatory journey of Gally who is the narrative point of the manga: it is through her eyes that the reader discovers Kuzutetsu, its surroundings and ultimately Zalem. But the ongoing disclosure is not merely geographical, it also encompasses, at every stage of the story, new technological achievements and the meaning they take through their implementation within society.

One of the most central characters in Gally’s peregrination is “mad-scientist” Desty Nova, a citizen of Zalem excluded from the floating city because of his immoral and hazardous attempt at transcending human determinism through various in vivo experiments. It is Nova who is behind many of the obstacles and challenges Gally has to overcome, though their first encounter takes place only on the 5th volume of the series. Following Lévi-Strauss’ work on the structure of Myth, Nova’s character can be interpreted as a trickster that establishes some relation between the two antagonistic spaces, mediating between Zalem and Kuzutetsu, but

creating at the same time confusion and disorder²⁰. As we will see later in the last section, the mediation figure is then overridden by Gally who finally succeeds in bringing together the opposites into what Eliade (1989) calls the “conjunction oppositorum”, thanks however to Nova’s nanotechnology.

Indeed, for now suffice is to say that nanotechnology appears in Kuzutetsu through the mediation of Nova who achieved the creation of the nano restorers Drexler was envisioning. The technological accomplishments of Zalem are thus far more advanced than the cyber technology prevailing in Kuzutetsu. As long as the brain is not entirely destroyed, nanotechnology can restore or reconstruct it as well as heal any corporal wounds. However, Nova uses nanotechnology to “play” with human destiny in order to overcome a determinism he associates with the second law of thermodynamics²¹ and the inescapable death of the world by increasing entropy. His struggle is therefore nothing but an attempt at overcoming death and the restrictions imposed by the inexorable decay of matter. Nanotechnology becomes, as Bensaude-Vincent has put it, a mean to “free the human from material determinism” (2009, 104), to constantly push back the limits instead of negotiating with them.

The flesh-and-bones humans of Zalem, whose “humanhood” lies precisely in their biological constitution, have access to a more powerful, intimate and subtle technology. They look down on the mechanical hybrids that populate Kuzutetsu and boast about their own superiority that enable them not so much to work on matter (fabrication, engineering) but to produce it de novo by reorganizing and reassembling its fundamental bricks. But Nova unveils a secret they don’t even know of: the initiation they undergo at 19 to become full citizen of Zalem is a surgery whereby their brain is replaced by a bio-chip containing a copy of their memory. Besides, this process is part of a eugenics program implemented by an Artificial Intelligence that controls the whole floating city: the computer Melchizedek²². Its purpose was to construct a “perfect” society by normalizing its members through a protected and “stressless” but complete management. The ultimate goal was to send them to other planets and establish new colonies outside the solar system, a long-term journey which cannot afford any conflicting human relationships if it is to succeed. But the project failed and the AI computer went mad as it lost its “beloved children”. It severed the skyhook link from the orbital station Jeru (the counterweight of the space elevator) and from Earth surface, secluding Zalem from any external influence.

Dematerialization of the body and the mind? What stands as human within the evolving natural/artefactual and body/mind polarities?

The progressive disclosure of technical achievements in *Ganmu* gradually calls into question the modern epistemological divide between the natural (as a safe and unchanging ontological ground) and the artefactual (as a man-made counterfeit of nature). Elaborating first from cybernetics, Kishiro illustrates the construction of the cyborg which, as K. Hyles points out: “presumes a conception of information as a (disembodied) entity that can flow between carbon-based organic components and silicon-based electronic components” (2) so that the materiality of the body is just an epiphenomenon of the informational pattern. Interestingly, Kishiro depicts two kinds of cyborg: a biological brain coupled with a mechanical body (in Kuzutetsu) and a bio-chip coupled with an organic body (in Zalem). The latter is however inspired by nanotechnology, and relies on the use of a more subtle and intricate technological trick echoing the transhumanists’ hope of downloading the human brain into a computer (Moravec, 1990). But then, where does the essence of “humanhood” lie if a bio-chip can act as a human brain and mechanical prosthesis replace the body, if an AI computer can display the same behavior as a human being?

