

Transmutations

Bio-sf, nomad science, and the future of humanity

TOM IDEMA

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CONTENTS

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Acknowledgments?

Acknowledgments	9
1. Introductions	11
PART 1 — THE PROBLEM OF LIFE	
2. Vital experiments: sf, science, and the shock of the biophysical	33
3. Thinking <i>a</i> life: nomadism as a challenge for (post-)genomics	51
PART 2 — TALES OF TRANSMUTATION	
4. Infected genomes: symbiogenesis in Greg Bear's <i>Darwin's Radio</i>	73
5. Trading traits: species encounters in Octavia Butler's <i>Lilith's Brood</i>	89
6. "Terrain is powerful genetic engineer": constructive interaction in Kim Stanley Robinson's <i>Mars</i> trilogy	109
PART 3 — A NEW PEOPLE AND A NEW EARTH	
7. Nomad science and cosmic life	129
8. Bringing science to life	149
Notes	157
References	181
Summary	205
Nederlandse samenvatting	211
Curriculum vitae	217

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— 1 —

INTRODUCTIONS

He has gone through a tremendous transformation, from a little water creature living in a realm of amniotic fluid, then coming out, becoming an air-breathing mammal that ultimately will be self-standing. It's an enormous transformation; it is a heroic act, also on the mother's part for bringing it about.

— Joseph Campbell —

All life starts and ends in a fuzz. The human embryo is a vague assemblage that, if all goes right, grows into a more or less discrete body, which at some point dies, dissolving into soil, water and air. On another scale, astrobiology traces the origins of terrestrial organic life all the way back to a pre-biotic soup in and from which it was ostensibly created, predicting that approximately 2.8 billion of years from now, all life on earth will have perished due the increase of the sun's luminosity (O'Malley-James et. al). Science explores the evolutionary adventures of organisms, space ship Earth, and even the universe itself, adventures in which order emerges from and inevitably returns to chaos (Prigogyne and Stengers; Kauffman, *The Origins*). Naturally, what goes for the universe also goes for the realm of words and thoughts, which assemble, combine, proliferate, transform and disappear. For example, the term "introduction" has found a specific niche in the discourse of biology, where it refers to the reallocation by humans of a species into an environment foreign to that species. The term "migration" has followed a different trajectory: first used to describe the cross-territorial movements of animals, this term was then applied to the journeys of insects, plants, trees, cells, genes, and even planets, while in every-day social discourse it usually applies to human beings. I present these particular etymologies because they convey something essential about life: each migration means a new beginning and each introduction must *come from somewhere*. In other words, there is no such

thing as a pure species, a natural habitat, or an original meaning. From the start, life means moving to another world, a world that will not leave any body unmarked.

This thesis aims to contribute to science studies², as well as to the allied fields of literature and science³ and science fiction studies, by examining strange events of the above-mentioned kind: introductions into foreign environments as a result of which species transform. The speculative element is that human beings are as much the “objects” as the “subjects” of these introductions. Not only are humans themselves experimentally introduced into new (fictional) worlds, but human bodies are also reconceptualized as habitats for microorganisms, reminding us that our bodies contain “a greater number of bacterial than human cells” (Margulis, “Prejudice” 37). Analogous to these evolutionary adventures, this thesis introduces different species of text—literary, scientific and philosophical—into one-another. Thus literature becomes a stage on which the dramas of science and philosophy are performed; philosophical concepts are enriched by adding literary and scientific ingredients; and science is revitalized by the philosophical conceptualization and literary “imagineering” of futures (Rossini, “Figurations”). Such epistemological encounters in foreign territory, often leading to symbiotic relations and triggering unexpected changes in each species, can be theorized as components of what philosophers Gilles Deleuze and Félix Guattari⁴ call “nomadic thought” (*A Thousand* 320). But before moving into philosophy, I will first sketch the theme of this thesis in broad strokes on the basis of examples from contemporary science fiction (sf) and bioscience.

In many sf narratives, humans migrate to (or find themselves introduced into) strange worlds, and in some cases, such journeys trigger transformations in human beings. In Kim Stanley Robinson’s critically-acclaimed *Mars* trilogy,⁵ for example, a group of one-hundred scientists establishes a new society on Mars, using drugs and gene therapy to enhance themselves in order to cope with the harsh Martian circumstances, and simultaneously using biotechnology to alter the planet’s atmosphere so that it becomes breathable. At the beginning of *Green Mars* (1994), the second installment of the trilogy, an unidentified narrator sheds a different light on the ideology of “terraforming” Mars—turning it into a second Terra (earth):

Of course all the genetic templates for our new biota are Terran; the minds designing them are Terran; but the terrain is Martian. And terrain is a powerful genetic engineer, determining what flourishes and what doesn’t, pushing along progressive differentiation, and thus the evolution of new species. And as the generations pass, all the members of a biosphere evolve together, adapting to their terrain in a complex communal response, a creative self-designing ability. This process, no matter how much we intervene in it, is essentially out of our control. Genes mutate, creatures evolve: a new biosphere emerges, and with it a new noosphere.⁶ And eventually the designers’ minds, along with everything else, have been forever changed. (*Green* 13)

This passage decenters the idea of the genome as the cradle of life itself, as well as the accompanying assumption that humans can modify life at will. In the course of the mission, increasing numbers of scientists become convinced that Mars isn’t a passive, dead world waiting to be animated and colonized by humans, but a world onto itself that will affect its inhabitants in

unpredictable ways. Their view is vindicated when the project of terraformation, partly due to political rivalry, spins out of control: transformations in the atmosphere, soil and ecosystems are no longer guided by scientists. The advent of a new world and a new people becomes even more apparent when second and third generation humans on Mars turn out to be physiologically adapted to Martian gravity from birth—taller, more slender, and more able to navigate the Martian landscape.

Rather than being mere fiction, the idea of permanent human settlement on Mars is a plan that has been scientifically developed by NASA and may become reality soon.⁷ Regardless of whether such a project will actually take place, what makes Robinson’s scenario significant is that it teaches us a great deal about the science and politics of the planetary dynamics of atmosphere, soil, weather systems, ecosystems, and so on. As contemporary history demonstrates, humans do not need to travel in space to arrive at new worlds: in a relatively short amount of time they have transformed the earth itself in dramatic ways, so that we now live in the world-historical era of the “anthropocene” (Crutzen).⁸ Historians like Rosalind Williams and David Nye have documented the construction of industrial habitats in the US, into which people from across the globe have been “introduced”—habitats that look, sound, smell, and feel different than previous (but relatively recent) environments. Moreover, not only have humans radically altered their habitats, they have also changed their behaviors and bodies through new forms of medicine, food, cosmetics, media, transport and household appliances. In a way, we are still catching up with these transformations. For example, new technologies require adapted cognitive and sensorimotor skills, and modern diets are out of sync with our genomes, thus challenging our digestive systems (Zwart, “Biotechnology”). All of this shows that the anthropocene does not refer to an era *controlled* by human beings. It would be more accurate to say that, at least since the Industrial Revolution, planetary dynamics such as climate and the survival and extinction of species have dramatically changed as a result of a feedback loop between human-induced changes and nonhuman processes, and consequently, that “human artifacts, such as machines, pollution, and even works of art are no longer seen as separate from the feedback processes of nature” (Margulis, “Gaia” 184).

The unorthodox statement from the narrator in *Green Mars*—“terrain is a powerful genetic engineer”—radicalizes a currently emerging insight that genomes are “reactive” (Gilbert; Stotz, Bostanci and Griffiths) rather than self-directing. As Paul Griffiths and Karola phrase it, “the factors that interactively regulate genomic expression are far from mere background condition or supportive environment; rather they are on par with genetic information since they co-specify the linear sequence of the gene product together with the target DNA sequence” (“Experimental” 12). This insight brings into view environmental factors as active elements in the generation of life, rather than mere results, influences, or perturbations, thus replacing the linear model of “genotype determines phenotype” for a multifactorial topology or complex systems model. In complexity theory, the units of development and evolution are not just genes, organisms or populations, but all of these at once. More significantly, what evolves are assemblages of systems that coincide with particular bodies. For example, in spatial terms, the development of an ant is constituted by internal systems (neuronal, vascular, digestive, etc.) and external systems (the colony, an ecosystem, climate, and so on). This inside-outside spectrum is

unstable, forever changing: the outside is incorporated (for example through consumption and learning) while the inside is extended or externalized (through building and communication). Temporally, systemic developments are emergent, non-linear and thus unpredictable, not only because they depend on a vast and unknown accumulated history, but because they tap from a virtual potential. In living systems, periodic behaviors (life cycles, migration patterns) and gradual behaviors (growth, learning) are punctuated with bifurcation points at which systems make phase transitions (puberty, metamorphosis, death). Informed by a legion of scientific insights, Deleuze and Guattari argue that bifurcation events, rather than being consequences of set laws, are like dice throws:

[N]o one, not even God, can say in advance whether two borderlines will string together or form a fiber, whether a given multiplicity will or will not cross over into another given multiplicity, or even if given heterogeneous elements will enter symbiosis, will form a consistent, or cofunctioning, multiplicity susceptible to transformation. (*A Thousand* 276)

While complexity theory was first conceived within the context of living organisms, theorists have shown that it conceptualizes many *mechanism-independent processes*, meaning that such processes occur in all known systems (Delanda, *Intensive*; Goodwin, *How the Leopard*; Kauffman *The Origins*). Complexity theory is a theoretical model that explains how order emerges out of chaos.

A particularly clear argument about the nature and significance of nonlinear topology comes from the biologist and complex systems theorist Brian Goodwin. I will cite him at length, for his statement summarizes the point of departure for this thesis:

The introduction of a new species into an ecosystem or a new gene into the genome of an organism will in general have unpredictable consequences. Ecological management and biotechnology are intrinsically unpredictable interventions into natural systems. Another way of putting this is that nature is, in general, unpredictably creative. Those aspects of the natural world that have turned out to be largely predictable and controllable, which constitute the basis of our major technologies (lights, computers, cars, TV, hydroelectric generators, etc.), belong largely to the linear realm of cause-effect relationships and occupy a very small fraction of natural processes. Most nature is non-linear and complex, and hence unpredictable in its response to disturbance. We see this in the climactic consequences of global warming that we are now being forced to recognize, in the increasing incidence of epidemics of new as well as old pathogens, and in the dramatic extinction of species that we have unwittingly unleashed through habitat destruction and irresponsible farming practices ... If we cannot predict, manipulate, and control complex systems, which include organisms, ecosystems (agricultural and natural), communities, organizations, and economies, what is the appropriate form of behavior in our relationship with them? Science itself has taken us to a new frontier of understanding, but it is not clear what form of praxis comes with it. We have lost the innocence of believing we can always fix things with new technology, but the alternative way of being in the world is only slowly emerging into general consciousness. ("Developmental" 342)

What Goodman conveys here is that science and technology should not be thought of as straightforward tools for human progress, but as radical reconfigurations of what it means to be human (Lemmens; Verbeek 27). The Industrial-instrumental mode of existence is running out of steam. As the philosopher of science Hub Zwart argues, instead of approaching transformations such as climate with the modern strategy of "containment," humans need to adapt themselves and their environments to turbulent developments (Zwart, *Denkstijlen* 218, 228-9). From my perspective, Goodwin's prospects of another science and an "alternative way of being in the world," in which human beings are not masters of the world but *participants in its unfolding*, are neither idle theorizing nor utopian fantasy, but matters of societal, epistemological and ecological urgency.

Each in their own way, Robinson's sf and Goodman's vanguard science bring to the fore the reality and significance of evolutionary existence, understood as symbiotic embodiment, ecological embeddedness, and susceptibility to transformation. These thinkers confront Western thought and culture with the pre-modern belief that everything is connected, a belief has never really disappeared, argues Bruno Latour in *We Have Never Been Modern* (1993). Darwin's descriptions of the overwhelming diversity of biological forms encountered on his journeys can be seen as just such a confrontation. In *The Origin of Species* he criticizes the "ignorance" of biologists denying "the mutual relations of all the beings which live around us," relations that determine "the future success and modification of every inhabitant of this world" (68-9). The challenge presented by Darwin and Goodwin is not to "return" to some hypothetical moment of unity, but to reinvent a world of immanent connections and readapt the tools of thought that have too often obscured this world. Darwin's speculative treatise on the mutability of species, targeted at a general audience, can be seen as a first draft of what biologist Lynn Margulis and her son the philosopher Dorion Sagan call "the greatest tale ever to be told," a tale that they argue *needs* to be written in a popular style because "it is everybody's story" (*Acquiring* xvi).⁹ Crucially, in Margulis and Sagan's work, evolution is not a linear story told from the vantage point of humanity, but a hodgepodge of actors and dramatic events. Margulis and Sagan argue that in popular science, and evolutionary biology in particular, it is possible to envision "the whole" (*Acquiring* 126). In this encompassing story, life is not *purely* biological. Evolution is not a biological theater piece performed on the stage of the inorganic world, a piece now partially directed by humans through science and technology. The "narrative" of evolution partakes of all the strata of life (physical, biological, social and technological), their mixtures (such as biotechnology), and all of the systems that pervade the strata (climate, economics, psychology, and so on). It follows that science studies cannot maintain the illusion of surveying the emergence of an evolutionary paradigm from a safe distance: it must actively participate in the story of evolution, which, according to Andrew Pickering, ultimately means forging "an evolutionary theory of indefinite scope" (*The Mangle* 247). Needless to say, this daunting task is long-term, collective, and interdisciplinary.

TRANSMUTATION AND NOMADIC THOUGHT

In the image of life presented by Goodwin and Margulis, human beings coevolve with their planetary others without ever controlling this process. If this vision of life as a complex becoming is relatively rare, it is hardly new, as evidenced by Heraclitus's aphorism *everything flows*

("panta rhei"). As Michel Serres has argued, what needs to be emphasized is the *temporal non-linearity* of life, its turbulence:

How can we not feel that time *percolates* rather than flows? Far from flowing in laminar and continuous lines, like a well-behaved river under a bridge, upstream to downstream, time descends, turns back on itself, stops, starts, bifurcates ten times, divides, and blends, caught up in whirlpools and countercurrents, hesitant, aleatory, uncertain and fluctuating, multiplied into a thousand beds like the Yukon River. (15)

On the one hand, some form of awareness of immanent transformation is clearly present in contemporary biology. Heraclitus's famous statement "one never steps into the same river twice" is complemented by modern biology's insight that *one never steps into the same river twice as the same person*: cells are renewed all the time, forming a similar but slightly different body. But what about the radical transmutations occurring in embryos and species? Remarkably, those biological fields that most explicitly see life as a transformative process—evolutionary biology, developmental biology, and embryology—have since the 1950s become subservient to a "molecular paradigm"¹⁰ (Neumann-Held and Christoph Rehmann-Sutter), and to genetics in particular (Kay; Fox Keller, *The Century*). Within the parameters set by molecular biology, the concept of evolution has been reframed as a genetic reproduction of sameness with minor (usually malign) mutations that are selected over vast areas of time (i.e. redundancies and copy-errors). Why did this happen? Furthermore, why are most debates on the technological capacity to transform life fraught with tension?

One possible explanation lies in history, and specifically the history of eugenics, a political ideology that promotes the enhancement and reproduction of particular "human races." After WW II, when eugenics was publically rejected as a doctrine and a scientific idea, literary texts about dubious experiments with human bodies have consistently reminded society of eugenic practices under the Hitler and Stalin regimes and elsewhere. These warnings against the power of states to tinker with human bodies, violating their integrity and dignity, frequently return in contemporary debates about biology and biotechnology, for example about embryo selection (Huxley's *Brave New World*) or the prospect of biopolitical surveillance on the basis of genetic identity (Orwell's *Nineteen Eighty-Four*; Atwood's *Oryx and Crake*). But the specter of eugenics is not a sufficient explanation: anxieties also pertain to the genetic modification of other organisms, for example those that end up in foodstuffs (leading popular media to speak of "Frankenstein food"). Moreover, fears surrounding the biosciences exceed human intervention altogether. The widespread and virulent resistance against the concept of evolution in Darwin's time indicates that anxieties concern *the very possibility of transformation as such*. While Darwin's ideas have come to be accepted, new challenges have emerged. For example, neo-Darwinists like Richard Dawkins and Daniel Dennett have been unwilling to accept the burgeoning idea, perhaps advanced most forcefully by Margulis, that the slow accumulation of random mutations selected by nature is complemented by evolutionary jumps in which new species emerge. The tendency to deny the real possibility of transformation must somehow be more structural.

An explanation can be found on the basis psychoanalytical approaches to science studies such as the one pursued by Zwart, who aims "to address *epistemological* rather than historical issues" (*Understanding* 12). Following the footsteps of Gaston Bachelard, Zwart holds that each science has its archetype: a fundamental fantasy that remains hidden but all the while co-determines the field (Zwart *De Waarheid*). For example, in chemistry, students may be fascinated by the idea of an explosion, yet in their pursuit of becoming real scientists, they are forced to lay this fundamental fascination to rest (47). Could it be that transmutation has the status of a biological archetype? I would argue that this is the case, but that it also constitutes a blind spot of Western thought as such, and can be linked, in one way or another, to all epistemological archetypes.¹¹ Following Deleuze, I attribute the neglect of biological transmutation to a general inability to think "becoming" (*Difference*). In *Difference and Repetition* (1968), Deleuze demonstrates that Western thought has systematically reduced difference to a negated or *comparative* difference (being different *from*), thus denying the full positivity of difference-in-itself, or becoming-different. As Elizabeth Grosz explains, instead of defining something by what it is not, Deleuze searches for a real "that lacks nothing, that is fully positive, that functions as a whole, as well as for a real that changes, that generates the new, that continues becoming, even as it undoes earlier becomings" (*Becoming* 54). A central epistemological habit associated with the neglect of difference as such is the division of the world in human subjects and nonhuman objects. Epitomized by the works of Descartes and Kant, Western thought continually reproduces the "I" as a ground, thus marking a fundamental difference between human beings and others that will determine the way all other differences are perceived. For Deleuze, the challenge of thought is to go beyond this habit in order to intuit the world of inhuman becomings, because this is where the conditions of life, including human perception and thinking, are generated.¹²

In Deleuze's work, modes of thought that envision the world as becoming are termed "nomadism." This term can perhaps be best read as a principle for thought, not in the sense of a constraining dogma but, quite the contrary, as a style of thinking that time and again encourages one to think otherwise, to cross into unknown territories. Nomadism has nothing to do with Enlightenment ideals of freedom and self-fulfillment: it means being continually at war with present conditions, including oneself. James Williams argues that in Deleuze's work there are actually two principles that vie for dominance: "connect with everything" and "forget everything" (4-5). These are strategies which, however much they contradict, must cooperate in a struggle to cope with changes in the world, forcing one to establish new connections while leaving the past behind. A major trait of nomadism is to escape habits of thought (opinion or *doxa*) such as the binaries of subject and object, human and nonhuman, by affirming the relations and becomings that simultaneously condition and transform them. The challenge of nomadism, I would argue, is not to somehow "get rid of" the notion of a human subject, but to question its centrality by rethinking life through the prism of nonhuman forces, and by actively changing what it is to be human through thought-experiments. In Deleuze's work, humanity is defined not by what it ostensibly is, but what it is capable of becoming (Bruun Jensen and Rødje 1; Colebrook, *Deleuze* 127). This capability is not some internal essence; rather, it develops in a web of relations connecting inside and outside, drawing and simultaneously blurring boundaries. In *A Thousand Plateaus* Deleuze and Guattari describe these dynamic

relations as “territorialization” and “deterritorialization,” a becoming striated (ordered) and a becoming smooth (fluid) of the world (59-82).

The nomadic desire for difference is detected by Deleuze in all three modes that he singles out for thought: philosophy, art, and science. It seems important to concisely discuss Deleuze and Guattari’s conceptualization of all three domains in *What is Philosophy*, since their singularities, oppositions and interactions are central to this thesis. The differences between the modes of thought hinge on a different relation to the virtual (the realm of pure potentiality or becoming) and the actual (individuated bodies and states of affairs). According to Deleuze and Guattari, philosophy attains a consistency that science never does; it consistently intuits becoming–time as a heterogeneous and continuous *event*. Deleuze and Guattari describe their difference as follows:

It could be said that science and philosophy take opposed paths, because philosophical concepts have events for consistency whereas scientific functions have states of affairs or mixtures for reference: through concepts, philosophy continually extracts a consistent event from the state of affairs—a smile without a cat, as it were—whereas through functions, science continually actualizes the event in a state of affairs, thing, or body that can be referred to. (126)

An event, for Deleuze and Guattari, cannot be quantitatively measured or otherwise referred to in a scientific way. Philosophy’s “smile without a cat” is an ideal event, an event “extracted” from a particular state of affairs. It presupposes an understanding of time not as a region between two points, but as a “meanwhile” (158), a time that never begins or ends, always becoming in the middle.

For Deleuze and Guattari, there is something essential about art that places it close to philosophy: art also moves in the direction of the virtual, away from the world of subjects and objects, but this time by creating affects and percepts: “affects are nonhuman becomings of man, just as percepts ... are nonhuman landscapes of nature” (169). Affects and percepts are “blocs of sensation” that are no longer dependent on the feelings and perceptions of makers or observers because they have become preserved in the art work as “monuments” (167). Deleuze and Guattari propose that rather than being created through memory or fantasy, all art is “fabulation” (168).¹³ Fabulation is what allows the artist to escape the realm of human feelings and perceptions (*doxa*), a dangerous act:

He has seen something that is too great, too unbearable also, and the mutual embrace of life with what threatens it, so that the corner of nature or districts of the town that he sees, along with their characters, accede to a vision that, through them, composes the percepts of that life, of that moment, shattering lived perceptions into a sort of cubism, a sort of simultaneism, of harsh or crepuscular light, of purple or blue, which have no other object or subject than themselves. (171)

While the artist escapes *doxa* by his own strength, there is also a sense in which he is absorbed into an adventure involuntarily. The artist perceives and feels differently, intensely, and loses himself in sensations, with the benefit of creating art, but with the risk of going mad and creat-

ing nothing at all. If it is true that all art is “timeless,” as is sometimes said, this is because even the most ephemeral art gives form to becoming: “So long as the material lasts, the sensation enjoys an eternity in those very moments” (166).

Science’s maintains an entirely different, and in some sense inverted relationship to the virtual or becoming. Science perceives the virtual as pure chaos that cannot be given form without actualizing it. Its task is to extract pieces of chaos and actualize them in *functions*, propositions that relate to bodies and states of affairs (155-6). Compared to art and philosophy, science moves in the opposite direction: science is a “fantastic slowing down” or “freeze-frame” (118): a movement from the infinite speed of becoming to actual bodies and states of affairs. However, as Deleuze and Guattari warn, science “is inspired less by the concern for unification in an ordered actual system than by a desire not to distance itself too much from chaos, to seek out potentials in order to seize and carry off a part of that which haunts it, the secret of the chaos behind it, the pressure of the virtual” (156). It is this tension within science—the necessity of getting a good piece of chaos, and the need to return safely from the frontlines in order to actualize it—that is central to this thesis. As Isabelle Stengers has argued, a pitfall for science is proceeding towards the actual too quickly, thus producing facts, solutions and answers that are simplistic and inadequate (“Another Science”). The challenge of nomad science is to *slow down the slowing down*, to stay with the chaos long enough. According to Deleuze and Guattari, this can be achieved, for example, by inventing “strange attractors,” functions that refer to chaotic behaviors of systems (*What is Philosophy* 206), thus avoiding deterministic models of the “program” type (209).

Science’s line of actualization or effectuation intersects with art and philosophy’s lines of countereffectuation (159). These intersections pose two dangers, “either leading us back to the opinion from which we wanted to escape or precipitating us into the chaos that we wanted to confront” (199). But as Deleuze and Guattari’s oeuvre itself demonstrates, the advantages of these interminglings are evident, preventing each mode of thought from becoming wrapped up in itself. Deleuze and Guattari stress that they have never tried to do the work of artists or scientists (161), but they often make use of art and science, because each function and each sensation also has its concept (217). Bruun Jensen and Rødje characterize Deleuze and Guattari’s relationship to science as *friendship*:

Rather than taking science apart, in order to expose underlying social powers and structures, Deleuze and Guattari look at the results of science and attempt to understand their actual and virtual capacities. They treat science as a distant and somewhat foreign friend whose tools and problems are different from their own, but who, precisely for that reason, can teach important lessons. (10)

These encounters with art and science have a great impact on the way Deleuze and Guattari do philosophy. For example, their allusion to the artist’s nonhuman adventure cited above, the artist who “has seen something that is too great,” is itself a kind of fabulation, a becoming-art.

Following Deleuze and Guattari, although this thesis positions itself precisely at the intersections of modes of thought, it is mostly invested in analyzing the underdeveloped term “nomad science,” specifically in relation to the biosciences, as well as experimenting with such a

mode within science studies. In *A Thousand Plateaus*, Deleuze and Guattari develop the concept of nomad science as a counterpoint to “State science” (which I reconfigure as “control science” in chapter 2 in order to make it more broadly applicable, for instance to “big” corporate science). Coterminous with the rise of the nation-state, State science is the dominant scientific mode intent on making things manageable, palpable, and predictable. In the folds and crevices of the state system, however, individual scientists may diverge from this standard model, moving with a certain degree of freedom between ideas, practices, disciplines, and institutions. Nomad is not the same as controversial, marginal, or pseudoscience (such as alchemy, phrenology, or parapsychology). Rather, nomad science is *the slowing down of the slowing down of science*—a science addicted to chaos. Nomad science more readily crosses the lines of countereffectuation of art and philosophy, which may help it to keep the chaos in sight. This thesis demonstrates that science can find interest in art works that incorporate (rather than merely allude to) scientific elements, as in Robinson’s *Mars* trilogy, a work that conveys essential aspects about science and its objects. But as Deleuze and Guattari stress, it is never a matter of influence, of the one becoming like the other, but of a becoming that passes between the two (*A Thousand* 262). Whether the intersections explored really amount to such becomings, or either to chaotic dis-solutions or loose associations (doxa), can only be determined afterwards.

As the work of Deleuzian philosopher Rosi Braidotti makes especially clear, nomadism is not just a matter of thought, but also of ethics and politics. According to Braidotti, nomadic ethics, through thought and activism, opens up the present to unforeseen possibilities by seeing subjectivity as a process of becoming different:

What this means is that the conditions for political and ethical agency are not dependent on the current state of the terrain. They are not oppositional and thus not tied to the present by negation; instead they are affirmative and geared to creating new futures. Ethical relations create possible worlds by mobilizing resources that have been left untapped, including our desires and imagination. They are the driving forces that concretize in actual, material relations and can thus constitute a network, web or rhizome of interconnections with others. Such a vision of the subject, moreover, does not restrict the ethical instance within the limits of human otherness, but also opens it up to the inter-relations with non-human, posthuman and inhuman forces. (“In Spite of the Times” 16)

Whereas ethics is not a formal analytical angle in this thesis, the epistemological “introductions” that compose it can be regarded as examples of Braidotti’s ethics of “mobilizing resources that have been left untapped,” creating a “network” of thought “geared to new futures.” By focusing on the *potentials* in ourselves and the world, nomadic ethics offers an alternative to a critical or reflexive ethics that risks being so preoccupied with present configurations of power and knowledge that it forgets to make a real difference. In resisting the present, nomadic ethics does not maneuver toward a particular end-state in the future, but rather affirms a virtual *becoming* suspended between actual presents and futures (Deleuze and Guattari, *A Thousand* 322).¹⁴ In other words, there is little use in saying that “we” have to “become nomadic”; rather it is nomadic practices that will make thought and humanity *become* in ways that no-one can tell in advance.

BIOSCIENCE AND HUMAN TRANSFORMATION

This thesis is more about nomad science than about control science, even though one can never discuss one without evoking the other. It presupposes that science studies, as well as literature and science and sf studies (fields that overlap significantly with science studies, see Chapter 2), can contribute to an understanding of life as becoming, and to the birth of another (bio)science that embraces this becoming. This can be achieved not by offering reflections or critiques from a distance, but by becoming implicated in bioscientific developments and, along the way, introducing foreign elements, for instance borrowed from sf. The goal of this thesis is fourfold:

1. to analyze a particular subset of sf novels as mappings of contemporary control (bio) science and nomad (bio)science;
2. to analyze a particular sub-set of popular science and science studies texts in order to flesh out nomadic potentials in contemporary (bio)sciences;
3. to demonstrate the use of particular sf texts and Deleuzian concepts for science studies;
4. to contribute to more robust understandings of life *as becoming* in science studies, biosciences, and beyond.

There is no hierarchy between these goals. Rather, they are pursued more or less simultaneously, with one goal challenging and strengthening the other. To put it differently, this thesis introduces elements from sf, (popular) bioscience, and Deleuze’s philosophy into one another in no particular order, thus preventing one type of discourse from being “influenced by” or “receptive of” another in terms of one-way transfers. This is what Deleuze and Guattari in *A Thousand Plateaus* call nomadism’s “logic of the AND,” (28) emancipated from the dominant, ratiocentric logic of the “OR.” In place of comparing and assessing, nomadism always brings in new elements or rejuvenates elements by introducing them in another context. Such epistemological cross-fertilizations and migrations become urgent, I argue, with the advent of global crises such as climate change, which connect the human and nonhuman worlds along many vectors, requiring map-makers from many disciplines.

The remainder of this chapter will elaborate this thesis’s aim to contribute to a mode of science studies that—in collaboration¹⁵ with other sciences, philosophy and the arts—takes on the challenge of mapping contemporary global crises as symptoms of the feedback between humanity and its environments. A point of departure for this endeavor is the broadening of the horizon for human becoming—past and future—made possible by recent developments in the biosciences, notably *genomics*—a conglomeration of fields that has played a crucial role in the past two decades, not only as a key field in what is often called “the life sciences,”¹⁶ but also as a perspective on life that influences science and culture at large. Genomics brings forth a range of insights and technologies that are extraordinarily significant in the sense that they elucidate and intervene in the genesis of organic life, making it increasingly recognizable, predictable and pliable. Research in genomics has laid the foundations for new ways of treating and possibly curing disease, and has promised revolutionary possibilities for modifying ecological environments, for example to clear pollution. Yet the implications

of genomics are ill-understood as long as we see them as rational and unambiguous solutions. Instead, they should be understood as *biopolitical*—as part of a historical (re)configuration of how humans influence themselves and their environments.

The notion of “biopolitics” refers to the ways in which (human) bodies become discursively and physically incorporated in regimes of power, notably the governance of “vital” aspects such as health, safety, mortality, and sexual reproduction (Rose). It is the simultaneity of intensified observation, access to vast genetic data sets, and new prospects for genetic manipulation that marks genomics as a biopolitical site *pur sang* (Marks, “Biopolitics”), a site that has been the subject of heated debates in scholarship and society alike.¹⁷ A critical question in debates about genomics is the *desirability* of new possibilities. For example, genomics is creating the knowledge and technology that will one day, perhaps quite soon, make it possible for parents to choose to have a child with certain mental and physical characteristics. Already, genomics has made possible far more radical interventions in animal and plant bodies, for example, enabling the production of “in vitro meat”: animal flesh that does not develop into an organism, a possible alternative to animal suffering in the bio-industry. Yet consuming in vitro meat could cause serious health problems—scientists have yet to understand its long-term effects on the body. Apart from questioning the desirability of certain prospects, scholars also aim to unpack the assumptions and promises of genomics on the premise that they are overtly speculative. Notably, critics have qualified the aim of the Human Genome Project (HGP), to unveil “the code of life itself,” as scientific hubris (Gould; Mayeri; Roof).

Although the outcomes of the HGP were far less spectacular than its promises, urging scientists to take on a more modest tone, they also—paradoxically—justified a call for further investments to continue the (post-)genomics pursuit, accompanied by new promises. Post-genomic research fields such as proteomics (the study of the structure and function of proteins) and systems biology (where researchers try to map the interactions between genetic, neuronal, hormonal and other systems) aim to unveil complex networks and interactions. This movement towards a complexity has consequences for debates around genomics and its societal implications. Genetic determinism—the belief in a one-to-one correspondence between a gene and a particular trait—no longer appears a viable position to take.¹⁸ Fundamentally, the question is no longer whether a given trait is “genetic” or which genes are responsible for it, but rather what particular role genes play in relation to other factors—inside as well as outside the body. This being said, it is still common that, in spite of its positioning among a host of other factors, the genome is interpreted as a kind of ground of origin, a final cause of life. One could speak here of “genomic determinism” (Crawford 26). This happens, for example, when life is reduced to a genetic *program*, making it predictable and susceptible to manipulation. In a 2012 lecture entitled “What is Life?” leading genomicist Craig Venter typifies the idea of genomic software as “a remarkably simple concept, remarkably complex in its execution.” It is this strange mixture of complexity and simplicity that allows molecular biologists to extract an enormous amount of data, work, money, prestige, and so on, while retaining a (deceptive) sense of control.¹⁹ As many biologists featured in this thesis point out, the idea of a program does not produce an understanding of life as becoming; it rather blocks such understanding. As long as the biosciences remain under the sway of determinism, they are unlikely to deal

effectively with the chaotic behaviors of interlocking systems that determine such problems as climate change.

In the meanwhile, a bioscientist like Venter can give us the impression that the key to life, the power of transformation, will soon be found. In his endless confidence in the concept of the genetic program, Venter has proposed that the costs of manned Mars missions can be drastically cut by simply sending digital information and regenerating life from the digital code (“What is Life”). Given the advancements of genomics, this does not necessarily mean cloning human beings. At least potentially, it means *making them*. As noted above, because the prospect of human transmutation is such a thorny issue, it is rarely touched on by mainstream scientists. Rather, it is either addressed by fierce critics or jubilant proponents. Given the pace of scientific developments, the time has come to take the debate beyond the crude positions adopted by “transhumanists” like Nick Bostrom and Ray Kurzweil, who believe that science will allow humanity to transcend its limitations (including death!), and the equally unproductive “technoconservatives” like Jürgen Habermas and Francis Fukuyama. As philosophers of technology have recently shown, this can be done by demonstrating that technology is not a mere conscious tool that we can choose to live without, but rather a necessary extension or mediator, thus blurring distinctions between human and nonhuman, nature and culture, the material and the spiritual (Bryant; Harman; Lemmens; Stiegler; Verbeek). From this posthumanist stance, the transhumanist notion that humans should strive to transcend their current biological constitution is actually based on rather outdated humanist values of control (Sharon; Verbeek). While this reconceptualization of technology remains a vital task, I follow a slightly different trajectory (divergent *and* overlapping), inspired by the recent work of Donna Haraway, whose oeuvre could be characterized as bearing on, as well as *performing*, introductions, migrations, and transformations.

Trained as a biologist in the 1970s, Haraway became interested in the historical, epistemological and political implications of bioscience and biotechnology. She moved to science studies, writing what has become a classic text, “A Cyborg Manifesto” (1985),²⁰ in which she emphasizes that the future of humanity is intimately connected with technoscience, to the extent that humans have already become, actually or virtually, cyborgs. After having written a number of studies during the 1990s in which bioscience and biotechnology figure prominently, another, more subtle shift occurs in Haraway’s work, leading her to write *A Companion Species Manifesto: Dogs, People and Significant Otherness* (2003). In her recent work Haraway chooses to emphasize the persistence of ecological, developmental, and evolutionary existence in a technoscientific world. The key message is that the future of humanity is conditioned above all by the ecological conditions of its earthly habitat and its relations to other life forms, without forgetting that technological artifacts play important parts in determining these conditions. Especially in *When Species Meet* (2007), Haraway is keen to connect to the work of biologists and biophilosophers such as Margulis who stress ecological embeddedness. Here Haraway uses Karen Barad’s notion of “intra-action”²¹ to reflect on her relation with her dog Cayenne and, in a wider context, the relations between human and nonhuman animals in sports, agriculture, the bio-industry and elsewhere: “Partners do not precede the relating; the world is a verb, or at least a gerund; worlding is the dynamics of intra-action ... and intra-patience, the giving and receiving of pat-

tering, all the way down, with consequences for who lives and who dies and how" ("Sf" 9-10). Haraway's dynamic understanding of culture, technoscience, and ecological relations serves as an antidote against the stark oppositions that have dominated debates about the future of humanity in a technoscientific age.

Haraway's work has been highly influential in feminist theory, science studies, cultural studies, and beyond. It pioneers a new scholarly field called animal studies (McHugh; Ten Bos; Wolfe), which aims to show that humanity is in large part defined by the relations it cultivates with animal others, building on Haraway's work, but also on Derrida's reflections on human-animal relations (*The Animal*). Furthermore, it feeds into new visions of the humanities under the banner of "posthumanities" (Rossini; Wolfe)²², as well as resonating with versions of environmental/ecological humanities, and Stotz and Griffiths' idea of "biohumanities," in which bioscience, philosophy, history, and society come together.²³ Furthermore, I would argue that Haraway's work exemplifies an "ontological turn" in science studies, where reality is no longer seen as a transcendent "truth" found only through experiments in natural science, but rather as "enacted" in practices in which scholars participate (Barad; Bruun Jensen; Latour, *Politics*; Mol; Pickering).²⁴ As Bruun Jensen argues,

epistemology collapses into ontology and the sciences are reformulated as practical activities aimed at (re)building the world by adding new elements with new capabilities and new relationships to it. Knowing (and thinking about knowing) are turned into particular styles and methods for connecting and cooperating with specific actors (human and otherwise)—thus shaping reality, or doing practical ontology. (248)

Following this ontological turn, the idea of science studies as a theoretical "meta-perspective" on science is unmasked. Science studies is as "empirical" as the natural sciences and is implicated in their most empirical questions, just as science is implicated in science studies's social and epistemological quandaries. But above all, as Haraway's work so vividly illustrates, both fields are fully implicated in contemporary technobiological existence and its (potential) transformations—there is no "gap" between science and society. As a consequence, popular science should no longer be perceived as a distortion or pollution of science, a necessary evil (Sismondo 170-1). The "unscientific" or "impure" narratives, images, and ideas of popular science cannot strictly be separated from scientific research, and they often inform it as much as they are informed by it.

With its emphasis on embeddedness and relationality, Haraway's work overlaps significantly with a burgeoning Deleuzian scholarship in science studies and philosophy.²⁵ Another reason why Haraway's work is important to this thesis is that it underscores the value of sf for science studies (Squier; Wald "The Art"). In an interview with Jeffrey Williams, Haraway qualifies her concept of worlding as an "sf term." Haraway's work reveals that sf does not so much "represent" science as think along with science about the changing conditions of a technoscientific world, a practice in which new possibilities of life are enacted by human and nonhuman actors. Sf opens up "our" worlds, revealing them as processes of becoming, teeming with potential. This utopian function of sf is vital in a time when, according to Eugene Thacker, sf imaginary threatens to become wholly subsumed into science and the (bio)technology industry. Technoscience

creates its own visions of the future based on the premise of unstoppable scientific progress. As Thacker argues, critical sf refuses to be "locked into the narrow path of simply realizing the future" according to the scheme of dominant science, instead exploring the "potentiality" of science and technology in unforeseen ways ("The Science" 158). Since public imagination tends to be dominated by simplistic narratives of progress and disaster, hope and fear, there is a great need for complex, non-moralistic stories that illustrate the non-hierarchical, changing relations between technoscience, society, and the nonhuman.²⁶ This observation about the use of sf narrative links up with Thacker's conviction that science studies should not settle for "'responding' or 'replying' to a technoscience that supposedly pre-exists theory"—rather, it needs to intervene in a "technoscientific event" ("An Era"). The critical aspect of sf and science studies alike is not to *reflect* on science from an outside position, but read science "diffractively" (Haraway, *Modest Witness*; Barad; Van der Tuin), that is, *together with* other forms of experimentation.

BIO-SF

As sf critic Fredric Jameson argues in *Archaeologies of the Future* (2007), the paradigm shift from physics to the biosciences in the latter half of the twentieth century is reflected in the rise of biologically oriented sf, especially from the 1980s onwards (68).²⁷ Bio-sf can be seen as a crucial element in the emergence of a "biocultural" imaginary (Davis and Morris), the double helix being one iconic image in this imaginary (Franklin; Nelkin and Lindee; Stacey; Van Dijck). However, bio-sf does more than express a culture's hopes and fears "around" bioscience. As a literary mode unraveling problems with references to, or strongly resonating with, the biosciences, it lays bare the "moral imperative or navigational system" (Canavan, Sklarr and Vu 208) of science *itself*. As Sherryl Vint has convincingly argued, sf and science studies are allies in thinking about science as part of an actor-network that includes nonhumans ("Archaeologies").

Starting from this basic idea of *thinking along*, I aim to use sf texts alongside popular bioscientific texts (science writing, biographies, lectures) and science studies texts in order to understand fundamental scientific ideas, desires, attitudes and practices (Zwart, "Understanding"). Bio-sf and popular bioscience mostly deal with the big questions—What is a species? What is life?—questions that may not inform everyday scientific practice, but that unwittingly guide scientific projects and careers. Reading these genres together through the prism of the concepts of State science, control science, and nomad science, I aim to map the fundamentals of bioscientific developments and to determine where and how nomadic approaches can be further developed. As I will demonstrate, nomadic *ideas* are produced most consistently in science writing and science studies, while sf is strong on revealing scientific *attitudes and desires*. The level of *practices* can be modeled as a "node" where ideas, attitudes, and desires are "enacted" (Mol). But in the same stroke, the cross-readings of literary, scientific, and philosophical texts are not just meant to elucidate contemporary biosciences, but also to contribute to an understanding of the world *as becoming* in science studies and beyond.²⁸

Nomad science is a rare phenomenon in science but also in sf. In spite of exploring new possibilities, sf often tends to reterritorialize on familiar grounds. Michael Crichton's *Jurassic Park* (1991) and *Next* (2002) can be taken as examples of (critical) literary representations of control

science. In *Jurassic Park* geneticists from the biotech company InGen manage to recreate dinosaurs by extracting and repairing DNA from dinosaur blood found in insects preserved in amber fossils (99). The goal is to build “a zoo unique in the world” on an island not far off the Costa Rican Pacific coast. As chaos theory specialist Ian Malcolm predicts early on in the novel, the dinosaurs prove impossible to contain; visitors get killed and some of the animals manage to escape from the island. Crichton’s novel *Next* is a pastiche of intersecting stories that explore the myth that there is a gene for everything, from sociability to thrill-seeking behavior, a myth kept alive not just by the media, but also by scientists and entrepreneurs who want to make money out of gene patents. Crichton’s novels deal with a desire to create new life, elaborating the idea of life as programmable, and sketching a number of attitudes vis à vis these desires and ideas, culminating in (dubious) scientific practices. Fascination and awe of genomics are coupled with a critical meditation on the idea of DNA as a reliable and endless source of profit, effectively turning life into a privately owned commodity. As such, Crichton’s novels are important contributions to the societal debate on the implications of genomics and biotechnology (Turner, “Jurassic”).

In spite of their critical impetus, Crichton’s novels do little to change the fact that “the deterministic program model of gene action is currently the only one available for popular discourse on human nature” (Leach Scully 354). By focusing on the genome sciences and presenting a character like the chaos theorist Ian Malcolm as a mere bystander, Crichton offers a *critique* in the usual sense of the word—a judgment from an outside position—while novelists like Robinson explore alternative possibilities from within science. Sf novels, I would argue, are particularly fascinating and useful not as a means of justifying or criticizing dominant scientific disciplines, as if they dictate what the future will look like, but as *literary experiments* with multiple scientific perspectives, dominant and recessive. Besides, as Sagan and Margulis warn, “if we simply extrapolate current trends, we arrive not at the future but at a caricature of the present” (“The Transhumans” 93).

A more complex example of bio-sf is Robinson’s *Mars* trilogy, which lays out a scenario of human and planetary transformation whose general thrust is neither utopian nor dystopian. Refusing to glorify or criticize developments in science such as space exploration and genetic engineering, Robinson *thinks along* with them, sketching their possible implications for society and the world at large. Texts like *Mars* offer fictional versions of Latour’s image of the “world wide lab” (“The World”): a lab that is open, collective and *performative*²⁹, problematizing the classical situation in which solutions are transported from the research lab to society. What I find most interesting about novels like *Mars* is that they take science seriously, yet without according too much authority to any one field in particular. As Robinson’s example makes clear, bio-sf is not necessarily based on biological determinism: it may also reveal the ways in which biology is enmeshed with psychological, social, cultural and physical processes. I would argue that in the most interesting examples of bio-sf, the biological is a biotechnoscientific hub or milieu that reveals the physical world as biophysical, sociality as “biosociality” (Rabinow, *Essays*) and politics as biopolitics. Narratives like Robinson’s exemplify sf’s ability, in Sherryl Vint’s words, to “explore and explain the relationship between changes in the material world—which might include new technologies—and changes in the human subjects who inhabit this world” (*Bodies* 19). Its strength lies in thinking about imperceptible becomings that are always already at work in science, society and the world at large, generative processes that undergird actual

symptoms of transformation. Bio-sf novels may turn (human) evolution into a tangible reality through the novum of time travel (H.G. Wells’s *The Time Machine* [1895]), through a narrator’s meta-historical point-of-view (Olaf Stapledon’s *Last and First Men* [1930] and Kurt Vonnegut’s *Galapagos* [1985]), or, as in the *Mars* trilogy, by imagining turbulent circumstances in which evolution itself speeds up. As I will demonstrate, science studies benefits from a more sustained engagement with such sf narratives, not only to fuel its exploration of nonhuman agency, but also to think the becoming or “emergence” of science and life itself (Pickering, *The Mangle*).³⁰ Great sf is not about the future of an enhanced humanity “out there,” but about making sensible and perceptible an evolution in which “we” are always already cyborgs (Haraway, “A Cyborg”; Hayles; Smelik) as well as another variation/species.

OUTLINE

Part I of this thesis, entitled “The Problem of Life,” introduces the challenge of thinking life nomadically as *becoming* consecutively in two areas: bio-sf and popular biology. Chapter 2, “Vital Experiments: Sf, Science and the Shock of the Biophysical,” rather than entering into a general discussion of the sf genre and its limits,³¹ reads Fredric Jameson’s theory of sf together with Deleuze and Guattari’s concept of “minor literature.” The advantage of Deleuze and Guattari’s approach is that it corrects Jameson’s assertion that sf is strictly about sociality. Apart from renegotiating social practices and norms, sf introduces biophysical becomings as *shocks*, or triggers of estrangement, that conjure up the possibility of another life. I argue that this perspective on sf as an experiment with nonhuman forces inevitably leads to an engagement with *scientific elements* in sf that is almost absent in Jameson’s approach. The aim of this chapter is to show that Deleuze and Guattari’s approach, combined with a focus on quasi-scientific problems, is especially useful for analyzing sf narratives in which humans and their habitats undergo significant changes. Such scenarios cannot be properly understood without addressing the entanglement of social, technological and biophysical processes. To provide an example, the chapter discusses Greg Bear’s novel *Blood Music* (1985), in which a nano-engineered virus escapes from the lab, infecting the whole population of North America in the course of the novel, and transforming human beings in a featureless, reddish flesh covering the landscape. I argue that Bear’s novel illustrates Deleuze’s idea that life is irreducible to social or biological or physical processes. The downside of Bear’s novel is that it favors deconstruction over construction, leaving rather limited prospects for actual nomadic ideas or practices. *Blood Music* marks sf’s zero-degree point for viably thinking life as becoming.

Chapter 3, “Thinking ‘a Life’: Nomadism as a Challenge for Postgenomics,” discusses the concepts of “State science” and “nomad science” developed by Deleuze and Guattari in *A Thousand Plateaus* (1980) through the case of (post-)genomics and the research projects of Craig Venter in particular. Modulating the term “State science” into “control science,” the chapter analyzes how science functions within contemporary regimes of technoscientific biopower in which corporations become important strongholds alongside states. The chapter observes that (post-)genomics, while providing new technologies of control, also contains the promise of nomadic approaches to life. Venter’s work reveals such nomadic potentials in (post-)genomics, but, arguably, he ultimately fails to pursue them. Glossing over Deleuze’s biophilosophy,

we can confront Venter's image of life as "DNA-software" (*What is Life*) with Deleuze's idea of "a life" that is irreducible to any substrate. I propose that Deleuze's abstract yet material conception of life can serve as a catalyst for nomadic ideas in molecular biology.

Part II, "Tales of Transmutation," conjoins the approaches developed in the two previous chapters, analyzing control science and nomad science in works by three sf authors. All three case studies deal with novels that portray a transmutation of humanity in which social, technological, biological, and physical factors play a role. Deleuze and Guattari's concepts allow for an analysis of these transmutations as epistemological and biopolitical "problem-events" that provoke a myriad of nomadic and control strategies from characters in the novels.

Chapter 4, "Infected Genomes: Symbiogenesis in Greg Bear's *Darwin's Radio*," reads Lynn Margulis's theory of symbiogenesis together with Bear's sf novel *Darwin's Radio* (1999). In Bear's novel, the course of human evolution is altered through the activation of an "endogenous retrovirus," ironically located in a "non-coding region" of the human genome. This activation, ominously termed SHEVA³², causes humans to metamorphose into another species. At first perceived as a global plague, SHEVA provokes mass panic. In the US a task force is assembled to control the crisis and to find out how SHEVA operates at the genomic level. However, as the story unfolds, it becomes manifest that SHEVA is too complex to locate, decode, or "treat"—and, moreover, that it may not represent a disease at all, but rather an emergent, posthuman stage in evolution. Bear's novel can be understood as a literary experiment with scientific ideas, notably Lynn Margulis's theory of symbiogenesis, which holds that a species' DNA is an assemblage of many genomes "acquired" in symbiotic relations. Bear's novel and Margulis's theory call the neo-Darwinian conception of slow evolution into question, turning evolution into an immediate biopolitical issue. The import of these speculations, I argue, is not crass "prediction," but a nomadic vision of life as always already *different* (impure, infected) and in becoming—a counterpoint to the image of the double helix as the bedrock of human identity and the promise of a man-made future.

Chapter 5, "Trading Traits: Species Encounters in Octavia Butler's *Lilith's Brood* Trilogy," reads Butler's trilogy (first published in separate volumes between 1987 and 1989) alongside the recent work of Haraway, analyzing it as an instance of biotechnoscientific "worlding" in which relations between different species are center stage. In *LB* an extraterrestrial species called Oankali has rescued humanity from Earth, which had become inhospitable to humans due to pollution and atomic warfare. They start an experiment of "genetic trade" in which humans and Oankali will eventually transform. The trade, however, is hampered by humans who fear that they will lose their identity and autonomy. Molly Wallace has argued that the Oankali's "natural" capacity for genetic engineering represents strategies of contemporary technoscientific biopower, where genetic engineering is presented as something inevitable and beneficial. I agree partially with this latter reading, although I emphasize that the Oankali also allow us to think in life nomadic terms as a continual challenge of connecting, forgetting and becoming. Taking the cue from Haraway's notion of "worlding," this chapter analyzes Butler's trilogy as an experiment in which literature and science "trade traits," and where species co-evolve, building a new world out of an uncomfortable contact zone. Butler's account of evolutionary "trade" connects technology, sociality, culture, and biology in inextricable ways, forging a literary prototype of a bio-based economy that uses genetic engineering but is not founded on determinism.

The third and last case study, "'Terrain is a Powerful Genetic Engineer': Constructive Interaction in Kim Stanley Robinson's *Mars Trilogy*," reads *Mars* together with evolutionary psychologist Susan Oyama's concept of "constructive interactionism," which offers an alternative to genocentrism and its reliance on a pre-programmed code. Oyama's work is akin to Deleuze's philosophy of difference, directed at thinking life without presupposing an objective code or a transcendent human subject as a ground:

Can it be that if we really reinsert ourselves into the world, see our development, investigations, and technological control as actions within a network that we support and alter and that supports and alters us, see freedom and responsibility not as denials of causality but as a particularly human acknowledgement of it, if we see nature, including our own, as multilayered and constructed in development, not prior to it, if we see the world as truly our home ... with all the loving reliance, multiple attachments, pride, and farsighted maintenance that "home" entails, is it possible that we will no longer need a mystical hidden message? Is it possible that the only message is our lives in our world and the life of our world in its universe? (*The Ontogeny* 193)

The *Mars* trilogy can be read as a literary counterpart to Oyama's theory, offering a turbulent world in the making in which epistemological and biopolitical dilemmas emerge in the midst of things, without a steady ground for decisions. While state and corporate forces try to control the process of terraformation, it soon becomes clear that the experiment cannot be controlled. As one character notes, "the planet is the lab" (*Red* 263), a lab in which humans, too, are transformed, and not primarily through (purposeful) technological interventions. Instead, as an unidentified narrator in *Green Mars* proclaims, it is the "terrain" (read: network of planetary systems) that is the most advanced "genetic engineer" (13). Those characters who understand the experiment along the lines of Oyama's "constructive interactionism" are most successful at coping with the tough conditions on Mars and contributing to sustainable ways of living.