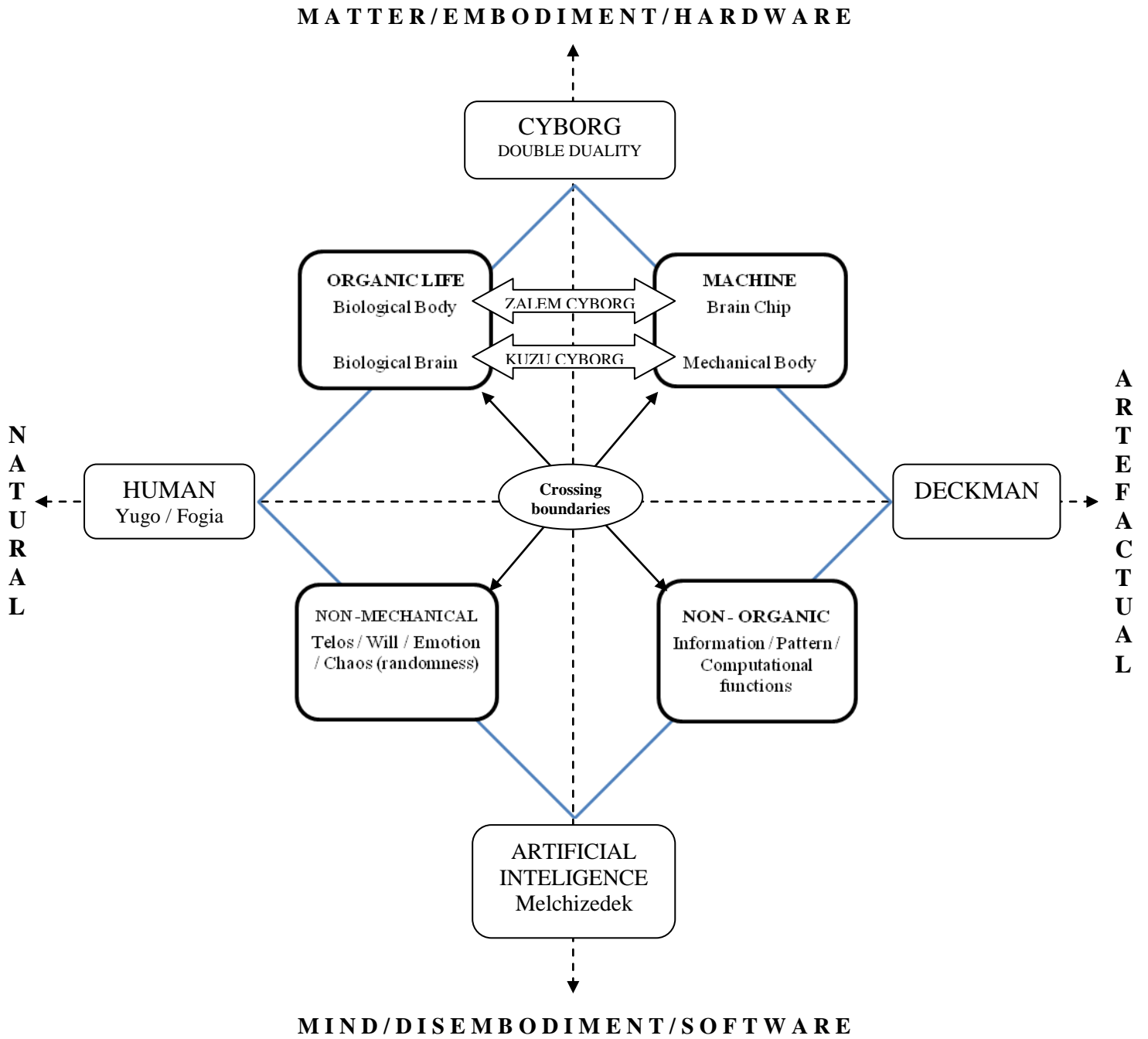
To deal with this question, the manga is based on an apparently unique dichotomy: that of organic life as opposed to machine²³. However, entwined around it, is a much more complex network of shifting relations. Drawing from examples of its use in narrative theory (Jameson, 1972, 2005 and Hayles, 1999), I have used the semiotic square as an analytical means of unraveling and interpreting those relations. The semiotic square (or Greimas' rectangle, from the name of the Lithuanian linguist Julien Greimas who theorized it) is a way of mapping two opposite terms (on the top) by adding a second opposition (on the bottom) with terms contradicting the first ones (the contradiction includes more meaning than the opposition: white is opposed to black, but non-black is much more than white). It is then possible to create complex terms by combining the first four elements (each combination corresponding to the different sides of the square) and generate new concepts that can help understand the narrative structure.

Applying it to the narrative of *Ganmu*, I have thus positioned the opposition between *organic life* and *machine* on the upper corners. In contradiction to organic life, *non-organic* appears on the lower right corner, pointing out to information as a reified entity "that can flow unchanged between different material substrates" (Hayles, 54). It is a pattern that can be processed by computational functions so that "the nervous system and the automatic machine are fundamentally alike in that they are devices which make decisions" (Wiener, 33) based on it. Contradicting the machine is, on the lower left corner, the *non-mechanical* concept which refers to that which possesses its own will or *telos*²⁴. It thus relates to emotion and stands in contrast to the non-organic corner (associated, as we have seen, with information and pattern) insofar as it brings randomness and chaos²⁵.