The title of the final part, "A New People and a New Earth," is a quote from Deleuze and Guattari's *What is Philosophy?*, where they formulate the ultimate goal of thought in a Nietzschean vein: to think *for* the future. I argue that this is precisely what the novels discussed aspire towards: not to simply "represent" a future for humanity, but to create the conditions for new ways of thinking and living that are different and more sustainable. The penultimate chapter, "Nomad Science and Cosmic Life," sums up the observations about nomadic ideas, practices, desires and attitudes in the case studies. It presents a number of clusters of nomadic traits that may serve as a rough map for understanding and reinforcing nomadism in contemporary bioscience. The thrust of these nomadic elements is to incorporate and connect to *everything*, so that bioscience ends up exploring life as cosmic. The final chapter, "Coda: Bringing Science to Life," presents some key findings and consequences of this thesis and points to possibilities for further research. It argues that narratives that innovatively couple biological and social, human and nonhuman existence, are vital in our time, and specifically for science studies. Such narratives bring science to life in the sense of revealing a dynamic picture of scientific tensions, but also in the sense of taking science closer toward the fiery chaos of life. They are narratives with the power of transmutation.

PART 1

THE PROBLEM OF LIFE

– 2 –

VITAL EXPERIMENTS:
SF, SCIENCE,
AND THE SHOCK OF THE BIOPHYSICAL

Science fiction has gone through a whole evolution taking it from animal, vegetable, and mineral becomings to becomings of bacteria, viruses, molecules, and things imperceptible.

– Gilles Deleuze and Félix Guattari –

INTRODUCTION

Sf literature has never had the reputation of being experimental in terms of prose, narrative structure, or other formal aspects. Furthermore, many sf novels, while rather explicitly evoking an air of otherworldliness, actually repeat conventional and shallow characters, plots and ideas. Paradoxically, these texts derive their popular appeal from the extent to which readers can *recognize strange elements*: as Terry Eagleton has acutely observed, extraterrestrial beings in popular culture “may have bulbous heads and triangular eyes, speak in a chillingly robotic monotone or emit a strong stench of sulphur, but otherwise ... look much like Tony Blair” (49). It is for these reasons that many critics of sf focus on a limited number of authors whose works manage to escape the clichés and to think a world that is no longer *comfortably* unfamiliar. These sf writers create a world that is out of balance, in becoming. The reader’s confrontation with this problematic world ideally creates an effect that Darko Suvin, expanding on German playwright Berthold Brecht’s notion of *verfremdungseffect*, calls “cognitive estrangement” (4):

the feeling that a fictional world is somehow akin to one's own, yet also different, *unheimlich* (I will return to this notion below). In presenting a world that appears thoroughly different but nevertheless contains relevant analogies to our own, we may not only perceive our present social context in a new light, but also open up vistas onto a new, transformed community in which, Suvin concurs, "human relations are organized more perfectly than in the author's community" (45).

In his seminal *Archaeologies of the Future: The Desire Called Utopia and Other Science Fictions* (2007), a collection of (revised) essays on sf, Fredric Jameson is in constructive dialogue with Suvin's work, arguing that sf at its best is "a representational meditation on radical difference" (xii). Immediately qualifying this statement, he defines sf as *the* genre "devoted to the imagination of alternative social and economic forms" (xiv). It is in the incommensurability between these two statements that I want to posit my argument about sf. If sf has the potential to bring radical difference into representation by imagining "the future as disruption" (211), then why should its import be strictly socio-economic? Is sf not rather, in Raymond Williams's words, "a reworking, in imagination, of *all* forms and conditions" (209), including those of organic and nonorganic life? As John Urry makes clear, the notion of "emergence" in complexity theory problematizes a bracketing of sociality in the way Jameson does vis á vis the prospect of another world in sf.

Emergent properties are never purely "social" and the kinds of processes that generate them are also not simply social. Complexity would argue against the thesis that "phenomena" can remain bounded, that social causes produce social consequences. Causes are always overflowing, tipping from domain to domain and especially flowing within and across the supposedly distinct physical and social domains. (Urry 8)

To translate this in Deleuzian terms, the transformations of bodies and states of affairs in sf experiments must be thought from the perspective of "pure events" (*The Logic*, 3), events that neither have a strict determination (social, biological, etc.) nor belong to a particular subject. Sf links such non-local events to particular scientific fields, but no field in particular can ever exhaust the problem of transformation.

Indeed, Jameson's focus on socio-economic transformation is perfectly understandable, since the vast majority of sf texts is ultimately not about a quasi-scientific interest in the world at large or in nonhuman processes, but rather about mental lives and social relations set in a technoscientific future. Yet there are exceptions, such as Robinson's *Mars* trilogy, in which the planet Mars itself is at least as important as the human characters, or even becomes, as Robert Markley has argued, the true hero of the story (782). To conceive of the planet itself as a major element of the story requires at least some form of engagement with physics, biology, geology, meteorology, space science, and other scientific fields. Nevertheless, in *Archaeologies* Jameson states that any scientifically grounded reading of Robinson's trilogy "must eventually develop into a second allegorical one, in which the hard sf content stands revealed as socio-political—that is to say, as utopian" (396). I want to argue that it is problematic that Jameson's work, which continues to have a tremendous influence on sf scholarship, refuses to take the scientific content and the nonhuman elements of sf seriously.

In this chapter I want to demonstrate that Jameson's work on sf can be complemented by Deleuze and Guattari's concept of "minor literature" in order to do justice to those rarer sf writers who take up scientific ideas in order to grapple with biophysical¹ existence. As this chapter's epigraph, taken from *A Thousand Plateaus*, indicates, Deleuze and Guattari were well aware of sf's potential for exploring the nonhuman, although they never explored this matter in earnest.² In *Kafka: Toward a Minor Literature*, Deleuze and Guattari show how Kafka's works produce a deterritorialization and a desubjectification of life: they break open established structures (territories) and ways of thinking (the idea of the human subject at the center of existence), revealing nonhuman processes of life that usually remain under the surface. While this approach is in full agreement with Jameson's contention that the struggle of thinking radical difference is not merely personal but socio-political, Deleuze and Guattari's emphasis on the nonhuman forces pervading and co-constituting humanity offers a better starting-point for dealing with the biophysical dimensions of sf. Relocating Deleuze and Guattari's concept, I argue that "minor sf" moves beyond the patently human world (mental lives, social forms, urban landscapes, technologies, etc.), zooming in on the microworld of particles as well as looking outwards to the macroworld of planetary and cosmic systems. Thus minor sf explores new possibilities for narrativity—not in the sense of creating new narrative forms, but in presenting physical and biological processes as constitutive narrative elements rather than mere objects or backgrounds for human action.

In minor sf, I will argue, humans and environments interact and transform in an open experimental situation. In order to make this experiment as consistent as possible, minor sf uses scientific ideas, desires, attitudes and practices as important resources. This relation between sf and science is captured in the following programmatic statement by sf critic and literary scholar Roger Luckhurst, who argues that genres like sf and popular science should not be figured as mere "pseudoscience":

The aim is to regard sf and allied genres as historically situated forms that constantly change shape and boundary as scientific and technological possibilities emerge, the genre seizing opportunistically on new anomalies or nascent states or breakthroughs, working proleptically to open up (or close down) their cultural and narrative possibilities ... It is less, then, that sf and its cognates are to be judged as inside or outside "proper" science but more that these fictions might be seen to occupy the temporary intervals when knowledge is controversial and in flux, in the phase-space between anomaly and normalization.³ ("Pseudoscience" 404-5)

Minor sf precisely finds its niche in the "phase-space between anomaly and normalization," but it continually tends towards anomalies—problems that cannot (at present) be solved by science and technology. The present chapter will illustrate this approach by analyzing Greg Bear's bio-sf novel *Blood Music*⁴ (1985), in which a new virus eventually changes the whole population of North America into a formless organic mass covering the land. It will be argued that this dramatic event of contamination and transformation, expressing a capricious, impersonal life, constitutes a nomadic sf problem: emergent, interdisciplinary (involving genetics, nanotech,

and other fields), and beyond human control. A novel like *Blood Music*, then, is not only a social-political experiment: it also spectacularly confronts readers with biophysical existence. Literary experiments such as Bear's are vital for imagining the future of technoscience and humanity in an age of great societal and biophysical transformations.

JAMESON'S THEORY OF SF

In his seminal *Archaeologies* Jameson offers a complete version of his theory, which focuses on sf but also encapsulates his broader philosophical work on postmodernism or, as he often hopefully calls it, Late Capitalism. As he argued before in *Postmodernity, or the Logic of Late Capitalism* (1991), we are witnessing a total expansion and unprecedented intensification of capitalism, causing widespread cultural amnesia and political apathy, and leaving only a minimum reserve for resistance. For Jameson, the problem of literature today, and any mode of thinking for that matter, is to think beyond the bounds of capitalism, a hideous task verging on the impossible. The impossibility of this task lies in the fact that producing a different world is hard when the dominating system is in and of itself a machine for producing difference. Capitalism easily accommodates utopian ideas about a new society within its own boundaries: these dreams are incorporated in popular culture and advertising, two genres that are increasingly indistinguishable. Claims to difference often end up as commodified fantasies, for example in those more individualistic versions of (cultural) diversity and cosmopolitanism that say "You can be anything you want to be!"

As Jameson argues in *Archaeologies*, most sf utterly fails the utopian test, indulging in technoscientific dreams that have nothing to do with social urgencies. Nevertheless, Jameson reserves a unique space for literature in the task of imagining a radically different future: "Literary forms (and cultural forms in general) are the most concrete symptoms we have of what is at work in that absent thing called the social" ("Symptoms" 407). What makes sf more suitable for this task than other literary forms, is its ability to conceive a new world that is total and systemic: "A reform which singles out this or that vice, this or that flaw or error in the system, with a view towards modifying that feature alone, quickly discovers that any given feature entertains a multitude of unexpected yet constitutive links with all the other features in the system" (39). This realization that everything is connected leads to a generic imperative in sf that "the modification of reality must be absolute and totalizing" (39). The sf writer produces this totality not just by meticulously describing the features of a unique world, but by introducing a central problem: that element that Suvin, borrowing from the Marxist philosopher Ernst Bloch, has termed the *novum*.⁵ This element is a genuine mode of production, whose mechanism is explored in the narrative. Characters bear witness to this *novum*, relate to it in one way or another, and determine its mental image and meaning; yet unlike in most mainstream literature, the characters and their psychological lives are *subordinated to the problem*, which is collective in nature. Immediately related to the notion of totalization or system is that of *closure*. For an sf experiment to work, its world has to be an enclosed space and/or contain enclosed spaces. Often this amounts to geographical isolation, most famously exemplified by Thomas More's *Utopia* (1516), and in its critical dystopian mode, by H.G. Well's *The Island of Doctor Moreau* (1896).⁶

Experimentation with the new requires a confined space safeguarded from the influences of the ordinary world. However, the creation of a utopia is never simply a matter of authorial will; as Jameson argues, it is only under certain historical conditions that a utopian space can develop as "a kind of eddy or self-contained backwater within the general differentiation process and its seemingly irreversible forward momentum" (15).

The most vital element in Jameson's approach to sf is the emphasis on form. For Jameson, any attempt to furnish a fully-fledged new world, ready to be actualized in the future, is bound to fail. Many traditional sf texts, so Jameson suggests, in fact fall into this trap, by seeing the challenge of utopia in producing a particular content—a promise of wish-fulfillment. True utopian thought, Jameson claims, is not about any particular world but about the process of imagination itself, a process that should be focused first and foremost on form rather than content.⁷ What counts is not any end-product but "the story of its production" (217). Sf texts, for Jameson, are especially significant because they are *overtly fictional*: they create another world that exists only in the imagination. For Jameson, the best sf texts reflect on the very process of world-making, presenting utopia as a textual, pluralistic, and emergent practice (*Archaeologies*). The detailed description of a world is only an epiphenomenon of an experiment with form through the *novum*, an experiment that is fundamentally processual (the very act of imagination) as well as being *about* a historical process whose end-point is not even on the horizon. Jameson calls "ideological" any sf text that gravitates too far to the side of content, thereby becoming merely an expression of this or that concrete fantasy predicated on and continuous with the present situation (i.e. capitalism). The naive wish-fulfilling impulse is vital, but it must be sublimated, worked upon, to produce with any consistency and viability something that is actually new.

The emphasis on form and on utopia-as-process in Jameson's work is fundamentally related to his evaluation of the role of science in sf. Jameson considers expositions in sf texts about scientific practices, theories, or data as mere interludes, blocks of content that may be fascinating but do not add anything to the working out of the central problem, which after all is strictly social in nature. In an analysis of Isaac Asimov's short story *Nightfall* (1941), which narrates the anomalous advent of a solar eclipse in a world that, being lit by multiple suns, has no concept of darkness, Jameson writes: "To be sure, we need not examine the scientific premise any too closely, since it is rather the mimesis of a scientific premise which is the crucial feature," and one page later, that "literary theory is best served by a conception of such scientific content as constituting a formal device" (90-91). For Jameson, science functions in sf only as a literary strategy ("formal device") that allows the writer to think another social order: science in itself belongs to the realm of content and is thus irrelevant to the utopian imagination. If one were to invest too much energy in exploring science itself, then the whole work becomes ideological: a maze of problems that are at best irrelevant, and ultimately illusory. Sf's intervention, for Jameson, is different from the basic operation of the sciences: reality is never represented in a direct way, but in a roundabout manner, through allegory: "Allegory happens when you know you cannot represent something, but you also cannot not do it" (Zhang and Jameson 376). In other words, in literature reality emerges as something constructed, which makes us realize that society could be organized otherwise.

But there is a positive role for science in Jameson's approach. Jameson relies heavily on Suvin's idea that the hallmark of sf is a sense of "methodically systematic cognition" that is borrowed from science ("the post-Cartesian and post-Baconian scientific *method*") and that moves in the direction of a speculative future (64-65). The estrangement of a different future does not come ready-made; it is a pain-staking process emanating from a novum which is totalizing, entailing "a change of the whole universe of the tale" rather than affecting merely of some of its elements (64). In *Archaeologies*, Jameson tries to demonstrate that this definition sets sf against the realism of naturalist fiction as well as the a-historicism of myth, fairy tales, gothic literature, fantasy and so on (24-25). In other words, sf writers, rather than creating merely fanciful stories, are concerned with real problems, and their struggles with these problems produce real knowledge. For Jameson, it is not scientific content but the scientific *attitude* that gives sf writers the vital tools to think a new society. However, as I noted above, the experimental potential of this attitude has rather rigid limits: the scientific outlook serves as a mere tool for the greater goal of societal transformation.

I want to point to what I perceive as a number of problematic aspects of Jameson's Marxist framework, first of all his treatment of science as developed from the work of Suvin. Suvin's idea that sf is unique in following "accepted scientific, that is, cognitive, logic" (66) is unconvincing, for it reifies a simplistic image of science as a unitary discourse of objective reality, and moreover, is unnecessarily condescending towards genres such as fantasy and weird.⁸ Jameson and Suvin are of course right in saying that literature is not equipped to handle the details of science (and neither, I would add, is scholarship), and that the end-result will never be scientific. I also agree with Suvin's contention that sf should not simply "extrapolate" from science and technology, thereby taking the current state of affairs for granted (28). However, to infer from this, as Jameson does, that it should be useless and even undesirable to take the scientific content of sf seriously, seems to me a denial of a crucial element of good sf: to think along with science about complex problems. When scholarship takes scientific elements in sf seriously, what materializes is a dynamic understanding of science in which the latter is taken as a highly differentiated set of fields, people, institutions, practices, ideas, attitudes, emotions and so on, rather than a single "attitude" or paradigm that can either be reproduced or criticized. Apart from offering a fictional ethnographies of scientific life, sf also taps from the *potentials* of science which are not given and, exactly because of that, offer fertile ground for literary experimentation. Importantly, sf is not necessarily *about* science or scientists. Instead, in exploring the complex stories of humans, animals, plants, planets, and other bodies, the most interesting sf novels move into areas that are usually avoided by other literatures—areas commonly seen as belonging to science.

A second problematic aspect of Jameson's Marxist approach is that there is only one machine, one mode of production: socio-economic production. Although Jameson repeatedly blames certain sf texts for being too humanist (i.e. utterly familiar, non-radical), there is also a deep humanism inherent in his Marxist framework: the telos of Man and his revolutionary road through History, a narrative of social struggle that is the story of life. The nonhumanist tenor of poststructuralism and radical feminism constitutes a forceful critique of this image, suggesting a more capacious understanding of the body: a social, racial, gendered, sexual, animal, biological body. Jameson does not pay nearly enough attention to scholars and writers who

bring the body and sexuality into the picture, against the grain of Western culture which has long repressed the body in favor of a rational subjectivity of which the works of Descartes and Kant remain the most famous articulations (Braidotti, *Nomadic*; Grosz, *Volatile*).⁹ The urgency of thinking politics as biopolitics has become urgent in a time when new biotechnological innovations and modes of biological understanding are emerging. There is a need for critically analyzing the ways contemporary bodies, human and nonhuman, are made, and sf is a genre in which exactly this is being done (Smelik; Vint, *Bodies*).

MINOR LITERATURE

In the following I present Deleuze and Guattari's approach to literature, revolving around the problem of life, as a useful complement and corrective to Jameson's approach. In one of the few instances in *Archaeologies* where Jameson uses a term developed by Deleuze and Guattari ("lines of flight"), he argues that in literary texts

the social totality is always unrepresentable, even for the most numerically limited groups of people; but it can sometimes be mapped and allow a small-scale model to be constructed on which the fundamental tendencies and the lines of flight can more clearly be read. At other times, this representational process is impossible, and people face history and the social totality as a bewildering chaos, whose forces are indiscernible (14)

In other words, utopian literature is not a matter of imagining a new society *de novo*. Rather, it entails an exploration of "tendencies," and it is the imaginative power of this exploration that determines the value of sf. Jameson's allusion to a "small-scale model" of the social totality harboring "fundamental tendencies and lines of flight" resonates with Deleuze and Guattari's idea that "writing has nothing to do with signifying. It has to do with surveying, mapping, even realms that are yet to come" (*A Thousand* 5). It expresses a desire to transcend the level of immediate individual concerns and to intuit the social production of reality. However, especially in *A Thousand Plateaus* and later works, Deleuze and Guattari emphasize that literature is a matter of mapping not just *social* tendencies, but tendencies of life.

In the light of Deleuze's nomadic principle, the question is not whether or how adequately literature represents life as an object—i.e. the lives of novelistic characters as representations or allegories of "real" life—but rather whether literature affirms life in all its complexity and potency by making the writing itself come to life. While perhaps all literature deals with life, not all literature expresses life intensively. As Daniel Smith has pointed out,

For Deleuze, it is never a question of judging a work of art in terms of transcendent or universal criteria, but of evaluating it clinically in terms of its "vitality," its "tenor of Life": Does the work carry the process of Life to this state of an impersonal power? Or does it interrupt the process, stop its movement, and become blocked in the *ressentiment* of persons, the rigors of organic organization, the clichés of a standard language, the dominance of an established order, the world "as it is," the judgment of God? (lii)

According to Deleuze and Guattari, it is only through consistent experimentation with the raw matter of literature–language–that literature becomes lively. This mode of literary experimentation they call “minor literature.” Deleuze and Guattari differentiate minor literature from major (majoritarian) literature, which uses language to create a fictional world that is ultimately familiar, and in that sense conservative. As Ronald Bogue explains, “A major usage of language limits, controls, organizes and regulates linguistic materials in support of a dominant social order, whereas a minor usage of a language induces disequilibrium in its components, taking advantage of the potential for diverse and divergent discursive practices already present within the language” (“Minoritarian” 168). Like anything else in the universe, language is continually changing; writers of minor literature thrive on this potential for change, affirming it through experimentation. Major literature, instead, reproduces standard grammatical, syntactic, and narrative structures. This reproduction of linguistic normalcy is correlated with the maintenance of received ideas and societal structures.

Minor literature is not a genre, but a potential in all literature. In *Kafka* Deleuze and Guattari propose three characteristics for minor literature, the first being *the disruption of language*. In minor literature “*language stops being representational in order to now move toward its extremities or its limits*” (23; italics in original): words, grammar and sentence structures are reconfigured, showing the endless variations possible in language.¹⁰ Independent of any content, this amounts to a joyfully unorthodox writing, an ability to make language “vibrate with a new intensity” (18). Deleuze and Guattari stress that Kafka’s Czech background is relevant for understanding how such a use of language typically emerges. Minor literature has nothing to do with minorities, even if the writer might belong to a minority group; it rather means to “become a nomad and an immigrant and a gypsy in relation to one’s own language” (*Kafka* 19). As Deleuze and Guattari state in *A Thousand Plateaus*, minor literature is about “the necessity of not having control over language” (417), opposing language as a power of domination (maintaining grammatical and syntactical constants) and affirming language as a power of becoming (potentia) producing “continuous variation,” an unpredictable evolution of language on the “virtual continuum of life” (122). When this potential for variation is exhausted to the fullest in an oeuvre like Kafka’s, literature becomes capable of creating visions of another society, another people.

The second aspect of minor literature is “the connection of the individual to a political immediacy” (18). Deleuze and Guattari lament the fact that most literature is preoccupied almost exclusively with the mental lives of individuals. The result is that literature is easily perceived as the pre-eminent place for experiencing and understanding personal feelings such as love, hope, fear, and exploring connoted philosophical questions such as human finitude, the meaning of life, and so on. In major literature, the story deals primarily if not exclusively with individual or familial concerns, “the social milieu serving as a mere environment or a background” (17). They propose that the role of minor literature is the exact opposite: it is to displace the sphere of self-reflection and dramatic personal relations, in order to reach the socio-political sphere. Criticizing Freudian psychoanalysis, Deleuze and Guattari deny that relations portrayed in novels should necessarily emanate from primordial family relations (Oedipal and other). Families are only one mode of triangulation (Father, mother, child); there are many other relations, each of them singular and complex. Instead of treating such relations as either a background or a

discrete content (a topic or theme), in minor literature the whole work becomes “a micropolitics, a politics of desire that questions all situations” (42). Kafka’s writing is propelled by problems: why is this happening? Who or what is doing this? What can be done? How to escape?

The third and final element of minor literature is the production of what Deleuze and Guattari call “collective assemblages of enunciation”: literary statements that express something collective. The production of such statements is a direct effect of a dramatic political immediacy in which the subject (the writer, a character) loses himself. Subject and object merge in the event, making it impossible to explain the narrative solely with reference to the (willful) actions of individuals. On the level of the writer, likewise, it is inadequate to explain the work as a natural extension of the author’s life or personality. Rather, for Deleuze and Guattari, Kafka’s personal life can be explained in the light of the social field which is expressed in his work. The name “Kafka” in fact no longer refers to this personal life, but to something collective: an oeuvre dispersed in time and space, a living thought. Kafka is an “expression machine” that inadvertently produces all kinds of social, psychological, and epistemological thoughts that tell something relevant about the world and about subjectivity:

There are no individual statements, there never are. Every statement is the product of a machinic assemblage, in other words, of collective agents of enunciation (take “collective agents” to mean not peoples or societies but multiplicities). The proper name (*nom propre*) does not designate an individual: it is on the contrary when an individual opens up to the multiplicities pervading him or her, at the outcome of the most severe operation of depersonalization, that he or she acquires his or her true proper name. (42)

The potential of such literary statements is to reach a level at which life becomes more intensive than the lives of human characters, a life of events that do not even “happen” in the sense of being circumscribed by and intelligible to persons or groups. It is the feeling of losing oneself in the sheer contingency of these events that makes minor literature escape signification: the production of a meaningful, ultimately harmonious world. Deleuze and Guattari are quick to stress, however, that any escape from signification and representation is risky, and that no escape is final. Language restructures itself by producing again “a subject of enunciation, who is in connection with sense, and a subject of the statement, who is who is in connection, directly or metaphorically, with the designated thing” (20).

A number of striking resemblances and connections can be discerned between Jameson and Deleuze and Guattari’s approaches. Both are uninterested in a general theory of what literature *typically* does; rather they reflect on the works of those authors who experimentally push the boundaries of what literature can do. Both view literature as a political rather than personal symptom, an analysis of life and a gesture towards a new society. Like Jameson, Deleuze and Guattari argue throughout their work that literature defies any structural representational relation to a present context. Jameson’s emphasis on the very act of imagination comes close to Deleuze and Guattari’s idea that desire is fundamentally “a procedure, a process” and therefore irreducible to any particular form (8). For both, then, a text that tries to represent difference, to *achieve* a utopia, can only be a version of Oedipal fantasy, where

one has finally found what had always been missing from life. Finally, Jameson's (and Suvin's) stress on narrative totalization and closure certainly has at least some affinity with Deleuze and Guattari's conception of a literary work or oeuvre as a world in itself, a unique assemblage or literary machine that is fundamentally "unattributable" to a subject or context, and that "also has no object" (*A Thousand* 4).

I would argue, however, that Deleuze and Guattari have theorized the connection between literature and life more thoroughly. Their work does more to undo the habit of representationalism—the idea that literature, and thought in general, can be understood from the viewpoint of human subjects representing the world to themselves. For Deleuze, thought is not the operation of common sense, reifying an autonomous thinking subject, but a moment of shock (Massumi). What emerges in this moment is a nonhuman, animalistic subjectivity, a "larval subject," that is not yet a fully formed, still plastic and heterogeneous (*Difference* 144-145). Moreover, thought is not merely introspective: through it, we learn that the whole world is full of experience, sensation, thought. Literature is able to trigger such a shock of the nonhuman by subverting the normal signifying function of language, bringing out its materiality—its raw sounds, perceptions and affections (*What is Philosophy*). As Deleuze and Guattari show, in Kafka's oeuvre this usage of language often coincides with the presence of animals and with processes of becoming-animal: literature stages a confrontation with the nonhuman with the purpose of challenging the limitations of what humans are and should be, and pointing to a different collectivity in the future.

EXPERIMENTATION IN SF

Having demonstrated how Deleuze and Guattari's emphasis on the nonhuman complements Jameson's theory of sf, I want to ask: Is it possible to "apply" the notion of minor literature to sf? Considering that the concept of minor literature designates a potential in all literature, the answer to this question would have to be affirmative. Indeed, much sf contains political immediacies (revolutionary inventions, wars, epidemics, etc.) and collective assemblages of enunciation (new subjects, societies, worlds). However, deterritorializations of language are much rarer in sf. Surely strange names of beings, planets, machines and so forth abound in sf, but these have very little to do with the creative uprooting of grammar and syntax that Deleuze and Guattari are after.¹¹ I would argue that the deterritorialization of language is not a distinctive experimental strength of sf and that, consequently, a simple application of Deleuze and Guattari's concept of minor literature will not suffice. When approached from the side of the literary text, the challenge may be formulated differently: how does Deleuze and Guattari's concept transform when placed in the new environment of sf? How does the essence of sf—the experimental production of worlds through the novum—link up with minor literature? While undoubtedly there are multiple perspectives from which these questions can be approached, including the Jamesonian emphasis on form, I wish to foreground sf's epistemological relationship with science.