Because *Ganmu* deals about shifting boundaries in a highly technological environment, no characters fit precisely into one of the corners only but rather symbolize the hybridization of some of them. Arising from the combination of organic life and machine, on the upper side of the square, is the cyborg, in a subtle duality because it allows the biological brain/mechanical body as well as the mechanical brain/biological body arrangement. The deckmen, on the right side of the square, clearly symbolize the union of the machine and the non-organic as mechanical information-computing systems whose sole function is to embody Zalem control. On the lower side of the square, the AI Melchizedek represents the entanglement of computational functions and emotions, the emergence of an intrinsic teleology out of a silicon-based computer. Finally, characters such as Yûgo or Fogia properly fit the association of organic life with the non-mechanical corner on the left side of the square. They both retain their biological body and brain, and live their life according to their own will and emotions, should it be deemed as irrational or stupid. The best illustration of it is Yûgo having his dead brother's biological hand transplanted instead of his own (the reverse procedure of enhancement).

From the mapping of those elements, we can now discern two main axes representing the natural/artefactual and matter/mind polarities. The first one is transversal, from fully biological humans with an intrinsic teleology to completely mechanical systems without will (though Kishiro ironically kept the suffix "man" in "Deckman"²⁶). The second one, vertical, runs from the figure of the cyborgs as embodied entities (whether the body or the brain are seen as hardware) to the AI which represents disembodiment (interpreted as mind/spirit or software).

The semiotic square



However, the poles of the axis are not maintaining nor securing the usual “modern” divides. Indeed, the natural side of the square is taken up by humans, as natural beings, products from the evolutionary process, but thanks to whom the artificial side is made possible. Furthermore, apart from characters such as Yûgo and Fogia, the cyborgs of Kuzutetsu seem more human than, for example, the fully biological assistant of Desty Nova, Eelai. According to her, humanity’s distinct trait rests in the flesh, through which humans feel pain and pleasure, and the ultimate evolution is immortality brought by nanotechnology. However, her definition exactly matches that of cybernetics whereby feelings and sensation are but a feedback loop that links a system to its environment through sensors, so that it can easily be reproduced in a cyber organism (Which echoes the fact that the word “organ” derives from the Greek “organon”, meaning “instrument, tool”). However hedonistic it may sound (pleasure as the most important pursuit of humanity), it lacks the wisdom associated with it, equating emotion and feeling with bodily sensation only²⁷ (thus departing from the “non-mechanical corner of the square). The embodied pole is not represented solely by organic life, but by the hybrid symbol of the cyborg; and the disembodied pole, the seemingly “boundless” and immortal spirit, concretely falls down from Zalem when “she” commits suicide²⁸. There are thus no formal boundaries between one side and the other, but a constant flux shifting back and forth, a process which is best exemplified by Gally. Indeed, if we sketch her journey into the square in a diachronic way, it appears that she navigates “freely” within it, mediating between the opposites and establishing some union (or at least an intricate imbroglio).

From an amnesic and “disembodied” brain at the beginning, it is through incorporation and embodiment that she is able set off on her quest for identity. The fighting technique she unconsciously masters reminds of the concept of “habitus” (in the sense defined by Marcel Mauss or Maurice Merleau-Ponty), as “body techniques” or actions anchored in the body by daily practice which eludes the self-conscious representation of such actions. Gally does not remember her skills, she does not even remember she has them, but her body does, even though it is mechanical. Her nanotechnologically-designed berserker body further blurs the distinction between embodiment and disembodiment, insofar as it seems to possess its own “will”²⁹ but still needs a brain to enter into symbiosis with. But then, who embodies who? who controls who? Gally remains in command but Zapan’s brain is literally swallowed and consumed by it³⁰. It also tangles up the natural and the artefactual in the sense that it is a “living machine”³¹ born from a type of nanotechnology Nova is not familiar with. We may thus infer that instead of a mechanically-engineered molecular assembly by nano robots, it might rather have been designed by a chemically initiated self-assembly of molecules. It is then difficult to call it completely “artificial” (because it relies on the “spontaneity” of natural molecules) as much as it is improper to view it as a natural entity (there is a designer responsible for its construction).

Gally, by later becoming a tuned agent, shifts to the right side of the square in that she relinquishes her free will to Zalem and mechanically performs the tasks she is given. It is only when she finally severs the enslaving link with Zalem that she finds love in the character of Fogia and decides to bring her journey to a conclusion by finding Nova and discovering the secret of the floating city.

We can therefore assume that it is the lower left-hand corner that helps resolve the different oppositions: for Kishiro, “humanhood” is not so much defined by its physiology (even though embodiment is central in the narrative, it may take many shapes), nor by its rational logos and self-consciousness (which can be assumed by an AI computer or a bio-chip); but rather by its will and emotions, its perfectibility. However, this perfectibility is not seen as an individual ability-enhancement but as a moral struggle towards a better harmony where some mediation is established between technological achievement and society at large.