What, then, is the status of science in sf? A suitable starting point for answering this question is Hub Zwart's *Understanding Nature: Case Studies in Comparative Epistemology* (2008), which builds on Zola's notion of the "literary experiment."¹² Zwart stresses the *complementarity* of literary

and scientific knowledge as "different strategies that enable us to gain important insights concerning nature or natural entities, such as landscapes, animals or plants" (6). Literature, Zwart argues, constitutes a more "intimate" form of knowledge in which "the subject seems to be one, more or less, with its object" (3). Moreover, according to Zwart, literature itself already becomes an exercise in comparative epistemology, for example in Melville's *Moby Dick*, which narrates a confrontation between a scientific and a literary (imaginative) approach to the question "what is a whale?" (86-88). For Zwart, novels become experimental mainly when they expose particular entities such as researchers, animals, and machines to one another in a systematic manner. Literature, then, takes on certain traits that we associate with science, while at the same time it reveals the imaginative or aesthetic dimensions of science. Zwart rethinks the relation between thought and aesthetics in ways similar to Birgit Kaiser, who has argued with Baumgarten (and Leibniz and Deleuze) that nature does not take "a leap from darkness into the clarity of thinking" ("Two Floors" 222), but rather emerges in a twilight of feelings and ideas. Thought and aesthetics relate to one another in a manner of enfolding, even though they operate "according to two different orders" (221).

Zwart and Kaiser's approaches are in agreement with Deleuze's basic view of literature as a map of forces (social, biological, physical, etc.) that must be read literally and not, as Jameson suggests for sf, exclusively as an allegory of social change. To perceive the strange worlds and events of sf as allegorical extensions of social (human) phenomena greatly diminishes sf's potential as thought. In *Kafka* Deleuze and Guattari try to reveal a "Kafka experimentation" that is based on "tests of experience" in which life emerges as something strange, unstable (7). As Réda Bensmaïa puts it in his introduction to Deleuze and Guattari's book, with Kafka literature becomes "an experimental machine, a machine for effects, as in physics" (xi). Rather than aiming at a particular outcome, the literary experiment is designed to be continued *ad infinitum*: "The problem is not that of being free but of finding a way out, or even a way in, another side, a hallway, an adjacency" (8). Just as in nomad science, where the practice of problematization does not lead from problems to fitting solutions but rather produces a multiplication of problems, in minor literature desire follows a logic of contiguity (in space) and continuity (in time), a path of continuous variation or "line of flight" (47). This line of flight is an affirmation of the nonhuman, "anorganic" life that makes possible a new health and "new possibilities for living" (Bogue, *Deleuze* 192). As Colebrook, Lambert and Bensmaïa have emphasized, a similar pragmatic task is reserved for scholars, who should resist becoming statist thinkers subjecting literary texts to judgment (establishing a canon) or interpretation (as if they carry some deeper meaning). Rather, scholars should take them as sources of inspiration for drawing their own lines of flight.¹³

In line with the above, I want to read sf literally, analyzing the way it contemplates the problem of life, not just the desires and activities of human beings. Moving into the micro-worlds inside (human) bodies and the macroworlds of outer space, sf treads on terrains that scientists are most familiar with. In order to build and navigate these worlds, sf incorporates scientific content, which—and this is crucial—*functions as part of the literary machine*, in particular through the novum. This incorporation can be regarded as a kind of epistemological "alliance" (Clayton, "Convergence" 824) or *symbiosis*: science becomes a symbiont that is useful for the

literary organism, but also a source of mutations. Taking scientific ideas, desires, attitudes and practices as important raw material, the sf writer adopts a language that is not his own, using that language in a completely different way (usually without deterritorializing language as such). He is free to delve into any field or problem, unencumbered by the disciplinary and methodological constraints that scientists have to deal with. This is a risky experiment with the limits of literature: How much scientific detail can the writer and the reader take? How much science can the story absorb without succumbing to its weight? The symbiosis of sf constitutes an exchange of traits, a becoming-scientific of literature and a becoming-literary of science, that needs to be managed carefully to prevent the experiment from losing consistency.

When exactly does sf become minor sf, a literary practice expressive of a desire for “the open, virtual potential to become in unforeseen ways” (Burns and Kaiser 12)? This happens, I argue, when the narrative is not just about the lives of human beings but about life itself, for example in Kim Stanley Robinson’s *Mars* trilogy, where a whole new world emerges in the interplay of human and nonhuman factors without humans being able to control the experiment. By starting from an unsettling event beyond human control, this mode of sf produces “collective assemblages of enunciation,” pointing to the possibility of another humanity and another world. The experimentalism of minor sf, then, transforms literature in a way different but akin to Kafka’s experiments. The writer’s dependence on a scientific language that is not his own can conjure up “the feeling of self-betrayal, or of ‘falsifying oneself’” (Lambert 26), which is similar to what the writer of minor literature experiences, belonging neither to the cultural majority nor to a specific minority. Just as minor literature manages to extract from language new forms that disturb our sense of subjectivity and point to a nonhuman life, minor sf *extracts from science ideas, desires, attitudes, and practices that co-construct a narrative in which science and the human subject are no longer stable, autonomous entities, but parts of planetary and even cosmic assemblages open to change*. In minor sf, narrative is a snap-shot of evolution, involving the becomings of animals, plants, and other nonhuman elements. Here, the novum constitutes what Paul Patton, drawing on Deleuze, has called a “problem-event” (*Deleuzian* 113): an ontological, epistemological and political problem that is all the more disquieting for being a *becoming* rather than a discrete, isolatable problem. The scientist-protagonist is completely immersed in the event of the novum, and thus unable to play the role of distanced, neutral observer. In other words, minor sf is not primarily about experiments *by* human subjects, but foremost about experiments *with* human subjects and their worlds.

If sf turns scientific practices, images, ideas etc. into a singular subject matter, minor sf goes one step further, truly *thinking along* with science, not by extrapolating from facts but by exploring problems such as planetary transformation in the *Mars* trilogy. Chapters 3 to 5 will demonstrate that while, at first sight, such problems divide science, eliciting divergent responses from various disciplinary and theoretical positions within and beyond the biosciences, under the surface these problems connect disparate scientific fields like a rhizome. It is often on the cutting edges of science, those nomadic areas between the disciplines, that minor sf finds fertile ground for exciting stories, riffing on possible connections between “hard” and “soft” sciences, anthropological and non-anthropological concerns. Reading sf literally, then, is emphatically not about claiming some kind of (scientific) factuality, or about taking things at face value, but about af-

firming the singular difference that each literary experiment produces.¹⁴ In Robinson’s trilogy, the problem-event of the Mars mission includes divergent processes that require different scientific vocabularies: the co-evolution and proliferation of species, the transformation of atmospheres, the psychosomatic ordeals of individual scientists living on Mars, the seclusion and blending of scientific and cultural groups, and the emergence of new societies and ways of thinking. Minor sf reveals a rich potential for *nomad science*, for making connections along a continuum or topological space, and complicates control science’s task of generating immediate solutions.

Like minor literature, minor sf produces nomadic characters, subjects who desire to be open to the world and to transform (Braidotti, *Nomadic*). In minor sf the windows of perception and understanding are opened up to the chaos from inside and outside, a chaos that threatens distinctions of inside and outside altogether, causing vertigo, but also enabling the creation of new possibilities for life and living. This is the object of minor sf: to follow problem-events occurring in a field of forces, exploring the ways in which characters are affected by these events and act upon them. An sf problem—say, the encounter with an extraterrestrial species—can be destructive in some ways, but it may also trigger new capabilities and even new species. In minor sf, humanity is no longer that which is *given*, the very ground of being, but that whose conditions of existence must be intuited and transformed (in congruence with Foucault’s idea that historians should seek to describe the “historical *a priori*”¹⁵ of what it is to be human). As the *Mars* trilogy illustrates, such literary experiments with the vitality of human bodies always involve wider conditions—ultimately the world, or life as such—so that it really is a nomadic *ontology* that is at stake.

This brings me to one last aspect: the transformation of politics into biopolitics. Minor sf radicalizes Deleuze and Guattari’s idea that in minor literature *everything* is political—not just psychological, social and cultural existence, but also biophysical existence. In the *Mars* trilogy, the stress, depressions, aches and injuries that characters have to deal with are all related to the conditions on Mars. It is the shocking experience of living on a foreign planet that makes characters aware of biophysical existence, which becomes inseparable from their psychosocial lives. The success in understanding and altering these conditions, as well as human bodies themselves, is a precondition for thriving as individuals, communities and as a society. This situation exemplifies Deleuze’s image of the “society of control” (see chapter 3) in which every part of existence is subjected to continual modulation. In the genomic age we are witnessing the emergence of an all-encompassing biopolitics—a politicization of *bios*, understood as human life. However, the experiment on Mars also harbors the possibility of *another* biopolitics that resists the idea of total human control, picturing human life as part of biophysical processes at multiple scales. This is what Braidotti has termed “zoë-politics,” an awareness of the agency in zoë or life as such: “Nature is more than the sum of its marketable appropriations: it is also an agent that is beyond the reach of domestication and commodification ... ‘Life’ has emerged as the subject and not the object of political processes” (*Transpositions* 47, 55). Crisis situations in minor sf trigger a realization that “our lives” are entangled with all kinds of processes that we do not control, but that we must come to terms with: the world is not a stage for human action, but a network of actors. As the case studies in chapters 3 to 5 will demonstrate, the most successful human characters are those who respect and respond to the agency of nonhuman life.

BEAR'S BIO-SF

If from a Deleuzian point of view, all great literary texts record a writer's unique struggle with a problem—ultimately the problem of life (Smith xiii)—in sf such guiding problems are often related to a particular scientific field. For example, the idea of the fabricated monster in sf narratives from *Frankenstein* to *Jurassic Park* is related to the hopes and fears inherent in biological research (Zwart, *De waarheid*). Other common biological novums in sf are the outbreak of a contagious disease or the encounter with an unknown (extraterrestrial) species. In his bio-sf novels, Greg Bear spawns a variation on these novums, imagining transformations of human life as we know it as a result of genetic infection through viruses. Bear's narratives of *change from within* are insufficiently understood when analyzed as allegories of social or psychological change (although his oeuvre is replete with political, psychological and parapsychological ideas). Rather, the event of genetic infection makes it possible to “discern beneath the merely personal the power of the impersonal” (Lambert 16), putting the integrity of human forms and behaviors into question, including the idea of the autonomous subject, the “I.”

The atypicality of Bear's narratives, in which human transmutation is described openly and scrupulously, becomes obvious as soon as one glosses over the history of sf. In Mary Shelley's *Frankenstein* (1818), often counted as one of the first sf narratives, scientist Victor Frankenstein manages to build a complete humanoid being *de novo* from a vast collection of body parts gathered from “the dissecting room and the slaughter house” (55). The reader does not witness a viable process of transformation from an inanimate to an animate body, but rather is presented with a sudden, miraculous moment when Victor sees “the dull yellow eye of the creature open” (58). In a similar vein, in H.G. Wells's *The Island of Doctor Moreau* (1896), a scientist specialized in vivisection retreats to an island where he manages to create new human-like creatures through medical experiments with animals, experiments that remain utterly opaque to the reader. More recently, Margaret Atwood's *Oryx and Crake* (2004) leads the reader into a dystopian future where genome scientist Crake has created a new species of man and killed all the “old” humans through the dissemination of a virus against which only he is protected. I want to point to three salient aspects of these literary representations of transmutation. First, the process occurs in confined, secret places (usually laboratories) whose environments play no role whatsoever, apart from displaying the *effects* of the transmutation. Second, these scenarios seem mostly concerned with warning against the dangerous possibilities of science, leaving alternative, positive uses relatively untapped. Third, by looking exclusively at the purposeful actions of human beings, these texts fail to account for transformation as a potential inherent in life itself.

In his bio-sf novels *Blood Music* (1985), *Darwin's Radio* (1999), and *Darwin's Children* (2003), Bear provides an alternative to these literary scenarios, unfolding the idea of a nonhuman life taking hold of humanity, changing it from within, without attaching moral claims to this event. In *Blood Music*, genetic engineer Vergil Ulam injects himself with a strange, seemingly intelligent cell culture he had fabricated as an alternative to laboratory rats. The cell culture then “takes over” his body, which slowly begins to transform. Ulam's “disease” spreads like a virus, contaminating the whole population of North America in the course of the novel. By the end, infected human bodies have completely dissolved into a featureless, reddish flesh covering the land, habitats for nanomachines or “noocytes” that keep the noosphere (realm

of thought) alive in the absence of human consciousness. *Blood Music* prefigures nanotech pioneer Eric Drexler's “grey goo” hypothesis presented in *Engines of Creation: The Coming Era of Nanotechnology* (1986), which entertains the possibility of artificial nanolife proliferating beyond control, overgrowing the Earth's continents. It feeds into technophobic and dystopian lamentations about new technologies signaling the end of human nature (Baudrillard; Fukuyama; Habermas).¹⁶ Seemingly informed by such worries, Jameson has argued that *Blood Music* is a “chronological marker” for a paradigm shift from physics to biology, a shift that “is calculated to make problems for conventional sf representation and narrative,” because “the complexities of biology and the genetic, indeed bio-power itself, offer a content and a raw material far more recalcitrant to plot formation than even Einsteinian cosmology and the undecidability of atomic subparticles” (*Archaeologies* 68). Jameson's discarding of *Blood Music* and his reservations about bio-sf as such are curious in an age of far-reaching biotechnological developments. Even if it were true that, as Jameson argues, contemporary bio-sf has not succeeded in offering convincing utopian narratives, would it not deserve critical discussion, including its relation to the biosciences and contemporary biopolitics?

In *Blood Music*, biological content is entangled with social existence in immediate, pressing ways, creating a situation that is *biopolitical*. Being or not being infected becomes the primary marker for one's existence. The story sketches a biopolitics of control vis à vis the “plague” involving the Centers of Disease Control and the US military. *Blood Music* critically interrogates a “prophecy” in science and society that nanotech is able “to accomplish almost anything called for by human desires” (Milburn, “Nanotechnology” 262). Epistemologically, Bear's story combines nanotech with genetics, imagining an intelligent entity based on biochips that behaves neither like an organism nor like a machine, imagining an extended eco-network that ends all (individual) human agency. In spite of being critical about techno-utopianism, Bear's representation of life is also problematic, because it presents a cybernetic model as if it were a kind of theory of everything, a key to life itself, thus reinforcing a scientific and political desire to control life. Yet in following the problem of horizontal genetic communication, Bear also brings into literary representation a hybrid, inorganic life, an important prelude to thinking humanity and its world *beyond* the notion of control.

The bio-cybernetic life form in *Blood Music* transforms humans into one large entity that can perhaps no longer be perceived as an organism, for it has no organs. This idea is akin to what Deleuze and Guattari call a “Body without Organs” (*A Thousand* 4), a term borrowed from the poet Antonin Artaud. Deleuze and Guattari imagine a different body—or, more aptly perhaps, a different *modality* of the body—that is not governed by a telos of organization and conservation. The notion of Body without Organs, which applies not just to biological bodies but to *any* body, refers to a site of intensive connection and transformation, rather than a body as already differentiated (in functional parts) and qualified (as a particular species).¹⁷ The organism is an actualization of virtual intensities that do not simply “belong” to it, but rather coincide with it. If organisms have no choice but to follow the “natural” developmental paths carved out for them, this process can be interrupted by events in which nature operates “against itself” (*A Thousand* 267). For Deleuze and Guattari, experimentation in art is a way of affirming this potential for disruption in nature, resisting the mundane demands of the organism and of society.

They argue that the work of writers like Artaud or William Burroughs, in questioning and mocking the specific arrangement of body parts, creates a body without organs, thus “liberating life” from the organism (169-70; 175-77). In experimenting with the body, these writers begin to believe that the idea of autonomous subjectivity, of “having” a body of one’s own, is but a limiting cognitive habit. At the molecular level, “every animal is fundamentally a band, a pack” (264), and all organisms are connected rhizomatically. Writing should be an affirmation of this molecular multiplicity, not the reification of human subjectivity.

According to Mark Hansen¹⁸ and Catherine Hayles, the concept of Body without Organs expresses a philosophical desire for endless variation, a desire that blinds Deleuze and Guattari to the highly specific, constrained processes of organic life.¹⁹ The critique leveled at the concept of Body without Organs is similar to many responses to *Blood Music*: when the push toward variation becomes too intense, the situation ends in chaos, leaving no hope for the future. *Blood Music* manages to dismantle the organism, bringing out life as an impersonal event, yet fails to construe something new, ending up in a homogeneous mass of self-replicating information-matter. The human body literally merges with the landscape, just like in J.G. Ballard’s novel *The Crystal World* (1966) where suddenly the whole world, organic and nonorganic, gradually crystalizes. Another example is Arthur C. Clarke’s *Childhoods End* (1953), in which an extraterrestrial power prepares humanity for transmutation into a different form, where all humans connect physically and mentally, eventually joining “the Overmind,” a God-like force pervading the universe. With such transmutation narratives, there are no characters and no narrators to continue the story—in Jameson’s words, such events are “recalcitrant to plot formation.” They may alternately imply a kind of verification of messianism—an arrival at the end of history where humanity fuses with its maker—or a “falling,” a regression to the pre-biotic soup from which life emerged.

However, it remains an open question whether the end situation of *Blood Music* really is one of homogeneity, inertia and simplicity, and whether it is good or bad. Deleuze and Guattari go at lengths to argue that the body without organs is never simply something positive or negative: it is both desirable and dangerous, and therefore experimentation should be carried out with great care.²⁰ In the story of *Blood Music*, it is careless experimentation that allows human life to turn into a decentered swarm, an idea that is disturbing “for its engulfing largeness and for the many, too many smallnesses of which it is made” (McGurl 551 n. 37). If Bear goes too far into the direction of chaos, something is gained from this nevertheless. In *Blood Music*, the swarm, a form of life that humans can hardly recognize as such²¹, becomes not so much intelligible as something that can be felt and heard through the actions and communications of the noocytes who gradually “take over” the human body. Whereas Jameson argues that the biological is recalcitrant to plot formation, I would argue the contrary: life, understood not as a given species or a molecular essence but as the *unfathomable inorganic life inhering in the organic*, is a most fertile source for sf experimentation. Narratives of transmutation such as Bear’s and Ballard’s do not fit the dominant picture of evolution as leading from simplicity to human civilization (Margulis and Sagan, *Acquiring* 22). They challenge us to think about evolution nonlinearly, and with no pretension to human superiority. Rather than reifying oppositions between the human genome (as informational essence) and the nonhuman environment, *Blood Music*

represents DNA as place where the outside becomes inside. As in the *Mars* trilogy, human bodies are part of an immense biophysical network open to change. If *Blood Music* can be called a story of monstrosity, then this monstrosity refers first and foremost to the very processes of contamination and transformation that become intelligible with contemporary biosciences. In the words of the character Bernard, “the situation itself is monstrous” (212). In this sense *Blood Music* is akin to Kafka’s *The Trial*, where the law is no longer a rigidly organized body, instead becoming an *event*, “an influence machine, a contamination” in which there is “no longer any difference between outside and inside” (*Kafka* 8).²²

CONCLUSION

The fact that Deleuze and Guattari chose as a subtitle for their book on Kafka the cautious “Toward a Minor Literature” indicates that they want to bring out a certain potential in literature that is still, and perhaps always, embryonic: a capacity to bring life as such into view. Deleuze and Guattari argue that Kafka’s short stories were short for a reason: the basic experimental idea was a dead-end. They argue that Kafka’s famous novels are far more successful precisely in being “interminable works” that bring out an immanent field of desire, a politics that includes everything. I have argued that sf novels like Bear’s perform something similar, recording the struggle with an ongoing problem-event that cannot be solved. Thus sf stops being, in writer and critic Brian Aldiss’s words, “the search for a definition of mankind and his status in the universe” (25), and becomes an exploration of conditions that make humanity possible (social, physical, biological, etc.) but also make its transmutation inevitable. This search for nonhuman conditions is aided by a plethora of scientific elements, not by something as vague as what Jameson (with Suvin) calls a “cognitive attitude.” In *Blood Music* science is not an authoritative window onto the world, which can either be promoted or criticized, but rather an assemblage of ideas, desires, attitudes and practices that become vital ingredients for narrative. The suspense of sf novels such as Bear’s lies mostly in the continuous feeling of discovery, a pursuit of anomalies that leads into epistemological and ontological boundary zones between the disciplines and on the borders of science as such. Minor sf thrives on that adventurous, nomadic side of science that is usually rather minimal or even absent from a scientist’s everyday experience.

Blood Music confronts readers with phenomena of molecular entanglement, swarm intelligence, and spontaneous transmutation, ideas that shatter the image of a superior, autonomous humanity. If *Blood Music* provokes a shock of the biophysical, then this shock leaves humanity literally paralyzed, as well as transmogrified beyond all recognition. I would argue that *Blood Music*, rather than representing a historical and, for Jameson, deplorable “watershed” for sf (*Archaeologies* 68), marks a critical threshold or zero-degree point where sf becomes minor, figuring life differently while balancing at the brink of chaos. *Blood Music* is not an especially careful experiment, but it does create the basic conditions for thinking a nomadic science, subjectivity and biopolitics. As I will demonstrate in chapter 4, Bear’s novel *Darwin’s Radio*, written a decade later, goes one step further. Here the transmutation of humanity does not involve a complete merger of humanity and world, but a moment of mutual feedback that leads to

new traits and physiological forms. Bear's desire to *think with* science, expressing in literature something essential about life—its immanent connections and ongoing transformations—both evokes and resonates with the basic tenets of a nomad science that introduces new transdisciplinary problems. It is to nomad science and the question of life that I will tend now, momentarily stepping out of the world of *sf* and into contemporary biosciences.

— 3 —

THINKING A LIFE: NOMADISM AS A CHALLENGE FOR [POST-]GENOMICS

*Life goes beyond the limits that knowledge fixes for it,
but thought goes beyond the limits that life fixes for it.*

— Gilles Deleuze —

INTRODUCTION

In *A Thousand Plateaus* Deleuze and Guattari propose that science has two forms. On the one hand there is “royal” or “State” science, which is organized in hierarchical institutions at the service of power. Power binds science to its own purposes—organizing and thereby controlling the world—and in return grants science a sense of autonomy and authority (412). The fundamental operation of State science, according Deleuze and Guattari, is *reproducing* knowledge as well as its conditions of production (410; 413). On the other hand, there is a mode of science that lacks a fixed institutional form, refusing to be directly and permanently linked to power; it is “itinerant,” “ambulant” or “nomadic” (411). Nomad science is characterized by four preferences: fluidity rather than solidity, becoming rather than being, topology rather than Euclidian geometry, and problematization rather than theorem (398-99). The basic operation of nomad science is “*following* the flow of matter” (412) without aiming to control it. Although Deleuze and Guattari emphasize that nomad science is not *better* than State science, “just different” (410), they clearly encourage nomad thinking. As we will see, State science, in its urge to arrive

at solutions sooner rather than later, can severely limit the potentials of thinking, and even produce “solutions” that are entirely unfitting.

A number of scholars have offered historical and contemporary examples of nomad science. Manuel Delanda traces nomadic traits in both sides of the debate between Isaac Newton (1642-1727), and Robert Hooke (1635-1703), Newton initially following nomadic lines (including those of alchemy) but eventually becoming an ultimate State scientist—the head of the Royal Society (“Material” 16). Andrew Pickering argues that the prospect for nomadic perspectives in contemporary science lies with “the sciences of complexity, emergence and becoming” (“Nomad” 155) which he traces back to early cybernetics specialists working outside state-funded research. Along the same lines, Sian Sullivan and Katherine Homewood link nomad science to contemporary ideas about non-equilibrium dynamics that fly in the face of government and corporate practices of control and postures of certainty (22). Jeremy Hunsinger argues that nomad science describes well those scientists advocating “open and mutable” cyberinfrastructures (277) and Marcelo Svirsky discerns a nomad science of political activism that resists strategies of incorporation in government and corporate programs of *participation*, instead spurring “creative acts of citizenship that actualize *ruptures*” (3). To summarize, keywords of contemporary nomad science appear to be complexity, open infrastructures, and non-institutionalized creativity (Hunsinger; Pickering, “Nomad”; Sullivan and Homewood; Svirsky).

I see two major challenges in working with the concepts of State science and nomad science in science studies. Firstly, the label “State” is outdated in the sense that it does not do justice to the increasing role of corporations in scientific research, often in combination with governmentally funded initiatives and programs. As a response to this problem, I want to propose to substitute “State science” for a new term, “control science,” to analyze corporate science as well as scientific projects where the state and corporations work in tandem. Control science can be understood in analogy to what Deleuze has called “societies of control,” a contemporary constellation of power emerging in the era of global capitalism in which control is no longer primarily disciplinary (as in Foucault’s notion of biopolitics), but rather distributed or networked. This new biopolitics is distinguished by heightened levels of flexibility—a capacity to “modulate” subjects, policies, methodologies, etc. in response to new circumstances. A second challenge is that, given the ubiquity of terms like “complexity” and “emergence” (also in state-funded programs), drawing distinctions between State, control and nomad science is often a difficult task.¹ As I will show below, scientific projects which appear to truly “follow” complexity wherever it leads them, can easily reterritorialize on the grounds of capital and the state, thus leaving nomadic potentials untapped. The challenge is not to determine easy labels, but to map the *de/re/territorializations* of science.

In order to start thinking about contemporary dynamics of control and nomad science, addressing the challenges mentioned above, this chapter analyzes the story of the Human Genome Project (HGP) and the subsequent scientific adventures of biologist Craig Venter. I do not wish to argue that Venter is somehow “representative” for all research done under the banner of (post-)genomics—quite the contrary, Venter is “biology’s bad boy,” as the popular media have it, someone who opens new territories for science. Venter’s autobiography *A Life Decoded: My Genome my Life* (2007) is fascinating because it reveals the deep ambiguity of his

ideas, practices, attitudes, and desires. On the one hand, Venter’s entrepreneurship, his capacity to think beyond scientific and national borders, his flexibility, and his dedication to making life as such susceptible to modulation on the molecular level, puts his research squarely into the category of control science. Indeed, scholars see a significant role for genomics in the new era of technoscientific biopower (Cooper; Marks; Rose). However, Venter’s recent effort to sequence “the genome of the ocean” (*A Life* 343) out of the DNA extracted from water samples collected in the Atlantic and Pacific oceans also points to nomadic potentials in (post-)genomics. The ocean is a “nomadic” space *par excellence*: a topological space that is difficult to navigate let alone to control. The water samples collected by Venter and his team are not discrete objects but fluid ecologies, becomings, whose complexity may problematize the way we think about aquatic and terrestrial life. The question is to what extent these potentials can be actualized within the parameters of Venter’s overall research project aimed at the unraveling of life’s essence, and I argue that this is difficult. To draw out the nomadic potentials of Venter’s (post-)genomics projects, I will confront his work with ideas about life from Deleuze’s philosophy and from the work of evolutionary biologists Susan Oyama and Lynn Margulis. This kind of cross-fertilization seems vital in order to recast (post-)genomics’s desire to understand and modulate life in more humble terms: as an experiment that is clearly beyond anyone’s control, but in which we participate nevertheless.

STATE AND NOMAD SCIENCE

In order to understand the role of power in State and nomad science, I will briefly introduce Deleuze and Guattari’s notion of the “war-machine,” which occasions their incursion into the nature of science in *A Thousand Plateaus*. As Deleuze and Guattari maintain, the state resembles an organism: essentially reactive and defensive, its primary objectives are the safety and stability of its territory (412). The war-machine has nothing to do with this image of territorial interiority. It is an open assemblage, a “deterritorialization” whose force is directed against any attempt to organize populations within stratified regions.² The war-machine is an anthropomorphic assemblage (a creation of thought or activism) whose intensity is measured by the number of connections it makes and its “power of metamorphosis” (*A Thousand* 565). The more intense a war-machine, the more it moves towards the plane of immanence, affirming life as becoming. The war-machine is not necessarily violent, even if, according to Deleuze and Guattari, (guerrilla) warfare is a necessary “complement” to social deterritorialization (466). It is associated with processes that destabilize and transform territories and populations, such as “underground” resistance, migration, and contamination. Deleuze and Guattari stress that the military institutions of the State are no more and no less violent than the war-machine. Although it is not a matter of determining which form is *better*, Deleuze and Guattari do claim a certain primacy and a positivity for the war-machine. The war-machine is a sea of potential for social arrangement out of which the states arise like islands, attracting populations and blocking free movement. Its positivity lies in creating new ways of living, or “lines of flight,” (466-7) that escape the diagrams of etatism and capitalism. The war-machine thinks in flows that threaten to open up the modes of thinking developed—enveloped—within the confines of the state, notably binary

oppositions: for example, between subject and object, normal and abnormal, nature and culture. Nomad science, a mode that is “difficult to classify” and whose “history is even difficult to follow” (398), can be seen as a war-machine that opens up State science from the margins.

The four key aspects of nomad science are intrinsically rather than coincidentally vague. Referring to a term from Husserl, Deleuze and Guattari concur that nomad science deals with “vague essences” rather than exact ones (405). Deleuze and Guattari use one aspect of nomad science to explain the other, which makes it even more difficult to present them in a lucid manner here. I will offer them all at once, in the original order, and then proceed to explain them in more detail, contrasting them with State science:

1. a use of “hydraulic models,” in other words, a preference for fluidity rather than solidity;
2. a focus on “becoming and heterogeneity, as opposed to the stable, the eternal, the identical, the constant”;
3. a topological approach that “operates an open space throughout which things-flows are distributed, rather than plotting out a closed space for linear and solid things”;
4. a model that is “problematic, rather than a theorematic” (398-99).

The four points overlap to the extent that they can be seen as perspectives on a single idea: before actualizing in bodies and states of affairs, the world is a *becoming*. The best way to explain State and nomad science is perhaps to stipulate their relations to this idea at the heart of Deleuze’s philosophy. While State science thinks of matter as a passive, dead “material” waiting to be formed, nomad science evokes “a life proper to matter, a vital state of matter as such” (454). There is movement in matter. The world is in first instance a topology, a fluid unity where each element is connected to the whole, and to change one element will necessarily affect all the others. The world is in flux, and nomad science affirms the potential of this flux by *following* it. Accordingly, nomad science defines matter not by a fixed identity or essence but rather by its singularities (critical points, for example the boiling point of water) and its affects, meaning its “ability to affect and be affected” (xvii). This idea applies to inorganic as much as to organic bodies. A concrete example that Deleuze and Guattari give is the craft and science of metallurgy, which carefully follows the singularities and affects of metals, rather than hammering form out of passive material (453-458). This susceptibility of matter to becoming that metallurgy attests to cannot be thought within the axioms of State science, which builds its structures on a homogenous, inert matter. State science is a science of laws: it discovers constants to which all phenomena can be related as “variables” via a rational method. Deleuze and Guattari qualify its logic as one of controlled *reproduction*, a procedure that implies “the permanence of a fixed point of view that is external to what is reproduced: watching the flow from the bank” (410). To think the openness of bodies to becoming, as in Deleuze and Guattari’s example of metallurgy, forces us to assume an open or “smooth” space to which the enclosed spaces of State science are only secondary.

Especially the idea of a “problematic” model perhaps demands some further explanation. For Deleuze and Guattari, to problematize is to never settle for a particular identity of a body or entity—rather, it is to inquire into its unique and ever-changing conditions of existence:

One does not go by specific differences from a genus to its species, or by deduction from a stable essence to the properties deriving from it, but rather from a problem to the accidents that condition and resolve it. This involves all kinds of deformations, transmutations, passages to the limit, operations in which each figure designates an “event” much more than an essence; the square no longer exists independently of a squadrature, the cube of a cubature, the straight line of a rectification. (*A Thousand* 398-99)

Mathematical and geometrical figures are not givens, but already answers to problems (how to design, build, etc). But what goes for figures and concepts goes for anything: life is nothing other than the continuous unfolding of problems. An organism’s conditions of existence, Deleuze argues, are problematic in-and-of-themselves, not by virtue of a scientist’s point of view. In fact, the organism is “nothing if not the solution to a problem, as are each of its differentiated organs, such as the eye which solves a light ‘problem’” (*Difference* 263). Organisms do not germinate from an internal or external cause, but materialize as solutions within a problem-field (i.e. actual and virtual conditions) that forces them into action—how to grow, sustain, create, recombine, transform. Every problem is already a kind of answer, a strategic response to higher level problems in the intermediary zone between organization and chaos.

Deleuze and Guattari oppose the problematic model to that of theorems and axioms. The theorematic model of State science, they argue, conceives of problems as obstacles (399). It is based on a positivistic outlook that envisions science as a rational puzzle-solver, with a strong tendency to neglect “the metamorphoses, generations, and creations within science itself” (399). Perhaps we could say that, from this perspective, truth is the state in which obstacles have been removed, where life is evened out, made homogeneous, peaceful. State science is a science of the actual, where the world comes ready-made, distributed in essences and properties, parts and wholes, subjects and objects. The heat or turbulence of the war-machine undoes the hardening of binary oppositions that theorematic models presuppose. Nomad science brings back the chaos, the violent movement of life under the surface of actualized bodies. Operating at the fringes of science, it is engaged in battling chaos on the one side and State science’s axioms on the other, opening up and boosting thought by connecting hitherto seemingly disparate phenomena.

Unfortunately, the chapter in *A Thousand Plateaus* on the war-machine hardly concretizes State and nomad science through clear examples.³ Deleuze and Guattari do mention metallurgists, “gothic journeymen” (medieval builders), and engineers as historical models of nomad science (457-58; 406; 400). What binds these craftsmen is an intimate relationship with matter, a taste for experimenting with new procedures and materials. These examples show that nomad science has an immediate practicality: its problems are not mere abstractions but calls to action, calls that seem to emanate from matter itself rather than from power. However, there is a more elaborated example that Deleuze and Guattari provide without actually using the terms of State and nomad science: the debate on the between Eighteenth-Century biologists Étienne Geoffroy Saint-Hilaire (1772-1844) and Georges Cuvier (1769-1832). This debate may serve as an entry point for thinking about the fundamental attitudes of State and nomad science towards the problem of life in the era of (post-)genomics.

Cuvier maintained that species are formally distinct, eternal types with a harmonious set of functions (organs), whereas Geoffroy Saint-Hilaire stressed that the species change in response to their environments, that they share universal elements (belonging to a common “plan of nature”), and that organs compete with one another. Geoffroy Saint-Hilaire was primarily interested in the *conditions of existence* of species—the very possibility of the generation of newness which is real but not easily demonstrated or described. For Cuvier, instead, there are only the empirically observable, actual differences, which are coherently organized in the genera, the species and in each organism. Cuvier resolutely denounced the idea of a plan of nature, calling it “metaphysical.” The two scientists differed not just in their thinking, but also in their careers. Both served Napoleon Bonaparte, but it was Cuvier who had been trained as an administrator and, increasingly during his career, became occupied with political tasks, delegating the scientific work to students, while Geoffroy Saint-Hilaire remained “the archetype of a disinterested scholar, avid for freedom” (Le Guyader 19). In *A Thousand Plateaus*, Deleuze and Guattari qualify the differences between the two scientists as follows:

The sweet and subtle Geoffroy and the violent and serious Cuvier do battle around Napoleon. Cuvier, the rigid specialist, is pitted against Geoffroy, always ready to switch specialties. Cuvier hates Geoffroy, he can't stomach Geoffroy's light-hearted formulas, his humor (yes, Hens do indeed have teeth, the Lobster has skin on its bones, etc.). Cuvier is a man of Power and Terrain, and he won't let Geoffroy forget it; Geoffroy, on the other hand, prefigures the nomadic man of speed. Cuvier reflects a Euclidian space, whereas Geoffroy thinks topologically. (*A Thousand* 53)

As this example shows, the dynamics of State and nomad science are fundamentally *dramatic*—a play of desires, passions, and achievements, a staging of confrontations, arrestments and escapes. It suggests that scientists like Geoffroy Saint-Hilaire, who have a propensity to think in terms of topological space, generally maintain a flexible position in relation to scientific disciplines as well as to the state. In the end, Geoffroy Saint-Hilaire was declared defeated in dominant scientific circles, and the idea of a “plan of nature” was generally considered unscientific. Due to this “defeat” Geoffroy became a somewhat neglected figure in the history of science. Unfortunately, there is a tendency in historiography to forget scientific nomads, obscuring, for example, the fact that Geoffroy Saint-Hilaire's work was much more influential on Darwin than Cuvier's (Tresch, *The Romantic* 19–20).

Geoffroy Saint-Hilaire's intuition of infinitesimal differential elements structuring and connecting all living creatures, and making new life forms possible, resonates with the ideas about evolution developed in the Eighteenth and Nineteenth centuries as well as with the birth of genetics in the Twentieth century (Deleuze, *Difference* 233–4). Furthermore, comparing Geoffroy Saint-Hilaire's debate with Cuvier with contemporary debates in the molecular biosciences, we can detect a number of striking similarities related to the interconnection between science and (bio)power. As Foucault's work has shown, the emergence of modern biology around the beginning of the Nineteenth century coincides with the birth of the modern state, and the two phenomena have been deeply intertwined from the start. Science provided important armamentarium

for mapping and controlling the behaviors of individuals and populations, enabling modern states to wield a more or less rationalized biopower or “power over life” (*The Birth* 19). The rigidity of Cuvier's taxonomies and his proximity to Napoleon Bonaparte can be fruitfully juxtaposed to the persistence of genetic and genomic determinism in the Twentieth and Twenty-First centuries, and the unprecedented role of the state in financing and recruiting the sort of research that reifies the genetic explanation of life. Although Geoffroy Saint-Hilaire's conception of invisible differential elements also resounds in genetics, his stress on connectivity, differentiability and generativity is hard to reconcile with genetic or genomic determinism, rather prefiguring the complex systems-based thinking of scientists operating at the fringes of the molecular paradigm in the biosciences.

GENOMICS AND THE NEW BIOWPOWER

Deleuze and Guattari's ruminations on State science, nomad science, and the war-machine, complemented with Foucault's historical analyses, can be used to understand how the confluence of (cold-war) militarization and state-funded science since World War II, particularly in the US, gave rise to a new form of biopower. After World War II, with the exodus of physicists to the biosciences, and, concomitantly, the introduction of the discourse of information and communication science into biology (Kay), the biosciences became increasingly dominated by a big science approach (De Solla Price), enabling unprecedented possibilities for prediction and control. In her influential historical study of the “cracking” of the genetic code, Lily Kay shows that in the 1950s molecular life became the preferred object of state-sponsored science. Kay describes how during this period “military power extended into the world of the mind” and came to dominate the biosciences “through its various discourses and representations, notably the discourse of information and the technoscientific imaginary of communication and control systems” (11). Through this novel constellation, Kay argues, the molecular biosciences helped to inaugurate a new form of biopower where “the genetic code became the site of life's command and control” (5). Kay's historical analyses form a highly significant backdrop for contemporary biology, which continues to be closely aligned with governments, military incentives, and discourses of control.

It is in this context of emergent biopower that I want to place the story of the Human Genome Project (HGP), a story that is compelling for at least three reasons. Firstly, in some sense, the story of the HGP is still unfinished because the debate about its results is still going on. While critical voices argue that the HGP suffered from basic misunderstandings which explain its allegedly unspectacular results (Gould; Sarkar), the leaders of the HGP tend to emphasize that it is part of a long journey toward understanding life. Secondly, the HGP has not just set the ground for new biomedical possibilities—Zwart and Penders have argued that “on the basis of emerging bioarchives that are now becoming available, a complex and comprehensive narrative is developing concerning the past history and possible future of *human existence*” (“Genomics” 228; my emphasis). Finally, the HGP was not the consensual international endeavor it sometimes appeared to be. Its central figures cooperated but also competed fiercely in a race to decode the human genome, quarreling over the adequate route to take in what has been dubbed a series of “gene wars” (Cook-Deegan). The story's culmination point was the

June 2000 announcement of the completion of the sequence of the human genome at the White House under the auspices of President Clinton. The protagonists—genome scientists Francis Collins and Craig Venter (on stage) and James Watson (in the front row of the audience)—presented the world with an image of the human genome as a “book of life” whose contents would bring to light the secrets of human biological existence once and for all. President Clinton likened the sequencing of the human genome to a mapping endeavor not unlike the famous expedition by Meriwether Lewis and William Clark, who in 1801 set out to explore the huge area of land to the West of the United States in order to pave the way for colonization. The celebration of the finalized HGP, an inner journey to the essence of humanity, marked a moment when the biosciences decisively claimed the cultural role of the pioneer, and the image of the triple helix attained a status more iconic than ever before, a symbol for the identity and destiny of the human species. As Zwart has observed, these mapping metaphors are not innocent (“The Adoration”). Clinton’s proud allusion to the Lewis and Clark expedition—a prelude to the full colonization of the North American continent—condones the controversial aspects of state sponsored scientific explorations.

Ironically, the moment when the human genome was announced decoded also became the moment when the idea of a genetic code, as a paradigm, began to crumble (unfortunately it remains as dominant as ever in the cultural imaginary).⁴ When the human genome was sequenced, it turned out that the human species has approximately 23,000 genes—much fewer than previous estimations which had ranged from 100,000 up to 300,000. Moreover, the human genome turned out to be extremely similar to the genomes of other species, thus positioning humans far closer to other animals, at least genetically. This realization has been interpreted by Zwart as a “narcissistic offense” to the human race (“Genomics and Self-Knowledge”), but it can also be seen as a major blow to the scientists involved as well as to State science, with its reliance on the reproduction of steady identities. With this number of genes, the one-trait-one-gene model became an historical artifact. The very scientists who had wholeheartedly embraced the discourse of genetic determinism for many years, using it to promote their research, were now forced to substitute it for an emphasis on (genomic) complexity, foregrounding the significance of such processes as gene interaction, gene transcription, gene splicing, and epigenetic regulation of protein synthesis. The possibilities for therapy that had appeared to be just around the corner, now seemed much farther away. Although certainly for its staunch critics, in the end the HGP was a humbling lesson (Gould) or even “an unmitigated failure, the most colossal misuse ever of scarce resources for biological research” (Sarkar 87), the end of the HGP did not signal the end of genomics. Rather, what has occurred in “post-genomics” is a shift in discourse and, to some extent, in research, which has moved towards the multiple elements at work in the expression of genes.

If molecular biology has taken a “post-genomic” course, it cannot be inferred that the bond between bioscience and power has weakened in any way—rather, molecular biology has been gradually moving from State science to control science. This reconfiguration is implicated in a shift towards new forms of biopower which was prefigured in a short text by Deleuze written in the early 1990s, “Postscript on Societies of Control.” Here Deleuze speculates on a new era that begins to take shape roughly around the 1950s, in which State ordained disciplinary

begins to wane, giving way to a multiplication of “soft” strategies throughout the various levels of society as well as beyond the borders of the state. Capitalism features prominently in this dissemination process, completely reshaping the role of classical centers of control as analyzed by Foucault, such as the prison, the school, and the hospital.⁵ Apart from taking biopolitics as a heuristic instrument beyond the disciplinary world of modernity that Foucault’s work maps, Deleuze intensifies the point that Foucault’s concept of the subject is not reducible to the notion of “the individual”—that bed-rock of humanist and Enlightenment understandings of the self (Revel). The notion of “dividual” presented here by Deleuze points to the ways in which the uniqueness of each individual life, whose psychological and social life was the object of disciplinary logic, is now being displaced by new assemblages in which the modern notion of “mass” gives way to “samples, data, markets, or ‘banks’” (3). The flexibility of individual and collective life under contemporary capitalism is thus closely related to the rise of global, computer-driven systems of modulation in place of the conventional modes of (re)production. Rather than organizing life through specialized enclosed spaces (families, factories, states), technoscientific capitalism’s global scale and 24/7-economy raises the imperatives of productivity and training to a level that is at once grand and molecular, totalizing and dispersive.

This historical shift of biopower sketched by Deleuze (a shift already implicit in Foucault’s work, who understood the disciplinary society to be vanishing) is the background against which the notion of control science becomes intelligible. Control science is epitomized by a decentralized, more flexible and fine-grained kind of reproduction of knowledge and information. In molecular biology genetic networks and cellular interactions replace the gene as guiding metaphors, which no longer apply to definite units (an individual, ethnic group or species) but rather establish transversal connections between (sub)levels of analysis (cellular, organismal, ecosystemic), disciplines, and species. In medicine, the distinctions between illness and health, hospital and home, patient and doctor, are blurring. Health is no longer a particular situation in the present—one is never really healthy—but something that is continually monitored and modulated. Patients are increasingly managing their health on the basis of genetic data and other bioinformation, even without a doctor acting as intermediary, for example through direct-to-consumer genetic testing and through devices that measure heart rate. Opaque notions such as “life style” are becoming increasingly important in thinking about health, thereby dispersing it, making it non-local, yet also personalized. It seems that the more information one has, the more one is able to prevent disease, but the more precarious and elusive one’s health becomes. In this sense, health is becoming an “event” in the Deleuzian sense—an event that rather than actually happening is always “that which has just happened and that which is about to happen” (*The Logic* 10).

Deleuze’s notion of societies of control and the idea of control science resonate with a number of important recent writings on biopolitics and genomics. Nikolas Rose argues that the linkages between power and biomedicine in the genomic age cannot be adequately interpreted within the framework of coercive control by the State (eugenics). Instead, what arises is a “politics of life itself” in which all citizens participate: “It is neither delimited by the poles of illness and health, nor focused on eliminating pathology to protect the destiny of the nation. Rather, it is concerned with our growing capacities to control, manage, engineer, reshape, and

modulate the very vital capacities of human beings as living creatures" (*The Politics* 3). What Rose argues here is that the newly available knowledge and biotechnologies are profoundly emancipatory if treated ethically and democratically. Civilian organizations such as patient groups give rise to a new "biosociality" (131-154) (a term coined by Paul Rabinow), ensuring that genomics does not become a tool for the top-down governance of life.

Melinda Cooper offers a more critical examination of the new possibilities offered by genomic knowledge and data, which function as new forms of capitalism-driven control, but also reterritorialize on the state. According to Cooper, what we are witnessing in the (post) genomic era is an intensification of the relations between biology, corporations, the state and the military, especially in the US. After the 9/11 attacks, the Bush administration developed an agenda of permanent warfare (the policy "preemptive strikes"), where war is waged no longer for states or for human beings, but

in the name of life in its biospheric dimension, incorporating meteorology, epidemiology, and the evolution of all forms of life, from the microbe up. The extension of preemptive warfare to include the sphere of environmental and biopolitics conflates the externalization of war with the evolution of life on earth—as if permanent war were simply a fact of life, with no other end than its own crisis-driven perpetuation. (98)

In other words, the biologization of politics and war goes much further than preventing pandemics and fighting bioterror; it concerns the recruitment of humans and other species in new regimes of safety and health that work according to a logic of continuous (pre-emptive) modulation. This regime makes use of new forms of technology and information, creating what Victor Toom has termed a mode of "forensic-genetic biopower" through which biological life increasingly comes to fall under the law (184).

These opposing assessments of genomics and contemporary biopolitics make it more challenging to mark a clear distinction between State science, control science, and nomad science. On the one hand, genomics, as a massive data-producing machine designed to forge a map of life itself, seems primarily engaged in *reproduction*, rather than the nomadic practice of *following* the singularities of matter (*A Thousand* 410). The question is what happens to genomics after the HGP: are nomadic notions of complexity and emergence being mainstreamed into a new control science? Or, more in line with Rose's work, is there an affirmation of nomadic potential in genomics after the HGP, altering the very axioms of genomics?

VENTER'S ADVENTURES

Genomics has produced its own stories through popular scientific publications and the media (Wald, "Patterns of Prejudice"; Zwart, "Understanding"). As Priscilla Wald makes clear, these stories are not merely "personal" anecdotes or marketing instruments. Rather, they are "fundamental in the production of scientific and medical knowledge and, therefore ... attention to them needs to be incorporated into scientific and medical research. ("Blood and Stories" 305-6). The stories genomicists tell are not just about their work: they narrate the processes of life itself,

for example, how *Homo sapiens* disseminated over the continents. Wald argues that the narratives provided by genomics and population genetics should not be taken at face value, since there are many possible narratives based on genetic information. Moreover, these biological narratives ought to be understood in the social context where they emerge—they necessarily merge with other narratives ("What's in a Cell?"). Starting from Wald's assumptions, I want to show that Venter's stories about science and about life are suitable for tracing nomadic potentials in genomics. We may then raise the question whether, or to what extent, his adventures are instances of nomad science, or rather expressions of the new flexibility of control science.

In his autobiography *A Life Decoded: My Genome: My Life*, published in 2007, Venter recounts his converging personal, scientific and entrepreneurial struggles and successes. The main text is interspersed by text-boxes in which Venter reflects on his own personal traits in genomic terms, producing what he calls a "genetic autobiography" (7). Even though many of these text-boxes stress that there is still a lot to be learned about the actual meaning of genomic information, and despite Venter's reference to new perspectives in areas such as epigenetics (332), the provocative formula of his autobiography reinforces the image of life as a genetic "book" that can be read but also (re)written. Venter's autobiography is a strong testament to what Zwart has called "a bioinformatization of the life-world": "Genomics-based technologies have begun to pervade our daily lives, our autobiographies and narratives, as well as our anthropologies, rather than our genomes as such" ("Genomics" 135).

In the following I will limit myself to some of Venter's descriptions of his major scientific achievements. In 1999, when the HGP was already nearing completion, Venter established his own research institute Celera genomics, competing with the state-funded genome sequencing efforts. Using his newly developed "shot-gun sequencing" method, Venter wanted to show that the instruments of the official HGP, funded by the US government, were too cumbersome and therefore too slow. His philosophy was that the map of the human genome should be a resource available to everyone, not the exclusive possession of the state or of corporations (*A Life* 260). Venter was struggling on two frontiers as it were. On the one hand, against William Haseltine (representing big business), he was fighting for his integrity and that of his team because he had promised to make the human genome publicly available (260). On the other hand, John Sulston of the Wellcome trust accused him of leaning too much towards privatization of the human genome (which is why Venter could not publish the results in *Nature* and had to opt for *Science* instead). A major incentive for writing this book seems to have been to strike back at his scientific adversaries (John Sulston, James Watson, Francis Collins, and Eric Lander, among others) who accused Venter of turning life science into a business rather than a joint effort for the common good. These struggles indicate how State science and control science vie for dominance, each mode offering different versions of what counts as the common good. The camp of Sulston, Watson and Collins, representing State science, wanted to keep the HGP centrally organized in order to make sure that it would benefit everyone, while control science, represented by Venter, opportunistically explored new possibilities, decentralizing and speeding up the project.

After the publication of the human genome in *Science*, which indicated that much more than the genome sequence alone was needed to understand life and develop new therapies, Venter decided that genomics needed to take up the challenge of the newly discovered com-

plexity of life. Venter literally embarked on a new adventure on his sailing boat *Sorcerer II* which took him and his team across the Atlantic and Pacific oceans to map “the genome of the ocean itself” (343). Every hundred knots his crew took water samples which were then stored in freezers and analyzed in his laboratories at the J. Craig Venter Institute, resulting in “four hundred newly discovered microbes and 6 million new genes, doubling the number then known to science” (346). Venter’s claims that the results of his expedition will contribute to a better grasp of oceanic and atmospheric “health,” to generating new biotechnologies that use microbes to generate clean fuel (334), and to methods for “engineering our sick atmosphere” (348). The *Sorcerer II* expedition took genomics out of the sphere of the human toward the natural environment that sustains human life.

In some respects, the Venter’s ocean expedition seems to illustrate perfectly a nomadic approach to genomics. In *A Life Decoded*, Venter presents himself as a *free* scientist with a passion for life, rather than a scientist working for the State or for a corporation. Zwart has argued that Venter’s “aquatic” desire for adventure can be opposed to the “territorial” style of his scientific adversary Francis Collins:

Mapping the earth is a practice that is part of strategies of colonisation and annexation, establishing firm governance on *terra firma*. It is an effort to transform the diffuse and unknown into something discrete and accessible, and therefore governable... The sea has always been associated with freedom of movement, with migrating beyond the spheres of action of established rulers ... Whereas Collins identified himself as a “trusted aid” in service of a governmental programme, Venter’s work has always had a rather different moral profile, that of embarking and setting sail to places where one is left to one’s own devices ... discovering new worlds, breaking away from entrenched positions. (*On Decoding*)

Indeed, Venter’s independence and mobility, most significantly his ventures into ocean life, can be regarded as tenets of nomad science *par excellence*. The water samples, each containing thousands of microorganisms, contain great complexity, a “milieu” of life rather than merely the genomic data. The same possibility is found in research fields like metagenomics and ecogenomics, which work with soil samples that hold information about ecosystems rather than single organisms.⁶ But does Venter’s work aim at understanding ocean life as a multiplicity in becoming? Does the smooth space of the ocean propel him to adopt more nomadic scientific practices and ideas? More concretely, are Venter’s unorthodox manners reflected in alternative views that problematize the idea of the genome as the control center and essence of life?