Reconfiguring the modern divides within an ethical frame

As we have mentioned it in the first part and further illustrated in the second, the technological achievements in *Ganmu*, stemming first from cybernetics and then from nanotechnology, tend to blur the oppositions between human and machine, matter and information, nature and artefact, organic and inert matter. However, Kishiro does not flatten them out boldly, but rather attempts at considering a new way of arranging them by way of mediation. This process is developed throughout the narrative, but it is the manga's conclusion which best exemplifies it. Brought to Zalem by Desty Nova, Gally penetrates with him the intimate core of the floating city and learns about the eugenics project led by Melchizedek. Unfortunately, the AI gets "out of mind", threatening to smash down Zalem on Kuztuetsu by committing suicide and destroying the skyhook. It is only the willing sacrifice of Gally which ultimately saves both microcosms. She reaches the skyhook where she merges with the carbon nano-tubes of the column through a transmutation triggered by a chemical reactive that resonates with her nanotechnological body, and succeeds into securing the architecture of the orbital lift. The result, unpredictable according to Nova (because it depends on Gally's subconscious and latent potential), is quite surprising indeed. The fusion of a woman cyborg with an inert structure, keeping in mind that Gally's body was built by nanotechnology and that the orbital lift is made out of carbon nano-tubes, results in a huge blooming tree, nicknamed "nano-man/tree"³².

The symbolism of the nano-man/tree: metamorphosis and mediation

It is quite interesting to look a little more into the signification of this blooming tree in terms of the symbolic imagination, especially in the context of nanotechnology developments. Drawing on Gilbert Durand's work³³, it is possible to identify the symbol of the blooming-tree with three intertwined groups of images.

First, it reminds of the alternation between life and death through the agrarian cycle, in that the flora symbolism is often used to depict metamorphosis. Durand further adds that the heroine's death always gives birth to a plant, announcing her resurrection (342). Thermodynamics might then only be considered as the late rationalization of the primeval intuition that vital energy is conserved despite the passing of the seasons and the temporary death in winter. Secondly, and in close relation to the first group of images, is the symbolism of the mediation, the "conjunctio oppositorum" (Eliade 1989) we had mentioned in the first part of this article. By fusing with the skyhook's structure, Gally operates a conjunction between the living, the organic and the inert matter which transmutes the mechanical structure into an organic edifice from which she later emerges as a full flesh-and-bone woman. This process of transmutation establishes a link between alchemy's attempt at achieving in a short span of time what nature can do over a long period and nanotechnology's goal of overcoming human determinism, that is, ineluctable death. Mircea Eliade has convincingly written that "Alchemy has left much more to the modern world than a rudimentary chemistry, it has also transmitted its faith into the possible transmutation of Nature and its ambition to master Time." (1956, 179) Thirdly, as a corollary of the first two groups of images, Durand notes (390) that the standing tree adds another dimension to the cyclical representation of life and death (through the agrarian symbolism) and the union of the contraries (the alchemical transmutation). Determinism is not overcome only through the reassuring confidence in some eternal return (repetition of the cycle which soothes out the irremediable loss of death) but because the bringing together of the opposites gives birth to a definitively new

“someone/thing” (the nano-man/tree). The verticality of the tree echoes the promise of a progress transcending the ever-repeating cycle and prefigures the resurrection of life. Interestingly enough, it is nanotechnology that enables the “conjunction oppositorum” and the ultimate resurrection of Gally in the manga. It provides thus as a new way of configuring the interplay between nature and artifact, an invitation to reconsider, again, the definition of nature and that of the artifact.

A new definition of nature and artifact that needs moral consideration

Indeed, the “nano-man/tree” symbolically epitomizes what Bruno Latour calls the “articulation of humans and nonhumans” into a “collective” whereby nature is not the world “out-there”, ontologically safe and separated from the human but the result of a historical process through which it is defined and redefined according to the scientific or technological means available at a definite time. Our understanding of nature is based upon our ability to device tricks that give us access to it, so that the natural is articulated by the artefactual and vice-versa. The questions raised by this collective is “How many humans and nonhumans are to be taken into account?” and “Are you ready, and at the price of what sacrifice, to live the good life together?” (Latour, 1999, 297)

Kishihiro’s narrative and graphic work echoes this question in a very interesting way. The seemingly dystopic world of Kuzutetsu is actually much more human than the aseptic society of Zalem because it does not assume a sense of perfection. This does not mean that an ethical assessment of technological development is made superfluous but it is precisely because the characters evolving within Kuzutetsu are not “perfect” that they can improve. Ultra-liberalism, gratuitous violence, hubris fed by individual enhancement do not escape Kishihiro’s critical eye but, as we have hinted at in the second section, Gally’s picaresque journey is not so much a quest to grow stronger (in the physical sense) but rather a moral pursuit of self-betterment.

In a form of answer to Latour’s question, Gally’s sacrifice symbolizes a kind of “promethean ethics” which, as the French philosopher Catherine Larrère has pointed out, is an altruistic move whose motivation may be called into question but which is intrinsically humanistic. When Prometheus stole fire from Zeus, it was to give it to mankind as a whole, not to let a few benefit from it to the detriment of others. Larrère opposes the promethean ethics to what she calls a “pelagian” ethics, from the name of the ascetic monk Pelagius who denied the original sin and asserted that man could reach salvation by its own means. She does not dismiss Pelagius’ objective of individual self-betterment, but illustrates that an ethics based solely on individual perfectibility eludes the aspiration towards a larger Good that includes the social link. According to her, a self-centered and egoistic vision permeates the transhumanist hope for human enhancement by nanotechnology because it strives only for a better efficiency in a world defined as ultra-liberal and competitive.