In a more recent scientific saga in which Venter stars, the potential of genomics is actualized in the form of a procedure and a research object that, I argue, unequivocally defies life as multiplicity. Venter has been engaged in various projects aimed at creating “synthetic life,” for example, by “transplanting the genome of one bacterium in another, marking the first example of species transmutation” (356). Whereas the objective is to create new life forms that may help make the planet healthier, there is a deeper scientific desire that animates Venter’s project of artificial life: “I want to take us far from the shore and into unknown waters, to a new phase of evolution, to the day when one DNA-based species can sit down at a computer to design another. I plan

to show that we understand the software of life by creating true artificial life” (357). It is striking how among Venter’s quotations of famous scientists like Watson, Schrödinger and Pasteur, Darwin is quoted by far the most in *A Life Decoded*. However, Venter’s ambition, it seems, is not just to rival Darwin: inaugurating a new era of the artificial transmutation of species is clearly not just a paradigm shift and a world-historical event—it constitutes an evolutionary leap.

Venter’s recent projects highlight a cybernetic view of life first developed by thinkers such as Norbert Wiener, Erwin Schrödinger and Richard Feynman.⁷ In a 2012 lecture entitled “What is Life? A Twenty-First Century Perspective,” given on the occasion of the seventieth anniversary of Schrödinger’s classic study *What is Life?*, Venter looks back in history to argue that his work is “consistent with Schrödinger’s code-script,” thus suggesting that the information-turn in biology was a crucial one in the search for the essence of life. Venter argues that the synthesis of new genomes and their successful transplantation into cells is proof of the idea that “life is based on DNA software; we’re a DNA software system. You change the DNA software, you change the species. It’s a remarkably simple concept, remarkably complex in its execution.” Venter ends his lecture with a spectacular image of the not-too-distant future:

Try to imagine 70 years from now in the year 2082 what will be happening. With the success of private space flight, the moon and Mars will be clearly colonized. New life forms for food or energy production or for new medicines will be sent as digital information to be converted back into life forms in the 4.3 to 21 minutes that it takes for a digital wave to go from earth to Mars. (*What is Life?*)

It is unclear what Venter’s scenario of the digitalization of life, which, he keeps repeating throughout his lecture, is so “remarkably simple,” promises for the future. In any case, it is consistent with a tradition of “command-and-control” cybernetics⁸, and with the transition to bioinformatic biopower described by Cooper, Kay, Zwart and others, with its belief in the economy and in technoscience to regenerate wealth ad infinitum. If a virtually endless assortment of bio-objects can be designed on a computer and engineered using a “minimal genome” as basic tool kit (Venter, *A Life* 354), then, in Judith Roof’s words, “DNA, a small operative molecule, becomes the twirling model of an imaginary of self-replicating wealth” (209).⁹

My point is not merely to criticize the “program” metaphor as a feat of biological determinism. Rather, I would like to point out that, as Haraway has shown more than three decades ago, there are multiple metaphors, and clusters of metaphors, for life at work in twentieth-century biology, for example the “organicist” metaphors of fields, liquid crystals and fabrics in developmental biology (*Crystals*). As Haraway demonstrates, these metaphors challenge the reductionist or determinist tendencies in genetics (and, to extrapolate her argument to the present, in genomics), bringing to light what biologist Paul Weiss termed a “molecular ecology” of the cell (183) as well as exposing analogies between the organization of “molecular populations, the cell, the whole organism, and the ecosystem” (205).¹⁰ As I will demonstrate below with reference to the work of biologist Lynn Margulis and evolutionary psychologist Susan Oyama, metaphors that are able to connect different levels and scales without reverting to reductionism seem more likely to correspond to nomad science.

Through innovative research methods, pioneering projects, entrepreneurial audacity and a planetary vision, Venter indeed brings about a degree of deterritorialization of State science, making it more flexible and adaptive. Venter's exploration of "unknown waters" undoubtedly yields new possibilities for understanding and modifying life. At the same time, Venter's projects reterritorialize on corporate profit and personal gain.¹¹ But what is really significant, is that the foundations of a molecular biology based on cybernetic models of control remain firmly in place. Venter's "shotgun sequencing of the oceans" (*A Life* 334) seems more of a planned effort at containment than a nomadic adventure: it literally freezes that which was fluid, forcing life into a reductionist model where it becomes intelligent software "building its own hardware" (*What is Life*). In Venter's reductionist discourse, the story of science becomes a molecular puzzle in which technical obstacles are gradually overcome until, finally, life's secrets are revealed and the genome becomes an infinite source of reproducible solutions. I would argue that nomad science, instead, puts itself genuinely at risk by immersing into an ocean of problems that are not man-made, much in the way that Manuel Delanda describes the practice of making "intensive maps":

What need to be mapped in this case are not the borders of entities possessing a spatial organization, like the boundaries of an ocean, a lake, or another body of water, but *thresholds of intensity causing spontaneous transformations* in the spatial organization of those bodies. (*History* 121)

Such a search for critical "thresholds" imply a differential spatio-temporal topology, not a neutral reservoir from which an essence, in Venter's case a "genome of the ocean," can be extracted. Instead of reducing ocean life twice—first to DNA and then to digital codes—a true exploration of the ocean's complexity would produce rich developmental and evolutionary stories featuring a myriad of species (including humans), cells, genomes, technologies, the elements, weather, and so on. Since humans, and scientists in particular, are part of the experiment, they too may be transformed in unpredictable ways.

THINKING A LIFE

As the case of Venter illustrates, (post-)genomics has nomadic aspects—searching for complexity and exploring prospects for new life—but these aspects are not sufficiently fleshed out to turn genomics into a genuine nomad science. In spite of the apparent scientific defeat of genetic determinism, science still operates within the dimensions of a "molecular paradigm," a general inclination in biology to reduce life to the workings of small parts that can be reproduced digitally as well as analogically (Neumann-Held and Rehmann-Sutter 3). Scientific efforts such as Venter's, aimed at reproducing and mastering life, may lead to impressive results and stories, but not, as Venter claims, to a capacious understanding of what life is. Venter's case shows that whereas (post-)genomics claims to be a multifaceted, non-deterministic line of research, it may still regard the genome as a "center" from which life is produced, thus swapping genetic determinism for genomic determinism. Some argue that, in fact, much research in genomics

still tends to treat the environment as a purely secondary, exterior "condition," a source of perturbations that has to be distinguished from a true genomic cause (Hoffmeyer 156; Ulrich 138).

Is a nomadic mode of molecular biology at all possible? As Maureen O'Malley and John Dupré argue, a true transformation in (post-)genomics "from a dissection of things to the dynamics of processes" (1270) requires a genuine effort to think through the idea of a biological *system*, which in turn hinges on "demonstrations that the behaviour of single components cannot be understood simply in terms of their intrinsic properties, but must be seen as simultaneously determined by features of the systems of which they are part" (1274). Some of the most convincing proposals for such an approach in postgenomics come from biologists and philosophers working together. In a paper entitled "Genes in the Postgenomic Era," biophilosopher Paul Griffiths and biologist Karola Stotz argue that if genes are currently defined by "the way DNA sequences are used in particular cellular and broader contexts, and not merely by their structure," then, strictly, genomics should also embrace the idea that "phenotypes are not simply expressions of genetic information but rather emerge from a 'developmental system'" (Griffiths and Stotz 515-16). In order to add more conceptual grounding to this systemic approach, I will now turn to Deleuze's biophilosophy, whose emphasis on connectivity and processuality strongly resonates with approaches in contemporary bioscience such as the above (Ansell-Pearson, *Germinal*; Grosz, *Becoming*; Marks, *Gilles*; Parisi, *Abstract*).

For Deleuze, if we want to understand specific differences, for example between biological species, we cannot simply presuppose the identity of these species. Organisms and species are the results of repetitions of differences across scales, including the molecular and the territorial, not the execution of a pre-existing *Bauplan* (Williams 11-12).¹² In *Difference and Repetition*, Deleuze looks to the field of embryology to develop this idea. An embryo is complex, "vague" body in a continuous process of transformation: it is a body that cannot be divided in distinct parts and whose developments are continuous, i.e. irreducible to a linear succession of phases. Rather than treating embryology as a special case at the margins of biology, Deleuze takes it as a starting point for the question of life, thus prefiguring a move in biology "from linear causal chains to non-linear dynamics" (Rose and Caduff 330).¹³ Even mature bodies are but coagulations or decelerations of life as intensive movement. This leads to a point that is perhaps counter-intuitive: the embryo and its intensive processes are ontologically prior to species and organs. This means that it is inaccurate to say that the embryo constructs itself according to a pre-existent set of instructions along the lines of "become a fish, form gills." Embryogenesis is the ontological problem-field (or, in Deleuze's terminology, the "Idea") in relation to which species and organs develop as solutions or reified categories. The individuation of intensities precedes their differentiation as species and organs (308-9). According to Deleuze, this primacy of intensities (or in-dividuals: entities that cannot be divided into parts) is also seen on the level of phylogeny:

A living being is not only defined genetically, by the dynamisms which determine its internal milieu, but also ecologically, by the external movements which preside over its distribution within an extensity. A kinetics of population adjoins, without resembling, the kinetics of the egg; a geographic process of isolation may be no less formative of species than internal genetic variations, and sometimes precedes the latter. (269)

Whereas the ordeals of the fetus testify to an “unlivable life” that remains hidden within the organism, the vicissitudes of populations bear witness to a fundamental openness of organisms to their surroundings and the “formative” (i.e., constructive) role of ecological connections. Like the embryo, the intermingling of diverse populations is a non-metric, topological phenomenon: population is a vague essence ontologically prior to the reified category of species.

The image of a creative and connective life is elaborated in *A Thousand Plateaus*. Here Deleuze and Guattari typify the dominant (neo-)Darwinian story of life as “arborescent” (tree-like) because it assumes a branching out from the one to the many, from sameness to difference, from the primitive to the complex. Discarding the image of life as linear transmission or reproduction, Deleuze and Guattari replace the arborescent model with a “rhizomatic” one. In biology, a rhizome is a network of plant-roots that overgrow and connect to one another in the soil in such a way that it becomes hard to determine where one plant ends and the other begins. Plants that may be easily identified above the ground appear to be local and temporary manifestations of a much more complex rhizomatic process. The connectivity and dynamic becoming of a rhizome, according to Deleuze and Guattari, offer a model that is generally applicable to all life. For example, while humans and other animals can be distinguished as separate species, they are fundamentally connected through symbiotic relations on the molecular level:

Under certain conditions, a virus can connect to germ cells and transmit itself as the cellular gene of a complex species: moreover, it can take flight, move into the cells of an entirely different species, but not without bringing with it “genetic information” from the first host ... We form a rhizome with our viruses or rather our viruses cause us to form a rhizome with other animals. (11)

Here Deleuze and Guattari suggest that, while contagion is commonly envisioned as something negative, threatening the life of the organism, from the perspective of evolution viral contamination can be a way of renewing life. In fact, for Deleuze and Guattari, real variation or difference is largely created on the level of the rhizome; the incredible diversity found in nature cannot be understood by the essentially conservative processes of random mutation and natural selection alone (Ansell-Pearson).¹⁴

From the perspective of Deleuzian biophilosophy, a fundamental challenge for (post-) genomics and molecular biology in general is to confront the question of life beyond the theoretical apparatus of that establishes the genome as a *center* of analysis. As Deleuze phrases it in his last work, *Immanence: Essays on A Life*, the challenge is to think life as “a life” that cannot be ascribed to this or that individual entity (organism, cell) or cause (genes, natural selection):

A life is everywhere, in all the moments that a given living subject goes through and that are measured by given lived objects: an immanent life carrying with it the events or singularities that are merely actualized in subjects and objects. This indefinite life itself does not have moments, close as they may be to one another, but only between-times, between-moments. (29)

It is here that Venter’s image of life as a “DNA software system” becomes most vulnerable to philosophical critique. Venter’s claim that life can be (re)produced from the digital code is wrongheaded because genesis always happens on a plane of immanence, not on a plane that is already organized and controlled. Genetics and genomics are revolutionary in the sense that they intervene in rhizomatic processes on the molecular level (horizontal gene transfer), but the idea of *reproducing* life is illusory—how can one reproduce a becoming which is never actual? Life as becoming cannot be represented, recorded or reproduced, because, in Elizabeth Grosz’s words, it is “not a capacity inherited by life, an evolutionary outcome or consequence, but the very principle of matter itself, with its possibilities of linkage with the living, with its possibilities of mutual transformation” (*Becoming* 52).

Deleuze’s approach to life as connective and processual, partially derived from embryology and the idea of the rhizome, resonates strongly with contemporary alternatives to the molecular paradigm in biology. A first example is provided by evolutionary biologist Lynn Margulis’s theory of endosymbiotic evolution, a critique of and alternative to genocentrism as well as neo-Darwinism. Neo-Darwinism reconciles Darwin’s ideas with the molecular paradigm in contemporary biology, stating that evolution (the production of biological novelty) occurs through the gradual accumulation of random DNA mutations subject to natural selection. In *Acquiring Genomes*, co-written with her son Dorion Sagan, Margulis argues that the genesis of new forms out of existing ones cannot be explained by examining species in isolation: “Animal evolution resembles the evolution of machines, where typewriters and televisionlike screens integrate to form lap tops, and internal combustion engines and carriages merge to form automobiles. The principle always stays the same: well-honed parts integrate into startling new wholes” (172). Margulis’s work examines the ways in which symbiotic relations between animals, for example bacteria living in the guts of mammals, are often useful, thus offering counterweight to the dominant idea of a *competition* between species. Radical transformation of species is simply unthinkable in neo-Darwinism, which is overly preoccupied with linear genetic transmission from generation to generation and thereby “misses the symbiotic forest for the genetic trees” (201). Margulis’s work on symbiosis as a generative process resonates strongly with Deleuze and Guattari’s adoption of the rhizome, and instantiates elements of nomad science. Rather than taking the gene or the organism as centers of analysis, Margulis starts from highly fluid *relations*, which allow her to explain the variety of forms and the potential of becoming in nature. The fact that a tree can offer food and shelter for a great number of species is an instance of life’s tendency to “literally incorporate more and more of its environment into itself” (“Welcome” 81). In place of a distinction between genetic causes and phenotypic effects, genome and environment, what emerges is a topological space in which everything is connected. Margulis’s theory of endosymbiogenesis has by now been accepted by the scientific community as an additional model of evolutionary change, but not, as Margulis proposes, a more significant model than the classical one.

A second example is the work of evolutionary psychologist Susan Oyama. Her Developmental Systems Theory, first formulated in the *Ontogeny of Information* (1985), articulates the idea that biological life must be approached as a set of interlocking systems that are continually constructed. The title of Oyama’s book is meant to suggest that the idea of information

as pre-programmed in the genes is a faulty one: information “neither preexists its operations nor arises from random disorder” (3). Oyama intends to remove the focus in biology from a bottom-up molecular approach to a multi-scalar systemic one. The genome is displaced, but only in order to purge its transcendental status as an “unmoved mover”; it remains a crucial factor in the developmental system (*The Ontogeny* 156). Oyama’s idea that nature is nothing other than the development of forms (phenotype) effectuates a move towards immanence: “Seeing natures as developmental products, and thus as phenotypic rather than genotypic, turns us away from the search for transcendent reality and back to the processes and products of development” (*Evolution’s Eye* 66). Oyama refuses to regard genes and environments as limitations on what a body can do; rather these are entities that emerge as parts of developmental systems. As Oyama argues, there is no opposition between nature and nurture, biology and history or genes and environment, where the first denotes something internal, determined and constraining and the other something external, contingent and developing: “Like potentials, constraints are most usefully conceptualized as relational, not ‘endogenous,’ and as emerging in processes, not as prior to them. Possibilities for change evolve; they are generated in interaction. To oppose necessity (physical, biological, or developmental) to history, then, is to misrepresent both” (89). Oyama’s stress on system, process, and immanence is strikingly close with Deleuze’s understanding of nature as a series of *ontological problems* (Delanda)—how to grow, sustain, multiply, transform, and so on.

Margulis and Oyama’s work testifies to Deleuze’s ideas that life is not determined by essences but by relations and becomings, which do not belong to organisms but subsume them (*A Thousand* 263). This scientific and philosophical position may serve as an antidote against presentism (“let’s stick to the here and now and be realistic”) as well as against the sort of speculative claims such as Venter’s that mechanistically project a future world of our own making. Margulis and Oyama rethink life in ways far more imaginative than the Human Genome Project could ever have achieved. Putting the very axioms of modern biology into question, they have met with great adversity in their professional lives. Yet for all its boldness, there is a humbling quality to the work of Margulis and Oyama, placing humans within this dynamic field of relations rather than at the top of the pecking order. They differ in that respect from the (predominantly male) celebrity scientists in the field of genomics like Francis Crick, James Watson and Craig Venter, who claim to have found the essence of life in DNA. If science, like literature, creates stories about life, stories in which science itself appears as a character (Wald “Blood and Stories”), then the figure-heads of genomics narcissistically allow themselves a far greater role in these stories. As several feminist scholars have argued, women are able to make a difference in science by resisting the climate of aggressive competition, fostering cooperative and caring attitudes not just toward one another but also toward (living) research objects and the world at large (Fox Keller, *A Feeling*; Mol; Plumwood). There seems to be a significant overlap between the work of female (and sometimes feminist) scientists working in the margins of science, emphasizing humility and togetherness, and the phenomenon of nomad science, an overlap that will be further explored in the chapters that follow and addressed explicitly in Chapter 7.

CONCLUSION

How can (post-)genomics, having moved from genome mapping to the study of bi-directional cellular processes, deepen its commitment to complexity, meaning its biological, scientific and social “outsides”? How can nomadically inclined scientists connect to the molecular paradigm to insert more complexity, without relinquishing their relative independence? These epistemologically and politically difficult challenges need to be addressed because our understanding of the biosphere, and our ability to intervene in it, I argue, depend on interdisciplinarity. The whole spectrum of sciences is needed to curtail and modulate anthropogenic transformations of the biosphere in order to prevent humanity from destroying significant parts of it, including itself. Humans’ exceptional abilities to affect their environments should be deployed in responsible ways, that is, based on a long-term, co-evolution perspective on life on Earth and perhaps even beyond. Interdisciplinarity also includes the social sciences and the Humanities, because social, technological and cultural processes are crucial in co-evolution (Jablonka; Sagan and Margulis, “Welcome”). But interdisciplinarity goes further: literature and art can let the biophysical aspects of human existence rise from the background (Kaiser, “Poésie”; Lambert; Thiele), enmeshing them with sociality, psychology, and culture, thus imagining, in Deleuze and Guattari’s words, “a new earth and people that do not yet exist” (*What is Philosophy* 108).

As I hope to have showed, Deleuze’s work, including his texts co-written with Guattari, offers scientists and scholars useful tools to understand the interaction between dominant and submerged perspectives on life, and offer potential routes to further develop nomadic ideas. The nomad-State science pair, complemented by control science, serves as a means for bringing more (bio)political analysis into science studies. Moreover, Deleuze’s elucidation, critical interrogation and recombination of ideas in biology can help to bring multiple branches of the (bio)sciences and the humanities closer together. In spite of scientific skepticism about philosophy¹⁵, we can observe unprecedented opportunities for such a joint-venture: genomics and other fields in the biosciences are devoting significant portions of their budgets to addressing the societal impact of their work. An important step to take in moving toward *nomadic* interdisciplinarity—a readiness to transform in the encounter with other disciplines. For science studies, nomadic interdisciplinarity implies not just engaging with social implications of science, but also with the ideas about life itself that science is investigating (Stotz and Griffiths 38). Paradoxically, it is through critically re-examining the fundamentals of biology that science becomes most thoroughly open to the concerns of society. Another paradox is that this engagement with fundamental ideas, practices, attitudes, and desires of science is perhaps best facilitated by genres that are *quasi*-scientific: popular science and sf. The following chapters will further explore the potentials for nomad science in contemporary biology through these genres. The thrust of these stories is not to predict or determine the future of science and humanity, but to create the conditions for another science in which humans are pictured not as masters but as participants.

PART 2

TABLES OF TRANSMUTATION

– 4 –

**INFECTED GENOMES:
SYMBIOGENESIS IN GREG BEAR'S
DARWIN'S RADIO**

We may be vessels, large ships, unwitting sanctuaries to the thriving communities comprising us. When they are starved, cramped, or stimulated we have inchoate feelings. Perhaps we should get to know ourselves better.

– Lynn Margulis and Dorion Sagan –

INTRODUCTION

In Greg Bear's *Darwin's Radio* (*DR*), the activation of a retrovirus in the human genome, ominously named SHEVA¹, causes anomalous and extreme symptoms in pregnant women all over the world, including miscarriages and a leathery facial skin. When the seemingly disparate discoveries of genomicist Kay Lang and archaeologist Mitch Rafelson are combined, a spectacular diagnosis materializes: rather than a regular disease, SHEVA is the trigger for a sudden and rapid metamorphosis of the human species. Partly inspired by Margulis's theory of symbiogenesis, describing how interspecies relations can lead to the emergence of new species, *DR* experimentally turns evolution into a dramatic, historical, even political event (Turner, "Open-ended Stories"). The novel won a Nebula award and provoked a limited number of responses from cultural and literary critics, who mostly praise Bear's engagement with science (its sequel *Darwin's Children* [2003] was, in several ways, less successful and will not be discussed here).² Lisa Lynch has argued that *DR* engages in genre-critique in the sense that it relinquishes standard plots of

medical/techno-thrillers by US authors like Robin Cook, Dean Koontz and Richard Preston, which portray a predictable succession of events around an epidemic outbreak, with medical professionals and scientists representing unambiguous heroes protecting “the political and biological security of the United States” (72). While in these other novels biotech companies often display criminal and otherwise unethical behavior, *DR* deals with problems arising from legitimate activities—the merger of science, industry and politics. In *DR* the virus is not a clearly defined threat from the outside, but, as Mayer describes it, “an ambivalent thing, an in-between creature” that “effectively undermines the binaries of healthy/ill, good/bad, and harmless/dangerous” (8).

DR gives narrative form to three major ideas in Margulis's work on evolution (which later became popularized in her books written together with her son Dorion Sagan), first of all that “symbiotic leaps can, in a few generations, establish new species” (“The Transhumans” 98). Secondly, by making a retrovirus the trigger of sudden evolution, *DR* fleshes out Margulis and Sagan's point that “evolution is not progressive” (*Acquiring* 22). In place of Descartes's image of humans as rational, transcendental agents, Margulis and Sagan imagine human beings as utterly dependent on other organisms for their well-being. Moreover, humans may even be seen as mere “vessels” for communities of microorganisms (see the epigraph of this chapter). Finally what emerges in *DR* is Margulis and Sagan's image of the genome as a strange multiplicity connected to the outside, which provides an alternative to the determinist image in popular culture of the double helix as “essence,” and a provocation to molecular biology and neo-Darwinism. In portraying an event of evolutionary transformation that can only be explained by symbiotic relations, *DR* promotes a non-anthropocentric view of life, highlighting humanity's ecological dependency and transience. Bear, Margulis and Sagan contribute to turning evolutionary change into a *collective problem* in the broadest sense of the term. As I hope to demonstrate, a combined reading helps to get a fuller grip on Bear's literary experiment with evolution, while simultaneously *dramatizing* Margulis's scientific struggles.

In spite of the apparent influence of thinkers like Margulis and Sagan, Lynch has argued that Bear's novel presents a biologically reductionist image of life by coupling genomics with a near-religious “blind trust in evolution” (90). While immediately seeing the dangers of such reductionism, I want to demonstrate that SHEVA is not necessarily a biological “cause” that determines the course of events in the novel. Rather than being reductionist, *DR* can be regarded as a literary experiment with evolution. As sf critic Roger Luckhurst has argued, *DR*, and Bear's oeuvre as a whole, is an interesting resource for science studies, because it maps the complex networks in which science participates:

As Bruno Latour has done for science studies, so Bear's fiction offers the opportunity to trace the networks that connect together wildly diverse hard and soft things: laboratories, parliaments, machine intelligence, galaxies, bedrooms, spaceships, survivalists, mitochondrial DNA, American presidents, geologists, viruses, high tech start-up capitalists, the undead, the posthuman, and the alien. (“Catastrophism” 217)

In his work Bear consistently imagines “the end or catastrophic transformation of humanity” (218) without confining his experiments “in isolated laboratories or in arcane arguments

between experts” (227). In other words, the novum of SHEVA operates in an unstable, ongoing situation that resists control. As Luckhurst suggests, Bear's desire to get to grips with the complexity of human transformation in all of its biological, social, psychological, and spiritual dimensions, can itself be perceived not as a bid for total control but as a *generic contamination*, a “car-crash of sf, thriller, gothic, conspiracy fiction, and noir” (230). From this perspective, the problems worked out in *DR*—What caused SHEVA? What is it? What to do?—stem from an emergent *event* rather than from a determined cause or a set of genre-conventions.

Rather than forming a unified group expressing pre-programmed behavior, scientists play highly ambiguous roles vis-à-vis the formidable problem SHEVA represents. These different epistemological roles or attitudes can be analyzed along a distinction between *control science*, epitomized by a search for constants, precise measurements and solutions, and *nomad science* concerned with continuous variations, approximations and problematizations (*A Thousand* 398-418). In the novel, control science is exemplified by the (failed) development of a vaccine by the Centers of Disease Control (CDC) based on a genomic analysis of SHEVA. Meanwhile, the protagonists engage in a nomad science that patiently *follows* SHEVA's unfolding, pointing to the limitations of established theories, and pushing for alternatives. These nomads ask complex questions inciting them to introduce phenomena, experiences and ideas that others deem irrelevant or even nonsensical. In the following I analyze the scientific elements of *DR* and their biopolitical implications along the lines of control science and nomadism. As I will demonstrate, the various intuitive responses to SHEVA developed in *DR*, including brainstorm sessions, epiphanies and dream interpretations, are not naïve or unscientific methods, but serious attempts at following SHEVA as a problem-event, bringing out the evolutionary dimensions of contemporary global crises.

THE QUESTION OF VARIATION

The path towards understanding SHEVA crucially involves an encounter between two scientists whose stories alternate in the first part of the book. The first story covers the vicissitudes of evolutionary biologist and genetic engineer Kaye Lang, who has been working on the role of mitochondrial DNA (DNA of bacterial origin) in human evolutionary change. Kay's work suddenly becomes of great importance in the wake of the SHEVA outbreak when it turns out that the genes involved in SHEVA correspond exactly with the ones she has studied. A governmental task force endowed with the mission of creating a vaccine for SHEVA hires Kay for her expertise. Conducting research at various affected locations, Kay discovers that during the Twentieth Century, large numbers of pregnant, SHEVA-infected women around the world have been killed and buried in mass graves—ostensibly because their bizarre symptoms instilled fear and shame in their husbands and communities. For Kay, it is an injustice that the fetuses should die and that the SHEVA-infected women are treated as deviant individuals, or worse, as threats. Soon the discoveries in field and lab work force Kay to dissent from the official definition of SHEVA as a disease, describing it as an “evolutionary computer” (101) picking up and responding to environmental signals (hence the title, *Darwin's Radio*). Kay proposes that a mixture of overpopulation and information overload cause SHEVA to respond by sending

signals along human neurological and genetic pathways, setting in motion a radical species metamorphosis within the course of a strange double reproductive cycle.