This is what *Ganmu* vividly characterizes through its very dark depiction of Kuzutetsu, where technological achievement serves only individual purposes (getting stronger, smarter, richer), and of Zalem where only a few benefit from apparently better living conditions. Gally only, but in a striking and conjuring stance, reminds of the need for a mediation between nature and society at large and, despite her strong individual will, highlights the importance of the social link. What Gally wishes for is that each and every human may be able to use his invisible wings to set off on his own journey³⁴. Individual freedom is however closely intertwined with the collective in the sense that it goes along with some sense of responsibility and moral behavior.

Building from cybernetics and the emerging nanotechnologies, Kishihiro offers through his work a new way of envisioning nature and society where the proliferation of hybrids calls for a mediated and harmonious co-existence. Instead of rejecting hybridity as denaturing, or

wholeheartedly embracing it as the ineluctable evolution of humankind, he makes the point that nature or “humanhood” are defined in a very complex way which is always in motion. It is therefore necessary to ponder over the possible new articulation between nature (as we construe it) and artifact:

Taking responsibility for the social relations of science and technology means refusing an anti-science metaphysics, a demonology of technology, and so means embracing the skilful task of reconstructing the boundaries of daily life, in partial connection with others, in communication with all of our parts. (Haraway, 181)

To conclude

From this very brief dive into a cyber-punk manga such as *Ganmu*, I hope I have been able to illustrate that science fiction can provide a very interesting interpretation of science worldviews, especially in the context of cybernetics and nanotechnology. The breakdown of ontological boundaries in the manga significantly echoes the blurring of the frontiers between “real” science and science fiction, as pointed out in the introduction. Even if this entanglement of science with science fiction seems of particular concern to some scientists, it does reveal that the practice of science is not confined in the ivory tower, that sciences and technologies are rather connected to society in what Latour calls a “network”. Japan offers particularly compelling examples in the form of symposiums gathering well-known scientists and science fiction writers. One of the latest, the 65th International SF Convention coupled with the 46th Japanese SF Convention, held in 2007 in Yokohama, was entitled “Front Line of Science and SF” and brought together SF writers with Japanese researchers from various fields (robotics, cognition...). Sena Hideaki, who presided over the meeting, is himself a pharmacologist as well as a famous SF writer and emphasized that:

The bond between Science and SF will not break off at the end of the symposium. Both have whirled into a reciprocal stimulation right from the outset. While scientific achievements have continually given birth to fiction, the imaginative and creative power of fiction has always provided researchers with renewing motivation. The dialogue between Science and SF is still unfolding.³⁵

When speaking about science fiction and cyber punk, it is usually works by American authors that come into mind (most notably by William Gibson or Greg Bear). However, Japanese SF is also present: Hoshi Shin’ichi, one of the most prominent SF writer in Japan, has nicknamed the 1960’s period the Golden Age of Japanese SF. According to him³⁶, the improved conditions of living after the War stimulated the genre precisely because Japanese could focus on other matters than mere survival. Science fiction specialists Tatsumi Takayuki, Istvan Csicsery-Ronay Jr. and Christopher Bolton acknowledge the world cultural presence of Japanese SF from the end of World War 2, but they argue that it was not in the shape of prose literature that it met with international success, but rather through “newer” and more popular media, especially manga and anime (Bolton, et al. vii). Indeed these media (it’s even truer of anime as it itself embodies new technology) add a powerful visual aspect to the narrative of science fiction, and aim at a much larger public (especially those who are not inclined to read prose but feel fascinated by science and technological development). Manga works like *Ganmu*, *Akira* or *Ghost in the Shell* sparked a worldwide enthusiasm that inspired other artists and helped trigger a reflection on the so-called post-modern blurring of the boundaries among other themes.

Notes

¹ *Haisha*, published in *Shūeisha's* magazine *Ultra Jump* from 1995 to 1996; and *Ganmu Gaiden (Gunnm : Another Stories)*, published in the same magazine between 1997 and 1998.

² In the interview he gave to the French magazine *Tsunami*, he explained: “External and personal circumstances made it difficult to continue the series. I then decided to end it. I wasn't forced to do it. I made the decision after some painful thought.” Another interview published in the 1998, Oct. 25th issue of *Ultra Jump Magazine* reveals the same weariness towards the original series: though Kishiro was thinking (while working on it) to have Gally travel to the space colonies, such a development of the story would have demanded tremendous work and the author felt too exhausted to carry on. According to him, the ending, however, turned out to be “quite unnatural.”

³ See the NNI homepage: <http://www.nano.gov/html/facts/whatIsNano.html> (last access: 07/2009)

⁴ See the European Commission homepage: http://ec.europa.eu/nanotechnology/index_en.html (last access: 07/2009)

⁵ See MEXT homepage: <http://www.nanonet.go.jp/japanese/nano/about.html> (last access: 07/2009)

⁶ See Marvin Minsky's foreword in Drexler's *Engines of Creation*.

⁷ See the debate between Drexler and Richard Smalley. Open correspondence between them is available on the website of the Foresight Institute. <<http://www.foresight.org/nano/Letter.html>> (last access: 07/2009)

⁸ I borrowed the expression from Christopher Toumey.

⁹ See Drexler's *Engines of Creation*, chapter 1: “molecular tools will bond molecules together to make tiny gears, motors, levers, and casings.”

¹⁰ Ibid. chapter 2: “they will have a set of assembler arms.”

¹¹ Ibid. chapter 2: “For an assembler arm to move a mere million times per second would be like a human arm moving about once per minute: sluggish. So it seems a very reasonable goal.” and further: “At the end of ten hours, there are not thirty-six new replicators, but over 68 billion. In less than a day, they would weigh a ton; in less than two days, they would outweigh the Earth.”

¹² Ibid. chapter 7.

¹³ “We have modified our environment so radically that we must now modify ourselves in order to exist in this new environment.” (48)

¹⁴ The term was invented by Manfred and Nathan Kline in 1960 to refer to a human-machine system that would better withstand outer-space conditions of living. Céline Lafontaine has clearly shown that the concept of a cybernetic organism has stemmed from a militaristic project of performance enhancement (especially during the Cold War).

¹⁵ The idea of a space elevator dates back to as early as 1895 (Russian scientist Konstantin Tsiolkovsky proposed a “Celestial Castle” in geosynchronous Earth orbit attached to a tower on the ground), but the discovery of the carbon nanotube (CNT) in 1990 spurred scientific to consider the project seriously. See the 2000 Nasa headline: “Audacious & Outrageous: Space Elevators.” <http://science.nasa.gov/headlines/y2000/ast07sep_1.htm>

¹⁶ Kishiro stresses out the fact that they are “Zalem robots”, to be thus understood as servants of Zalem in the sense of Karel Čapek's robot in his play *R.U.R.* (the Czech word “robot” meaning literally work, labor, serf labor).

¹⁷ Non-neuronal cells of the brain which play a role in the nervous system.

¹⁸ Radio Frequency Identification Devices that contain an electronic product code to identify any individual object (and possibly “subject”).

¹⁹ “genuine” refers here to a physically unenhanced or unmodified human who retains his/her biological body.

²⁰ As we will see later, Nova partakes of a double nature whereby he attempts at overcoming human determinism (seen as an oppression) by using trickery and deceit. His goal is to transcend the limits imposed upon human destiny (hence his name “Desty nova” can be interpreted as “new destiny”) to attain a deathless world freed from human misery, but he also understands that perfection necessarily entails a part of shadow. As a former citizen of Zalem, his brain is a bio-chip but it presented some defect that prevented the embedded limiting system to work properly. He is not a “perfect” creation of Zalem eugenics so that this “defect” makes him closer to the cyborgs of Kuzutetsu.

²¹ Pointing out to the loss of energy of any thermodynamic system (including the universe) and the evening out of differences. As Kishiro states in a note from the 9th volume, hot tea will cool down as time passes by, but the

reverse process is impossible. 「エントロピー増大の法則。ほっておくと熱いお茶はさめるが、その逆はないという経験則」(98).

²² A reference to the Tanakh (the Hebrew Bible) where Melchizedek is mentioned as the “king of righteousness”, the King of Salem (an alternative reading of Jerusalem). Although there is confusion on the interpretation of Melchizedek, Kishiro quotes an excerpt from King James Bible: “Without father, without mother, without descent, having neither beginning of days, nor end of life; but made like unto the Son of God; abideth a priest continually”(Hebrews 7:3). See *Ganmu* 9th volume, 「父もなく、母もなく、系図もなく、その生涯の初めもなく、いのちの終わりもなく、神の子に似た者とされ、いつまでも祭司としてとどまっている」(204). Kishiro thus lays emphasis on the fact that the computer AI resembles an immortal entity, seemingly beyond material determinism.

²³ When Nova, unveiling the secret of Zalem, ponders over the difference between a cyborg with a biological brain and a mechanical body and one with a mechanical brain and a biological body (Vol. 9, 20).

²⁴ From the Greek *τέλος* for “purpose”, “end”, in Aristotle’s sense of an intrinsic purpose of organisms (for its own sake), opposed to an extrinsic or imposed goal (as when a machine performs the action designed by man). Keekok Lee provides an in-depth analysis of the word (33-40)

²⁵ Just as the name of Nova’s son (ケイオス) whose split personality gives birth to the character Den (電, literally «electricity» in reference to the flow of information between Chaos and himself). In order to set the violent personality of Chaos free, Nova inserted a molecular-embedded transistor in Chaos’s nervous system so that it remotely controls an entirely mechanical body. Chaos himself was not initially aware that Den is actually his violent “shadow” (Vol.9, 118-121).