The parallel story revolves around the archaeologist Mitch Rafelson who has been expelled from the scholarly community for his excavation of sites that were claimed by native Americans as sacred burial grounds. Tempted once again by the adventure, Mitch joins a friend on an expedition in the Austrian Alps where he stumbles upon two frozen Neanderthal mummies, a man and a woman. To his bafflement he discovers that the woman's uterus contains a fetus that is not Neanderthal, but Homo Sapiens. When Mitch hears Kaye speaking on television, he realizes that SHEVA may explain his discovery of an immediate evolutionary leap. With the help of some colleagues, Mitch finds scientific proof that the Homo Sapiens fetus is indeed SHEVA-infected. It is at this point, when the parallel stories merge, that the reader realizes that SHEVA is not just an ordinary disease, but an evolutionary signal that may change human destiny. Soon the two scientists meet in person to share their insights, and, as it happens, they fall in love.

Although much of the science in *DR* is accurate (Goldman), Bear has stated that the main function of the novel is to "provoke debate," to stimulate bioscientists to rethink evolution ("When Genes" 324).³ In a 2003 speech before the American Philosophical Society, Bear qualifies his speculations in *DR* as an attempt to reopen the question of what generates variation, a question that according to Bear has been carefully suppressed by scientists since Darwin. The dominant neo-Darwinist theory of evolution supposes that variations occur randomly in populations and that the beneficial ones are selected in each generation, bringing about a gradual transformation of the species. Bear stresses that there is a consistency to the production of variation that exceeds the relation between the blind processes of natural selection and natural drift. In his speech Bear explains that this consistency lies in a complex co-operation between living entities, rather than in mere selfish behavior:

Like genetics, evolution is not just one process, but a collaboration of many processes and techniques. And evolution is not entirely blind. Nor must evolution be directed by some outside or supernatural intelligence to generate the diversity and complexity we see. Astonishing creativity, we are discovering, can be explained by wonderfully complicated internal processes. These newer views on evolution involve learning and teamwork. Evolution is in large part about communication—comparing notes and swapping recipes, as it were. It appears that life has a creative memory, and knows when and how to use it. ("When Genes" 329)

While adhering to Darwin's main principles, Bear suggest that something more than just random mutation causes variation in species: speciation has a strategic function, it "jumps" at significant moments.⁴ Not only does the genome function as a kind of mind: it is connected to "an extensive, species-scale neural network that solves problems on a much vaster scale than science has ever anticipated" ("The New Biology"). But what causes these entangled minds to activate SHEVA? In *DR*, the "virus hunter" Christopher Dicken first speculates that SHEVA might have been triggered by the Chernobyl disaster (61), subsequently developing a more complex theory about SHEVA's activation involving urban overpopulation, deteriorating social conditions,

increasing stress, radiation and information overload (130-131). During his research with SHEVA patients, Dicken discovers that SHEVA only occurs in relatively steady heterosexual couples. Dicken suggests that, in accordance with Darwin's theory, SHEVA causes a "sexually transmitted disease, but a selective one" (130): the new children will be born in solid families, increasing their chances of survival.

Bear's ideas about "wonderfully complicated internal processes" recalls writer and journalist Arthur Koestler's evolutionary theory presented in *The Ghost in the Machine*, in which human evolution is depicted as a succession of different brains that grow over and overcode one another.⁵ According to Koestler, the human brain plays an important part in filtering and processing information from the environment, information that triggers particular adaptive responses in organisms and populations. As Koestler argues,

before a new mutation has the chance to be submitted to the Darwinian test for survival in the external environment, it must have passed the tests of internal selection for its physical, chemical and biological fitness. The concept of internal selection, of a hierarchy of controls which eliminate the consequences of harmful gene-mutations and coordinates the effects of useful mutations, is the missing link in orthodox theory between the "atoms" of heredity and the living stream of evolution. Without that link, neither of them make sense. There can be no doubt that random mutations do occur: they can be observed in the laboratory. There can be no doubt that Darwinian selection is a powerful force. But in between these two events, between the chemical changes in a gene and the appearance of the finished product as a newcomer on the evolutionary stage, there is a whole hierarchy of internal processes at work which impose strict limitations on the range of possible mutations and thus considerably reduce the importance of the chance factor. (133)

Reviving Lamarck's discredited theory of the heritability of newly acquired traits, Koestler's work is a very early challenge to the Modern Synthesis comprised in the 1950s after Watson and Crick's publication on the structure of DNA. In Bear's thought, the Koestlerian notion of intelligent evolution is manifested at the level of internal selection by a "genomic computer," but also at the level of a species-wide "neural network." If Bear's work is vitalistic, this is not the "old spooky vitalism," (104) as Kay calls it in *DR*, which summons an intelligent force *behind* evolution, but a vision in which life is the capacity to differ, the differential element of a set of systemic forces. Evolution, for Bear, is a creative process involving communications between organisms and ecosystems rather than an abstract process of natural selection acting on successful selfish behavior. In this sense, Stephen Dougherty's rather harsh assessment of *DR* as uncritically following bioinformatics's reduction of human beings to "mere conduits of information" (280) seems unwarranted.

DR is organized around a problem similar to Bear's earlier novel *Blood Music*: how to cope with a proliferating infection transforming humanity itself (see chapter 2). The main differences are that in *DR* the change occurs without human intervention, *from within* the human body, transforming humans in a viable way, leading to a new variation or species. In *DR*, the idea of an *infected genome* messes with the dominant image of the genome as a relatively stable

individual memory. The genome is revealed as hybrid and permeable, animated by mobile elements such as transposons.⁶ Consequently, it does not serve as a passive ground for a struggle between “good” characters trying to honor and protect it, and “bad” characters seeking to exploit it for selfish purposes. As Lynch has argued, what differentiates *DR* from medical thrillers like Richard Preston’s *The Cobra Event*, in which ecoterrorists cause a disease outbreak, is that finally in such novels “the crisis is contained: nothing much changes in the world the novel has described,” while *DR* leaves the reader “with a description of a world in the process of being remade” (75). Bear’s focus is not the intrigue associated with the thriller genre, but the inhuman processes of transmutation.

SYMBIOGENESIS

Although with its strong focus on genomics *DR* is one of the few examples of what could be called a “genomics novel”⁷ (Zwart, “Genomics Metaphors” 166), one of the most obvious resources for understanding the literary experiment conducted by Bear is the work of Margulis and Sagan. In the brief reading list offered in *DR*’s sequel *Darwin’s Children*, Bear acknowledges his indebtedness to Margulis and Sagan, whom he calls “the most stimulating popular writing team in modern biology” (490). Margulis is even attributed a minor role in *DR*. After having appeared on national TV to announce her discovery, Kay is called on the phone by “Lynn,” who congratulates her on her success (90). Kay compares her experiences specifically to the “criticism and injustice” experienced by both Darwin and Margulis during their careers. Indeed it makes sense to regard Margulis’s work as a recommencement and deepening of Darwin’s quest for understanding variation. Darwin’s work gave more credence to the idea, already proposed in the Eighteenth Century by his grandfather Erasmus Darwin and by other thinkers including Geoffroy Saint-Hillaire, that the species are not fixed, that there are all kinds of connections between them. While Darwin in his work demonstrated the diversity and malleability of species and argued that variations are selected through natural selection and sexual reproduction, he never really answered the question of what *produces* variations before they can be selected. “Origin of species” is an odd title, for it is precisely this question that is left unanswered. According to the Modern Synthesis, the lacuna in the evolutionary puzzle was solved in the early Twentieth Century with the discovery of Mendel’s work and the birth of genetics. Margulis and Sagan try to demonstrate that this has been an invalid assumption.

In a series of articles and books written from the late 1960s onwards, Margulis demonstrated that mitochondrial DNA, which comprises approximately two-third of all human DNA, is of viral origin: we are populated by strange visitors, and have been all along. In fact, speciation in general is the result of long-term symbiotic relations between different organisms that combine their genetic material to create wholly new species, a process she calls endosymbiosis.⁸ SHEVA might well be a product of such a long-term symbiotic relationship. In the popular scientific book *Acquiring Genomes: A Theory of The Origins of Species* (2002), written together with her son the philosopher Dorion Sagan, Margulis argues that there has been a fundamental misunderstanding about the work of Darwin in the dominant paradigm of neo-Darwinism. Margulis and Sagan debunk the idea that male-female sexual intercourse has been central

in the evolution of life on earth. Hybridity, or the recombination of genetic material through mating, is an important element in the development of mammals, but not in plants or bacteria. Moreover, like Gould and Eldridge, Margulis and Sagan challenge the neo-Darwinian conception of evolution: “The reliance on accumulation of random mutations in DNA is not so much ‘wrong’ as oversimplified and incomplete: It misses the symbiotic forest for the genetic trees” (201). Although they recognize the role of random mutation, they state that these changes are “nearly always inconsequential or detrimental” and that their role has, in the past half-century, been “dogmatically overemphasized” (15). The authors wish to call into question a whole apparatus of terms in modern biology, beginning with the most influential ideas such as Richard Dawkins formulation of the “selfish gene”:

There is no life in a gene. There is no self. A gene never fits the minimal criterion of a self, of a living system. The time has come in serious biology to abandon words like competition, cooperation and selfish genes and replace them with meaningful terms such as metabolic modes (chemoautotrophy, photosynthesis), ecological relations (epibiont, pollinator), and measurable quantities (light, heat, mechanical force). So many current evolutionary metaphors are superficial dichotomizations that come from false clarities of language. They do not beget but preclude scientific understanding. (17)

Margulis’s theory of symbiogenesis regards life as a series of associations that cannot be reduced to “selfish genes or combative male mammals” (87). It is a theory about the association and potential fusion of materials that is neither incidental and random nor guided by transcendental goals; rather, development and evolution are immanent to life. If there is such a thing as an evolutionary “strategy,” then it has nothing to do with the metaphors mentioned above; in a Deleuzian vein, such a strategy is simply the name for a particular ecological situation, a set of entangled and embedded populations set in motion by tendencies or desires.

Margulis work on small-scale, miniature life evidently helps Bear to make humanity strange, to confuse subjectivity and objectivity. Countering molecular biology’s tendency to represent microorganisms exclusively as “disease agents or food contaminants” (95), Margulis and Sagan argue that “bacteria are exemplary genetic engineers: splicers and dicers and mergers of genomes par excellence. We people just borrow their native skills” (“All for One” 45). The dexterity and creativity of microorganisms that Margulis and Sagan admire so much is clearly reflected in a dream sequence in *DR* occurring after Kay has examined SHEVA-infected corpses found in mass-graves in the Republic of Georgia:

After hours she dozed off and dreamed of bacterial buildups inside the bodies within the trench graves. Biofilms, that most people thought of as slime: little industrious bacterial cities reducing these corpses, these once-living giant evolutionary offspring, back to their native materials. Lovely polysaccharide architectures being laid down within the interior channels, the gut and lungs, the heart and arteries and eyes and brain, the bacteria giving up their wild ways and becoming citified, recycling all; great garbage dump cities of bacteria, cheerfully ignorant of philosophy and history and the character of the dead hulks they now reclaimed. (41)

Rather than thinking about the people and the lives they lost, in her dream Kay loses herself in an inhuman world where microorganisms build environments and make livings, worlds that Margulis and Sagan have described in great detail.⁹ It is clear that none of the above is meant to be metaphorical. As we shall see below, in *DR*, dreaming becomes a revelatory moment in which the inhuman appears.

NOMAD VS. CONTROL SCIENCE

Scientific ideas in *DR* figure neither merely as metaphors nor as plain facts: they are vital ingredients of the narrative. Bear's novel is a potent example of the way in which literature is able to move beyond the critique (in the sense of external judgment) of scientific developments and ideas and *think along with* science about problems that exceed current understanding. Whereas most characters and groups in the novel are directed at controlling SHEVA, the main characters Kay and Mitch, along with a small group of friends and colleagues, take on the challenge of "following" SHEVA as an emergent, complex problem, and to remain open to any idea that will help to truly explain its workings. In the course of the novel, the protagonists discern how SHEVA works by putting together the pieces of a puzzle. The first symptoms occur when, strangely, large numbers of women around the globe have two subsequent miscarriages.¹⁰ Furthermore, in the course of their pregnancies, women develop strange pigmentation on their faces, as if they are wearing brown masks. Many women are afraid to report the unexplainable deformations, fearing that these will be interpreted as diabolical or punishments of God. The inexplicability of the symptoms leads to aggression and denial: SHEVA-infected women around the world are secluded, attacked or even killed. The obscurity of the "epidemic" makes it hard for investigators to map its development and dissemination. As the sequel *Darwin's Children* makes clear, even when SHEVA babies are finally born, the confusion is hardly solved: the children are widely perceived as deviant.

Coming to terms with species metamorphosis is problematic (for the writer and for the characters) because it never actually *happens* in the sense of an occurrence between two pinpointed moments: it is a largely imperceptible, emergent event. The intangibility and sheer terror of the idea of sudden transspeciation trigger a "black box" (Latour, *Science*) response: SHEVA must be decoded, solved, controlled, and this transformation of SHEVA into a fact (a pathogen) obscures its true history. Yet this response is challenged by the main characters who gradually begin to realize that the struggle with SHEVA's "symptoms" is doubled by a more complex story that is not about disease control, but about evolution. This tendency towards complexity can be theorized through Deleuze and Guattari's notion of nomad science. I will focus on two important tenets of nomad science: problematization and mobility.

In *DR*, nomad science and its diagnostic role are represented by the main characters, Kay and Mitch, who explore an emergent problem by grappling with its symptoms, while the Task force, representing control science, incessantly tries to control the problems, as well as to incorporate the scientists in their approach. The tensions caused by competing desires for mobility versus stability, problematization versus solution, are manifested throughout the novel. While the extreme symptoms related to SHEVA remain anomalous, the Task force nevertheless

decides somewhat haphazardly to capture them under the name "Herod's Flue," thus coupling the dramatic appearance and biblical proportions of the symptoms with degrees of familiarity and intelligibility that the government, the scientists and the general public are seeking. In anticipation of a vaccine, the primary instrument suggested by the Task force is abortion. Pregnant women come under enormous pressure to abort—those who do not co-operate risk forced abortion and social deprivation. Several women infected with Herod's flu are even murdered by their husbands. The disease itself becomes something of a funding asset: Mark Augustine, the head of the CDC, wonders whether SHEVA could be "something so horrible, so provocative, that funding for the CDC would be guaranteed to rise" (58-59).

Against this current of state and corporate interests as well as public opinion, Kay explains SHEVA as the activation of an evolutionary memory reacting to environmental pressures. Kay's epigenetic understanding of the SHEVA-induced mutations as creative responses to the outside raises many questions. As one scientist in *DR* asks, where is this evolutionary memory stored? How is it activated? These questions are not answered in the novel, but the contours of an answer become visible in Kay's treatment of human evolution as a complex system that suggests a far more intricate notion of heredity than does neo-Darwinism. The latter accords full agency to genes and organisms, whereas Kay in *DR* displaces individual agency in favor of a systemic view. In a meeting with Mitch and colleague Christopher Dickens, Kay tries to express her intuitive thoughts:

All individual creatures are networks of cells. All species are networks of individuals. All ecosystems are networks of species. All interact and communicate with one another to one degree or another, through competition, predation, cooperation. All these interactions are similar to neurotransmitters crossing synapses in the brain, or ants communicating in a colony. The colony changes its overall behavior based on ant interactions. So do we, based on how our neurons talk to each other. And so does all of nature, from top to bottom. It's all connected. (242)

Kay's view, resonating with contemporary visions of life as *network* in science and fiction¹¹, is in accordance with Deleuze and Guattari's concept of nomad science, first of all because it assumes a topological development which, when mapped a posteriori, does not lead back to a site of origin. Kay's desire is not for origins or control but for connection, contamination, and transformation. The genome, from this point of view, is not a discrete cause of the organism's phenotype but one of the elements of development and evolution. Kay's theory meets with strong resistance from other members of the Task force, not predominantly for its lack of scientific evidence, but in fear that, true or not, neither politicians nor the wider public will accept it. As Mark Augustine suggests to the Task force board: "Let's go with what's solid ... SHEVA is Herod's. It causes gross birth defects and miscarriages" (133). The potential for nomadic fluidity is denied by a top-down decision to go for "what's solid."

After a series of heated discussions with the board, Kay resigns from the Task force and continues her work as a nomad scientist travelling through the country together with Mitch, gathering ideas and forging alliances with other scientists and journalists. They believe so ve-

hemently in Kay's theory that they decide to conceive a child, even though no children have been born since the SHEVA outbreak. Kay perceives their decision as an act of science: "I once worried that work and family wouldn't fit together. Now, there's no conflict. I am my own laboratory." (357). The act of proving her theory through self-experimentation, blurring all boundaries between private and public, science and life, can be seen as an ultimate act of nomad science. Kay's decision is not a narcissistic or selfish one, aimed at establishing her name as a scientist, a pioneer, or something the like, but an unselfish immersion into a larger evolutionary story she cannot predict. Kay's nomadic following of SHEVA's unfolding is an open-ended experiment—risky, yet thought-through and conducted carefully.

Alongside her *in vivo* experiment, Kay continues her thought-experiments, often conducted together with her colleagues and with her colleague-husband Mitch, leading her to the concept of "emergent properties" that has become commonplace in contemporary fields such as complexity theory. As Manuel Delanda explains, an individual body cannot be reduced to the sum of its parts; what matters is a certain capacity inherent in this body to generate new properties (*Intensive* 72). Somewhere toward the middle of *DR*, Kay tries to convince Mitch of the idea that evolution is not the property of a given species, hidden in the genome as it were, but belongs to a complex ecological system "with emergent thought-like properties" (242). Even in Mitch, who is generally supportive of her theories, her efforts at explanation evoke resistance:

Mitch shook his head. "Emergent properties confuse me." Kay glared at him for a moment, both challenged and exasperated. "We don't have to posit self-awareness, conscious thought, to have an organized network that responds to its environment and issues judgments about what its individual nodes should look like," Kay said. "Still sounds like the ghost in the machine to me," Mitch said, making a sour face. (242)

Referring to Koestler's controversial work *The Ghost in the Machine* (1967), Mitch questions the scientific solidity of Kay's thoughts. Kay, in turn, tries to defend herself, to attain credibility, by placing her ideas against Lamarck's theory of the inheritance of acquired traits ("Is this Lamarckian evolutionary theory? No!" [242]).¹² This conversation is exemplary for the ways in which thought-experiments and brain-storm sessions—scientific practices that have a tendency to go nomadic—clash with control science's presumption of discrete, locatable causes. It is as if the Task force even blocks nomadic thought after Kay has resigned from it: the tendency to control has been partially internalized.

MOLAR AND MOLECULAR BIOPOLITICS

While in his work Bear is often concerned with biopolitical issues such as bioterrorism (*Quantic* [2005]) and new military technologies (*Mariposa* [2009]), *DR* is unique in the sense of sketching a global biopolitical scenario in which not just people's health and security are at stake, but the very integrity of human bodies and populations. Bear's novel engages a number of biopolitical issues: what are the roles of men and women in the dissemination of the virus? Who is entitled to diagnose the symptoms and what alternatives do SHEVA-infected women have?

In the attempt to control the outbreak, whose health is being protected? What *kind* of health is this? What happens when disease turns into a criminalized or even militarized issue of national security?¹³ Through these questions, Bear's novel aggrandizes societal tensions and trends related to the biosciences, biomedicine and the governance of health and security—notably the molecularization, commercialization and globalization of health (Rose). Rather than trying to do justice to all relevant biopolitical aspects¹⁴, I will focus on the biopolitics of SHEVA as a scientific problem.

The political dynamics in the novel can be analyzed in analogy to the scientific processes in terms of a politics of control operating mainly through the CDC, the SHEVA Task Force, and pharmaceutical corporations (the "molar" level), and an almost invisible nomadic politics of individuals and loose alliances ("molecular" level).¹⁵ On the molar level, scientists, medical professionals, government officials, journalists, and patient groups treat SHEVA as an impingement on human health. Scientists, politicians and entrepreneurs claim to understand SHEVA in order to secure their positions and to meet the public demand for clarity. Head of the CDC Marc Augustine is concerned that the general public, in its ignorance, will go with a religious explanation and that "science will go right out the window" (*DR* 337). Patient groups accuse the government of withholding information and failing to protect SHEVA-infected people. Panic is raised in large parts of society, but the possibility of a steady human world is still prevalent. Lynch, who has analyzed these political processes in great detail, compares the cooperation and competition between corporate and government players in *DR* to the negotiations around the Human Genome Project (78-9). The key idea is indeed that SHEVA is framed as a problem in the genome that can be localized and "treated."

Meanwhile, nomad scientists problematize the situation rather than trying to solve it. When it becomes clear that Kaye's ideas about SHEVA are not just useless but antithetical to the goal of forging a vaccine, she is eliminated from the task force. Expelled by their academic communities, Mitch and Kaye straddle the borders of science and civil society, traveling around the country to prevent sequestering or quarantine, gathering information, creating theories and meeting many different people. They affirm the momentum that SHEVA presents, allowing themselves to change, while others try to contain SHEVA as a dangerous "thing" that has to be controlled. I see Kay and Mitch's nomadic approach to SHEVA as akin to what Beatriz da Costa and Kavita Philips have called "tactical biopolitics": a mode of artistic, scientific, activist and philosophical experimentation with life (xviii). The voices of renegade scientists subvert the capitalist and nationalist vestiges on the molar biopolitical plane, engaging in a molecular politics of contagion: through befriended colleagues and a curious journalist, news of their actions and ideas seep into scientific and political networks and even into the public media.

By the end of the novel, Mitch and Kaye have a child together—the first reported SHEVA child—and call it Stella Nova. They immediately notice that Stella has new bodily features, including the ability to speak from birth, a double tongue that enables her to utter two sentences at the same time, and the ability to emit odors that sooth humans around them. Kay suggests that these features will allow a new generation of humans to tackle problems associated with augmented population and information density (including stress). Stephen Dougherty has suggested that, for all of the complexity *DR* evokes, its jubilant denouement reinforces a rather conservative message:

In submitting ourselves to the genome ... we are merely following the true genius of the species; we are merely affirming the true principles of life and the deep biological structures that reflect them; and we are wisely assenting to the superior knowledge of technoscience. (281)

While seeing the rationale behind this reading, I want to stress that the fact that certain characters in *DR* interpret the genome as a program does not force the reader to understand the narrative, and evolution as such, as the execution of such a program. Although *DR*'s apex may strike some as unbelievable as well as unnecessarily conjuring a sense of vindication on behalf of the protagonists,¹⁶ the implications of Stella's birth are neither comforting nor clear. Rather than predetermining the narrative frame on the basis of scientific dogma or a moral take-home message, I would argue that Bear delivers an account of scientific exploration and human evolution without a clear cause or conclusion. If in the novel evolution becomes a biopolitical event, it is not because evolution comes under human control—quite the opposite: evolution brings about a situation that, ultimately, cannot be controlled.

PASSAGES OF INTUITION

DR contains many references to religion and spirituality that lend the event of species transmutation an almost messianic allure. As in the Biblical story, where Herod's politics fails to prevent Jesus' birth—and with it, the arrival of a new way of life that will contaminate not just the Middle-Eastern provinces but the Roman empire as such—the birth of Stella Nova is bound to inaugurate a new era of mankind. The Christian motif of redemption has prompted Lynch to criticize Bear for delivering a scenario based on “a blind trust in evolution” (90). According to Lynch, *DR* carries as its final message the “ultimate wisdom of the human genome,” and consequently, the novel “downplays the role played by social and political realities” (90). Furthermore, Lynch places the spiritual aspects of *DR* in *opposition* to the role of science. For her, the novel as such has a mystical bent, for it suggests that “Lang is not correct about SHEVA because she's a scientist: she is correct because she is intuitive and visionary, able to take the leap of faith necessary to see the grand design dictated by the human genome” (87). Similarly, Schell argues that in their spiritual zeal, *DR*'s protagonists naively “realize that they are nothing more than bodies expressing innate genetic propensities” (816). Lynch and Schell highlight some of the potential political effects of a novel that, albeit in a very complex and original way, turns evolution and science into mesmerizing spectacles of a quasi-spiritual nature, thus potentially distracting readers' attention from social aspects. They also stress that the ideas presented in the novel are intuitive explorations that may easily be misinterpreted by the lay reader as scientific facts. While sharing some of Lynch and Schell's concerns, I nonetheless want to argue that Bear's assumed “trust” in evolution need not represent a political or epistemological dead end. In my view, Lynch and Schell's critical reading of the spiritual elements in *DR* leads to an unnecessarily rigid separation of science and faith. Essentially, the kind of faith Bear communicates is not a dogmatic belief but an intuition articulated in hypotheses.

Bear's novel can be regarded as a move towards new modes of relating to the biological aspects of human existence, balancing the tendency towards control with an intuition of and rev-

erence for the ultimately unknowable complexity of life. While akin to the world of the spiritual, this attitude, expressed in what I will call “passages of intuition,” is also intrinsically part of science and politics. With “passages” I mean both literally the *text sequences* and the *trials of the characters* struggling to come to terms with transformation. Passages of intuition in Bear's novel include dreams, reveries, epiphanies, eureka moments, brain-storm sessions and passionate actions that recur throughout the novel as interludes. These are not flights away from the flow of events, but critical points within the topology of the novel, points at which hitherto separated elements connect, and the main characters move in unforeseen directions. A key example of such a critical point is when Kay brain-storms about SHEVA in the company of Mitch and Christopher:

This is so clear to me, guys. Why can't you see it? Here's the complete feedback loop: the environment changes, causing stress on organisms—in this case, on humans. The types of stress alter balances of stress-related chemicals in our bodies. The set-aside-memory reacts and movable elements shift based on an evolutionary algorithm established over millions, even billions of years. A genetic computer decides what might be the best phenotype for the new conditions that cause the stress. We see small changes in individuals as a result, prototypes, and if the stress levels are reduced, if the offspring are healthy and many, the changes are kept. But every now and then, when a problem in the environment is intractable ... long-term social stress in humans, for example ... there's a major shift. Endogenous retroviruses express, carry a signal, coordinate the activation of specific elements in the genetic memory storage. Voilà. Punctuation. (243-44)

Kay's critical insight comes to her appearing obvious, even necessary: as a revelation. At the same time, the dots in the above fragment illustrate the difficulty of expressing an idea that cannot be explained by existing paradigms. Passages like these constitute attempts to come to terms with SHEVA, not by representing it on the basis of a scientific methodology, but by trying to “approach” it intuitively, using imaginative terms that are necessarily vague (“set-aside memory,” “evolutionary algorithm,” “genetic computer,” and so on). If control science is intent on reaching a solution in a straight path, intuition takes a roundabout, nomadic route. This nomadic approach becomes quite outspoken when the main characters are no longer willing or able to place themselves at a distance from the problem of SHEVA and start to *embody* it. In a Deleuzo-Guattarian vein, to imagine SHEVA in this way does not mean to represent it from a distance, but rather to become (with) it through active, affective connection.