²⁶ But doesn’t Donna Haraway convincingly make the point that the cyborg figure “takes irony for granted?” (181).

²⁷ As Gally ironically points out, she is only “meat” (Vol.9, 42-6). She lacks the “mens sana” of the “mens sana in corpore sano.”

²⁸ The AI does possess a «core» (“hontai” 本体) that embodies its mind, so that death of the mind also entails death of the body and that the reverse process holds as well (Vol.9, 215).

²⁹ When Ido found the body, its bearer’s brain had already died but “it” didn’t. It was as if “it” was waiting for a new “host” (Vol.1, 96-7). Nova subsequently understands that it “longs” for a brain to merge with (Vol.5, 86-7).

³⁰ Zapan is the name of another character (Vol.5, 87).

³¹ According to Desty Nova 「これ自体一つの機械生物といえる」(Vol.5, 83).

³² Nanomanju 「ナノマン樹」(Vol.9, 246).

³³ Giving an account, even a brief one, of the monumental work of Durand is beyond the scope of this article. I will only point out to the possible significations of the blooming tree according to his classification of images and symbols.

³⁴ 「人には誰にでも見えない翼がある」and 「私がたった一つこの世界に望むことがあるとしたら、全ての人が自分の翼で飛ぶことだ」(Vol.9, 193).

³⁵ 「本日のシンポジウムが終了しても、サイエンスとサイエンスフィクションの関係が途切れるわけではありません。もともとこの両者は、螺旋を描くようにして互いに刺激し合ってきたのだと思います。サイエンスの成果は次のフィクションを生み出し、フィクションの創造力と想像力は研究者らへ新たなモチベーションを与え続けてきました。サイエンスとサイエンスフィクションの対話は続きます。」(Komatsu Sakyō and Hideaki Sena, 12)

³⁶ 「なにもかも昔の話。テレビの出現と普及のためか、経済成長がはじまったためか、活力のベクトル(方向)が変わったためか、一つの時代が終わってしまった。」 "It’s now an old story. Was it due to the advent of television and its spread in society, was it related to the beginning of economic growth, or simply a shift in the orientation of social dynamics? Anyway, it was the end of an era" (Hoshi, 11).

Works cited

- Baudrillard, Jean. *Simulacres et simulation*. Paris: Galilée, 1981.
- Bensaude-Vincent, Bernadette. "Two Cultures of Nanotechnology." *Nanotechnology Challenges: Implications for Philosophy, Ethics and Society*. Ed. Baird D. and J. Schummer. Singapore: World Scientific Publishing, 2006. 7-28.
- *Les Vertiges de la Technoscience, Façonner le monde atome par atome*. Paris: La Découverte, 2009.
 - *Se libérer de la matière, fantasmes autour des nouvelles technologies*. Paris: Quae, 2004.
- Bolton, Christopher, Istvan Csicsery-Ronay Jr. and Takayuki Tatsumi, eds. *Robot Ghosts and Wired Dreams, Japanese Science Fiction from Origins to Anime*. Minneapolis: University of Minnesota Press, 2007.
- Čapek, K. *R.U.R. (Rossum's Universal Robots)*. Trans. Claudia Novack-Jones. Penguin Classics, 2004.
- Drexler, Eric. *Engines of Creation: the Coming Era of Nanotechnology*. Oxford University Press, 1986.
- Durand, Gilbert. *Les Structures anthropologiques de l'imaginaire*. Paris: Dunod, 1992.
- Eliade, Mircea. *Forgerons et Alchimistes*. Paris: Flammarion, 1956.
- *Mythes, rêves et mystères*. Paris: Gallimard, 1989.
- ETC Group Communiqué. "The Strategy for Converging Technologies: The Little BANG Theory." Issue 78, March/April 2003. Downloadable from <http://www.etcgroup.org/en/materials/publications.html?pub_id=169>
- Feynman, Richard. "There's Plenty of Room at the Bottom: An Invitation to Open up a New Field of Physics." *Engineering and Science* 23 (Feb.1960) : 22-36.
- Goffette, Jérôme. *Naissance de l'anthropotechnie, De la médecine au modelage de l'humain*. Paris: Vrin, 2006.
- Haraway, Dona J. *Simians, Cyborgs, and Women: The Reinvention of Nature*. New York: Routledge, 1991.
- Hayles, Katherine N. *How We Became Posthuman, Virtual Bodies in Cybernetics, Literature, and Informatics*. Chicago: The University of Chicago Press, 1999.
- Heinlein, Robert A. "Waldo" (1942). *Waldo & Magic, Inc*. New York: Dell Rey, 1986.
- Hoshi, Shin'ichi. *Are kore kōkishin* (Small talk about one thing or another). Tokyo: Kadokawa bunko, 1988.
- Jameson, Fredric. *Archeologies of the Future*. Verso, 2005.
- *The Prison-House of Language*. Princeton: Princeton University Press, 1972.
- Kishiro, Yukito. *Ganmu (Battle Angel Alita)*. Tokyo: Shūeisha, 1990-1996.
- *Ganmu: Last Order (Battle Angel Alita: Last Order)*. Tokyo: Shūeisha, 2000~.
- Komatsu, Sakyō and Hideaki Sena, eds. *Saiensu imajinēshon, kagaku to sf no saizensen, soshite mirai e (Front Line of Science and SF)*. Tokyo: NTT Publishing, 2008.
- Lafontaine, Céline. *L'Empire cybernétique. Des machines à penser à la pensée machine*. Paris: Seuil, 2004.
- Larrère, Catherine. "Éthique et nanotechnologies: la question du perfectionnisme." *Bionano-éthique, Perspectives critiques sur les bionanotechnologies*. Ed. Bensaude-Vincent B. R. Larrère and V. Nurock. Paris: Vuibert, 2008. 127-41.
- Latour, Bruno. *Nous n'avons jamais été modernes, Essai d'anthropologie symétrique*. Paris: La Découverte, 1991.
- *Pandora's Hope, Essays on the Reality of Science Studies*. Cambridge: Harvard University Press, 1999.

-
- Laurent, L. and J.C. Petit. "Nanosciences and their Convergence with other Technologies: New Golden Age or Apocalypse?" *Nanotechnology Challenges: Implications for Philosophy, Ethics and Society*. Ed. Baird D. and J. Schummer. Singapore: World Scientific Publishing, 2006. 249-86.
- Lee, Keekok. *The Natural and the Artefactual: The Implications of Deep Science and Deep Technology for Environmental Philosophy*. Lanham: Lexington Books, 1999.
- Lévi-Strauss, Claude. "The Structural Study of Myth." *Journal of American Folklore* 78.270 428-444 (Oct - dec. 1955).
- Lopez, José. "Bridging the Gaps: Science Fiction in Nanotechnology." *Nanotechnology Challenges: Implications for Philosophy, Ethics and Society*. Ed. Baird D. and J. Schummer. Singapore: World Scientific Publishing, 2006. 327-56.
- Mauss, Marcel. *Sociologie et Anthropologie*. Paris: Presses Universitaires de France, 2004.
- Merleau-Ponty, Maurice. *Phénoménologie de la perception*. Paris: Gallimard, 1976.
- Milburn, Colin. "Nanotechnology in the Age of Post-Human Engineering: Science Fiction as Science." *NanoCulture: Implications of the New Technoscience*. Ed Hayles, Katherine N. Bristol: Intellect Books, 2004. 109-29.
- Moravec, Hans. *Mind Children: The Future of Robot and Human Intelligence*. Harvard: Harvard University Press, 1990.
- Ratner, M. and D. Ratner. *Nanotechnology*. New Jersey: Prentice Hall, 2003.
- Roco, Mihail C. "Government Nanotechnology Funding: An International Outlook." Report of the National Science Foundation (June 30, 2003).
<<http://www.nano.gov/html/res/IntlFundingRoco.htm>>
- Roco, Mihail C. and William S. Bainbridge, eds. *Converging Technologies for Improving Human Performance, nanotechnology, Biotechnology, Information Technology, and Cognitive Science*. Dordrecht: Kluwer Academic Publishers, 2003.
- *Societal Implications of Nanoscience and Nanotechnology*. Dordrecht: Kluwer Academic Publishers, 2001.
- Shirō Masamune. *Kōkaku kidōtai: Ghost in the Shell*. Tokyo, Kōdansha: 1991. Later adapted in a famous animation movie directed by Oshii Mamoru: *Kōkaku kidōtai: Ghost in the Shell*, (Ghost in the Shell). Dir. Oshii Mamoru. Production IG, Bandai Visual, 1995).
- Sulivay, Bounthavy. "Quelques représentations de la Nanotechnologie dans le Manga." *Alliage micro & nano* 62 (April 2008) : 89-98.
- Taniguchi, Norio. "On the Basic Concept of Nano Technology." Proc. Intl. Conf. Prod. Eng. Tokyo, Part II, *Japan Society of Precision Engineering*, 1974.
- Toumey, Christopher P. "Anticipating Public Reactions to Nanotechnology." *Nanotechnology Challenges: Implications for Philosophy, Ethics and Society*. Ed. Baird D. and J. Schummer. Singapore: World Scientific Publishing, 2006. 383-411.
- "Interview de Kishiro Yukito." *Tsunami*, 18 (Nov. 1995).
- Wiener, Norbert. *Cybernetics and Society, the Human Use of Human Beings*. Boston: Houghton Mifflin, 1954. Republished by Da Capo Press: 1988.