Mitch's medium of intuition is the dream. After his journey to the Alps, Mitch is haunted by dreams about Neanderthal men and women living in exile from their tribe, ostracized for their physiological deviances triggered by SHEVA, and eventually killed. Mitch draws an immediate connection between this imagined past and the uncertain present: “Perhaps this was the original sin of our kind, that our Neanderthal ancestors wished to stop progress, hold on to their unique position ... By killing the new children. Those who would become us. Now we do the same thing, perhaps?” (330-31). As dreams about the Neanderthals keep returning, Mitch begins to feel a strong affective relation to these ancestors, and develops a deep urge to fight for a people that does not yet exist.

Kay's intuitions of SHEVA rather take the form of epiphanies, moments when a "caller" suddenly becomes present to her, a caller that does not utter words but causes "waves of amazement, of child-like glee and adult consternation" (280). She takes the caller to be a divine entity that uses her as a medium to announce a new era, a ruthless yet "gracious" force that she claims has "shaped human history" (280). One day at work when the caller returns, Kay decides to have a colleague make a brain-scan to find out whether her experience has any neurological basis. Remarkably, her scan shows a significant overlap with the brain-scan of a SHEVA child. Despite the lack of a scientific explanation, this finding affirms her hypothesis and makes her realize "we were all virus children" (262).

The imaginative sequences each have their own levels of intensity. Mitch's dreams connect him to prehistory in uncanny ways, causing him to oscillate between past and present, dream and reality. Kay's epiphanies position her towards the future, producing in her a disconcerting yet strangely intimate feeling of vertigo, leaving no distinctions between science and spirituality, personal and collective. Mitch "recalls" what has essentially been forgotten—that humans were, and will be, another species—while Kay literally carries the future of humanity inside her body. I read these sequences not as flights from reality but as encounters with the problem represented by SHEVA, encounters that are inseparable from the characters' scientific adventures. These sequences testify to an essential aspect of nomad science: it throws scientists into problematic events they cannot control, events affecting every part of their lives. If these passages consist mostly of chance events and passions, they are not therefore chaotic. Rather, they follow a nomadic route, connecting hitherto separated areas of research and introducing scientific ideas that have not yet been accepted by the mainstream scientific community. Moreover, Mitch and Kay's passages of intuition lead to crucial decisions—first and foremost the decision to have a child.

Significantly, epiphany in *DR* is not merely "about" evolution—rather, it *constitutes an evolutionary signal*. In a short commentary entitled "Caveats" at the end of *Darwin's Children*, Bear interprets Kay's epiphany as follows:

As Kay experiences her epiphany, she is made aware that her caller is not talking just to her, but to other minds within and around her. Epiphany is not limited to our conscious minds, or even to human beings. Imagine epiphany that touches our subconscious, our other internal minds—the immune system—or that reaches beyond us to touch a forest, or an ocean ... or the vast and distributed "minds" of any ecological system. (476)

Bear's interpretation is highly speculative, but not unheard of in contemporary bioscience (Lipton).¹⁷ I read *DR* as an exercise in thinking societal turbulence at the turn of the 21st century in ecological and evolutionary terms. Bear's novel supports what biologists Scott Gilbert and Jan Sapp and philosopher Alfred Tauber call "a symbiotic view of life," a view that changes the classical definition of an immune system:

The "defensive" role of immunity, so prominent in the medical and agricultural contexts, must be balanced from evolutionary and ecological viewpoints. Immunity does not merely

guard the body against other hostile organisms in the environment; it also mediates the body's participation in a community of "others" that contribute to its welfare. (333)

This participation in "a community of others" is what makes the body sensitive to calls from the outside. Could it be that in times of upheaval, strong stress signals induce genetic transformations that are accompanied by emotionally intense experiences and imaginative ideas?

CONCLUSION

Every event in *DR*, from the scientific explorations in competing research consortia to the love between Kay and Mitch that leads to one of the first virus children, is part of the situation that SHEVA has triggered. However, as I have tried to show, SHEVA is not a biological "cause," but a bifurcation point in a chain of different processes. Far from a commodified "package," the novelty that Bear unleashes is an experimental, collaborative exercise involving a literary novum (SHEVA), scientific theories, biopolitical practices, and ethical responses. The narrative event of metamorphosis-through-contagion connects humans horizontally to other species and ecosystems, and vertically to the "genome time" (Clayton, "Genome") of its past and future becomings. While in Bear's novel the actions of characters and groups are crucial to the ways in which the central problem unfolds, there is also a movement away from characters' intentional and controlled actions, a suspension of "suspense" (in the sense of intrigue), a gesture of opening up to the "organic tendencies" that, as Margulis and Sagan contend in *Acquiring Genomes*, are the forebears of what we today call "conscious choice" (99).¹⁸ Exploring the inhuman processes of evolution, Bear proves Margulis and Sagan's point that "no whodunit could be more spellbinding than some of these cases of symbiogenesis" (xii).

In *DR* the dynamics of control and nomadism are played out in various ways: determinism vs. complexity, control vs. affirmation of change, critique vs. collaboration, secrecy vs. openness. Control science is intent on determining discrete causes, while nomad science, conversely, throws certainty into question by confronting a life capable of radical and momentous change. Nomad science follows and affirms the flows of life, not for personal gain but in and through collaboration. It navigates a world that is fluid and unpredictable, resisting habits, identities, established meanings and values associated with dominant epistemology. For nomad thought, the question is always: how much world can one include in one's map without falling into chaos? As the novel dramatically shows, the price to pay for intellectual overstretch is not just scientific incredulity, but impending mental and physical collapse and social exclusion. Dedicated to truth yet unfaithful to control science's entrenched ideas, nomad scientists in Bear's novel actively participate in a process of contamination—not to cause misery, but to reveal or bring about a transformation, to open up science to a different world. In Bear's novel, it is exactly the coupling of hitherto largely separated fields of research—archaeology, evolutionary biology and genomics—that provides the key to understanding a complex event. Serendipity, rather than protocolled experiment, plays a great role here: it is only when Kay and Mitch's knowledge coincidentally comes together that science becomes capable of seeing SHEVA in a larger evolutionary context.

This chapter shows that *DR*, for all of its provocative discourse about internal mechanisms of evolution, is not a work of biological determinism, but a literary demonstration of Margulis and Sagan's idea that health is "less a question of resistance to invasion from the outside and much more an issue of ecological relationships" (*Acquiring* 19). Indeed, as Stacy Alaimo has argued, *DR* "enacts a powerful posthuman environmental ethics, in which human bodies—from the prehistorical past through unknown futures—are inextricably connected with material worlds" (25). With SHEVA the environment "returns" as a delayed effect of symbiogenesis, altering humanity from within. At the same time, the presence and significance of the environment is left somewhat implicit in the novel. Being offered only scant speculations about the circumstances that may have triggered SHEVA, the reader is stuck with a somewhat abstract sense of "environment." In spite of Bear's allegiance to complexity, it is easy to read into *DR* a dichotomy between a dynamic "social environment" and a pre-programmed biological core. A key challenge of minor bio-sf, I concur, is to zoom in *and* out, capturing in narrative form Margulis and Sagan's suggestion that "we are composed of smaller selves, and we form parts of the more inclusive selves" ("The Uncut" 28). In the chapters that follow, the idea of "environment" multiplies and enters sf narrative in a more forceful way, making tangible the ecological, planetary and even cosmic nature of evolution.

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TRADING TRAITS:
SPECIES ENCOUNTERS
IN OCTAVIA BUTLER'S
LILITH'S BROOD

Unnatural participations or nuptials are the true Nature spanning the kingdoms of nature.

— Gilles Deleuze and Félix Guattari —

INTRODUCTION

Alien encounter, one of the most popular themes in sf since H.G. Wells's *War of the Worlds*, is paradigmatically undergirded by a telos of preserving human autonomy (Malmgren)¹, often amounting to warfare.² In a way, many of these stories are not really about encounter at all, but about *evading* encounter. Only rarely do sf authors develop stories of genuine human-alien contact in which humanity is allowed to transform. In what can be seen as a form of genre critique, Octavia Butler's sf trilogy *Lilith's Brood* (*LB*)³ starts off after an alien life form called Oankali has rescued humanity from a world that has become inhospitable to humans due to pollution and atomic warfare. The human survivors have been brought to an animate space ship where they stay in "suspended animation" while being studied. After a while, human survivors are awakened and placed in separate cells. Unfortunately, the moment that the Oankali present themselves and explain the situation, humans respond with disbelief, fear, panic and aggression.

When offered a choice to cooperate or to return to their inert state, humans consistently opt for the latter. After many of these trials, Lilith Iyapo, a middle-aged American anthropologist, is the first human who is successfully “conditioned.” Without offering an explanation, the Oankali declare to Lilith that they are desperately in need of “trading” their genes with humans—their own survival depends on it. They promise Lilith that together with a group of humans to be awakened by her, she will eventually be brought back to earth to establish a new civilization, one that is more durable than the previous. Later, when the experiment is in full swing, Lilith discovers the true goal of the trade: a long-lasting, symbiotic relationship resulting in a brood of human-Oankali hybrids.

LB recounts the evolving relations between humans, Oankali and their offspring, relations characterized by physical and emotional dependency and divergent philosophies of life. Afraid of losing their autonomy, most humans refuse to even listen to the Oankali; they become known as “resisters.” The Oankali, while insisting that the only viable future is a shared one, are unwilling to force humans to live with them. From the Oankali’s point of view, resistance against encounter and transformation is a genetic trait of the human species, a trait they label as “the human contradiction.” The Oankali maintain that the dominance of this trait is bound to lead to the extinction of the human species unless it is overcome through genetic trade. There is no easy way out of this paradoxical situation. When a character in the first book named Joseph suggests that the Oankali might as well engage in a trade with cloned humans, the Oankali Nikanj rejects this solution:

A partner must be biologically interesting, attractive to us, and you are fascinating. You are horror and beauty in rare combination. In a very real way, you’ve captured us, and we can’t escape. But you’re more than only the composition and the workings of your bodies. You are your personalities, your cultures. We’re interested in those too. That’s why we’ve saved as many of you as we could. (154)

As this statement demonstrates, for the Oankali, all is not in the genes: rather than a single procedure of genetic exchange, a successful trade must be achieved through multiple generations of human-Oankali life.

Scholars have analyzed *LB* as an allegory of relations among human “aliens,” notably racial tensions in the US and the Cold War (Jameson, *Archaeologies*; Peppers) and as a meditation on genetics and symbiosis (Clarke; Peppers). Stacy Alaimo has praised Butler for trying to forge an eco-centric narrative that takes the far-reaching possibilities of the biosciences seriously without relapsing into genetic determinism (“Cyborg”). Similarly, Cathy Peppers has argued that Butler’s engagement with genetics is aimed at “changing the sociobiological story from within” (52).⁴ Building on these (partially) science-inflected analyses, I want to show that, with the help of science, evolutionary sf narratives like *LB* can also be analyzed without reverting to allegory. In *LB*, the shock of difference experienced by the characters does not only lead to a reconfiguration of social relations, but also to new physiological traits and ecological relations. Butler’s narrative demonstrates that such biological becomings always occur in ongoing, mutual relationships with other bodies and with the environment. If this is a utopian moment, it is

decidedly not of the program type—born from nostalgia and aimed at a particular state of being in the future. Rather it composes what Haraway has called a “cyborg ontology” (*Simians*), a permanent reminder of the unforeseeable co-evolution of matter, organic life, and technologies.

The Oankali’s extraordinary genetic engineering abilities seem to make them all-powerful arbiters of (human) life and ultimate exponents of control science. As the story progresses, however, the image of the trade as a controlled experiment begins to lose validity. The Oankali are utterly dependent on human cooperation. Furthermore, the success of the experiment hinges on unforeseen transformations, some of which are the result of mistakes. The protagonists’ journeys can be seen as nomadic practices of problematization: explorations of the problem of species encounter. Whereas in Bear’s *Darwin’s Radio* elements of nomad science become apparent in a search for new knowledge and understanding (see chapter 4), in *LB* nomad science is expressed foremost in practices, attitudes and desires which precede and exceed knowing. As such, *LB* testifies to Deleuze and Guattari’s statement about the “nonscientific activities” of nomad (“ambulant”) science:

In the field of interaction of the two sciences, the ambulant sciences confine themselves to inventing problems whose solution is tied to a whole set of collective, nonscientific activities but whose scientific solution depends, on the contrary, on royal science and the way it has transformed the problem by introducing it into its theoremativ apparatus and its organization of work. (413)

I interpret the experiment of genetic trade in *LB* as such a nomadic “invention of problems,” a nonplanned yet rigorous search for ways of living together, which only at the very end appear to culminate in a new “organization of work,” a fusion of human and Oankali ways of thinking and living. However, the story ends rather abruptly, so that the reader does not know for sure whether a solution has in fact been reached.

In the following I will demonstrate that the trilogy can be productively read alongside the recent work of Donna Haraway as a story of species encounter, one that shows resemblances to encounters between humans and other animals in food industries, health care, science, sports and other areas. Butler and Haraway are at their strongest when they explore the emotional, embodied, affective dimensions of species encounter. Apart from performing modes of intimate interaction, their work also allows us to think co-evolution as a continuous, nonlinear process that is inherently embedded or, as Haraway calls it, “worlded.” From this perspective, Butler’s trilogy is not so much an allegory as a literary experiment in which characters construct and dwell in multispecies contact zones that are uncomfortably *problemativ*. Each in their own way, Butler and Haraway create topologies of nomadic ideas, desires, attitudes, and practices centered on problematization without solution. However, these topologies are not devoid of elements of control: even the most “nomadic” characters in *LB* experience episodes where control becomes a dominant tendency. To illustrate this, I will first discuss some elements of Butler’s trilogy that scholars have interpreted as instances of genocentrism and (liberal) eugenics, elements that can be understood through the concept of control science.

OANKALI BIOCAPITALISM

Butler has pointed to Margulis's theory of endosymbiosis, Lovelock and Margulis's Gaia hypothesis, as well as E.O. Wilson's book *Sociobiology: The New Synthesis* (1975) as key inspirations for her work.⁵ While Margulis's work, as argued in the previous chapters, has strong nomadic traits, Wilson's sociobiology can be seen as a key example of control science, with its emphasis on the genome as the origin and essence of life. In *LB*, genocentrism and ecocentrism sometimes occur within a single sequence, for example when the Oankali Jdahya tries to explain to Lilith that cancer is "the result of a tangled combination of factors that only begins with genes" (39), while a few moments later he qualifies genes as "the essence of ourselves" (40). Butler's meshing together of partially contradictory sources becomes clear in Jdaya's image of the Oankali as "natural genetic engineers,"

We do what you would call genetic engineering. We know you had begun to do it yourselves a little, but it's foreign to you. We do it naturally. We must do it. It renews us, enables us to survive as an evolving species instead of specializing ourselves to into extinction or stagnation. (40)

On the one hand, the Oankali's gene trade resembles the lateral gene transfer explored in Margulis's work on symbiosis, in which case the Oankali can be seen as akin to bacteria. The Oankali also resonate with Haraway's "cyborg," a figuration embodying the synthesis of biology and technology (Clarke; Peppers). On the other hand, Oankali life is presented here as something that inheres wholly in the genome. This genocentrism becomes the ground for a seemingly impeccable knowledge. As Jdaya explains to Lilith, the Ooloi know "everything that can be learned about you from your genes" (22). The Oankali deploy knowledge and technology to modify humans, the most incisive interference being sterilization, which is designed to get rid of the last (vainly) hope for a human future.

Notwithstanding the initial stage of controlled experimentation on humans in a state of suspended animation, I would argue that the model of eugenics, a top-down control over human life and death, is inappropriate for describing the story of *LB*. Significantly, the Oankali never kill human beings, nor do they force them to comply in an immediate, coercive way. Butler's story-world comes closer Deleuze's "control society," a more flexible mode in which human bodies and behaviors are constantly monitored and modulated in non-coercive ways (*Postscript*). More specifically, the trilogy can be read as a rumination on what has been called a "liberal eugenics," the soft strategies of enhancement and control operating through corporations and states (Rose).⁶ The benefits that Lilith and her companions receive include life-time extension, genetic therapy, tissue regeneration, and longevity. The resisters, apart from being deprived of their fertility, are faced with enormous health challenges in a world without technology, putting optimal pressure to succumb to the Oankali way of life.

Several scholars have compared Butler's trilogy, written in the late 1980s, with contemporary biotechnology and biocommerce. According to Slonczewski, *LB* presciently sketches the trading of bodily assets such as ova as commodities ("Octavia"). Molly Wallace more broadly compares the Oankali's genetic trade to neoliberal capitalism, and particularly to the con-

temporary merger of venture capital and biology in biotechnology and in research fields such as genomics. For Wallace, the air of innocence, wisdom and benevolence around the Oankali obfuscates their unilateral imposition of the trade:

Though the Oankali do not explicitly use the language of property, their control over the reproducibility of life, both human and non-human, has the effect of ownership. The Oankali have altered human biology with a gene that makes humans (re)productively reliant, and having thereby acquired a kind of biological patent on human DNA, the Oankali protect their investment. (119)

In other words, the Oankali do not trade opportunistically, but with the intent of spreading and continuing their way of life. In each encounter, humans are subjected to temptation-cum-manipulation. As Nikanj explains to the ex-resister Tino, although the Oankali cannot "read minds," they can "stimulate sensations and send your thoughts off in all sorts of directions" (293). Oankali communication can be interpreted as an allegory of contemporary marketing's saturation of the public sphere, in which people's desires are continually molded to secure the success of new products, while neo-liberalism's official story is that entrepreneurs only produce what customers demand. Contemporary capitalism has much to offer (especially to those with money), but the choice for another *system* is made almost impossible.

The image of ubiquitous control turns the whole experiment of the gene trade into a product of control science. For several reasons, this seems a valid assessment: the Oankali comprise a unified group working in a planned way; their activities seem strictly oriented toward a single outcome (a successful trade); and they are obsessed with genetics as a key to success. Control science is perhaps best illustrated with the Ooloi's discovery of cancer, a special human "talent," which they have incorporated to instill new capabilities:

They get real pleasure from healing or regenerating, and they share that pleasure with us. They weren't as good at repairs before they found us. Regeneration was limited to wound healing. Now they can grow you a new leg if you lose one. They can even regenerate brain and nervous tissue. They learned that from us, believe it or not. We had the ability, and they know how to use it. They learned by studying our cancers, of all things. It was cancer that made Humanity such a valuable trade partner. (294)

From this description cancer is a "solution" to the problem of the trade, the result of a well-planned experiment. If for humans cancer is a disease, a chaotic growth that destroys the body's balanced organization, the Oankali redefine it as a mechanism that can be used in a constructive manner. As Cooper notes, the properties of cancerous cells—proliferation, migration and transformation—resemble those of embryonic stem cells, which can still differentiate into any kind of cell—brain, blood, skin, and so on (139). Cooper argues that in embryonic stem cell research, a scientific fascination with life's mutability and perpetual "surplus" tends to re-territorialize on a capitalist incentive to create ever new promises for new biomedical applications and commodities, promises that can be banked on through patents. Is this interpretation

also applicable to *LB*? Does Butler's story culminate in a situation in which life, understood as a potential for differentiation, is finally understood and controlled? I want to argue that this is not the case, and that the dominant mode in *LB* is nomad science. In the following, I will work towards an analysis of nomad science in a roundabout manner, by examining the trilogy's affective moments of encounter and practices of worlding.

UNNATURAL PARTICIPATIONS

Although *LB* is a story about encounter, throughout the trilogy a deep abyss divides the species. Most humans try to resist the Oankali while secretly or subconsciously craving contact with them, a situation that is so disturbing that they can only perceive it as *unnatural*—as something that should not and cannot be happening. The experimental encounter between Oankali and humans is focalized first through Lilith, and subsequently through her son Akin⁷ (in the second and third volumes). At Lilith's first encounter with an Oankali called Jdaya, her body stiffens with fright, and she is hardly able to bear the specter of its tentacled appearance. Lilith has to search for words to express her disgust: "Medusa children. Snakes for hair. Nests of night crawlers for eyes and ears" (43). Lilith makes clear that she would rather return to the inert state she had been in for the past 250 years than endure the horrors of alienness. After repeated encounters, however, Lilith's gets used to Jdaya and follows him outside her cell. The Oankali world turns out to be a living entity spectacularly called Chkahichdahk (imagine Butler's joy inventing these names). The reason why Lilith is brought to consciousness is to learn to live with the Oankali and to instruct the other humans how to do so. After having spent some time with an Oankali family, and especially with the Oankali child Nikanj, she is sent to a special room where thirty people lie in suspended animation, waiting to be awakened by her. In batches of ten, Lilith awakens the people and tells them about the Oankali's plans. Many of them refuse to believe Lilith, until the Oankali finally appear to them. Although at first repelled, the humans gradually get used to the Oankali, who seem to be attaining a more human shape, as if adapting to their symbiotic partners. Human heterosexual couples develop a strange, irresistible attraction to a specific kind of Oankali, the Olooi⁸, who are neither male nor female. This leads to sexual encounters that are as frightening as they are pleasurable (not unlike *any* first sexual experience), for example between Lilith, her human mate Joseph, and Nikanj:

Lilith saw Joseph's body stiffen, struggle, then relax, and she knew Nikanj had read him correctly. He neither struggled nor argued as Nikanj positioned him more comfortably against its body. Lilith saw that he had closed his eyes again, his face peaceful. Now he was ready to accept what he had wanted from the beginning. (190)

This is not an ordinary ménage-a-trois. Although erotic encounters between humans and Olooi are not further explained in the narrative, for most humans it is clear that something "improper" transpires. Despite their continuing attraction to the Olooi, they fiercely resist the trade, seeing the Oankali as enemies who want to transform humanity according to their own

designs. The resisters, who accuse Lilith and others of being traitors, indulge in multiple acts of violence, including beatings and even the murder of Joseph. The first part of the trilogy ends with Lilith being told by Nikanj that he has made her pregnant using Joseph's sperm (allegedly in a modified form).

Moments such as those cited above are the main reason why *LB* is such a gripping book, and a superb example of *sf* estrangement (how is it possible that Jameson, in his seminal *Archaeologies*, merely mentions *LB* off-handedly as an "allegory of race," thus ignoring its gender, sexual, biotechnological and ecological dimensions?).⁹ In the irreducibly paradoxical situation of symbiotic encounter, nothing appears "natural" anymore: all is artificial, experimental, a grotesque *reality show* in which everyone has to play a part. Yet from a Deleuzian perspective, this situation demonstrates that evolution is an experiment. As Bruce Baugh explains, experimentation for Deleuze is a vital effort

to reveal the effects of combinations of different bodies and elements, and especially whether these combinations or encounters will increase the powers of acting of the elements combined into a greater whole, or whether the combination will destroy or "decompose" one or more of the elements. (91)

In other words, for Deleuze, thought-experiments are tests determining what a body or group of bodies is capable of. As both *LB* and Deleuze's work illustrate, such experimentation is never an opportunistic, individualistic affair as in the notions of "free competition" and "level playing field" in neo-liberal economics, which have been applied to evolution (I will return to this issue below). For Deleuze, true thought goes beyond representation—the imposition of a foundational schema in which a rational human subject re-presents to himself a messy, nonhuman world as well as his own interiority.¹⁰ Thought is an expressive immediacy, an a-personal affect or percept (art), function (science) or concept (philosophy), that short-circuits attempts at distancing and self-reflection.

From a Deleuzian point of view, the encounters in *LB* are not "unnatural" or "artificial" in the sense of being uncommon, fabricated or wrong. Rather these events express a tendency in life toward migration, variation and transformation. A major difference between Deleuze and philosophers of technology such as Bernard Stiegler and Graham Harman is that the paradox of an artificially altered or "extended" nature is not reserved to the human realm.¹¹ Rather, artifice or "unnaturalness" is the hallmark of life, whose fundamental tendency is to *differ from itself*, to become, in a way that is not dictated by heredity:

Propagation by epidemic, by contagion, has nothing to do with filiation by heredity, even if the two themes intermingle and require each other. The vampire does not filiate, it infects. The difference is that contagion, epidemic, involves terms that are entirely heterogeneous: for example, a human being, an animal, and a bacterium, a virus, a molecule, a microorganism. Or in the case of the truffle, a tree, a fly and a pig. These combinations are neither genetic nor structural; they are interkingdoms, *unnatural participations*. That is the only way Nature operates—against itself. (Deleuze and Guattari, *A Thousand* 266-7)

The focus on “contagion” rather than “filiation” is accompanied by a focus on populations (or ecologies) rather than species. This same focus is found in *LB* where, as Wald has argued, fixed species-being is replaced with a notion of population, offering “an alternative in which hybrids embody the breakdown of exclusionary categories, social as well as biological” (“Cells” 262). Although the trilogy ends with the promise of a hybrid population and thus a potentially successful “trade,” this situation is not at all peaceful or self-evident. What Deleuze and Butler’s work share is a tendency not so much to go “beyond” rigid categories to arrive at a utopia, but to precede them and to move between them, expressing a potential to become-other.

BUTLER MEETS HARAWAY

Human-Oankali relations can be seen as a model or prelude to another form of living together with other species that Haraway calls for in *When Species Meet*, fostering “the capacity to feel and think with other mortal beings, not just *about* them” (6). When humans *become with* other species, this amounts to a trading of traits that affect both parties in the short and the long run. Several scholars have gone before me in connecting the works of Butler and Haraway (Bollinger; Clarke; Goss and Riquelme; Greenwald Smith; Peppers; Wallace), but they have focused on Haraway’s former, rather than her more recent work. A strong connection between the two is the feminist critique of patriarchy and phallocentrism. Lilith is given the privilege of co-creating a new world, but as the mother of a new race, she bears the brunt of radical dislocation and transformation like no other. She laments that resisters—predominantly males—hold her responsible for the loss of human dignity, calling her “a second Satan or Satan’s wife or some such idiocy” (297). Lilith’s ordeal mirrors the fate of many mythological and real women in history. Her name is an immediate reference to the myth of Lilith, allegedly Adam’s first wife who after being banished from Eden for disobedience slept with demons, producing a brood of monsters. Another example can be found in histories and myths of colonization, where women have often been blamed for facilitating the destruction of the indigenous culture through their alleged disloyalty and promiscuity.¹² What Butler makes excruciatingly clear through literary means, Haraway persuasively argues in practically all of her scholarship: the Enlightenment, phallogocentric strategy of self-preservation through domination, fencing off the human from the nonhuman world, is self-defeating. There is a need for new ways of thinking humans, other species and technologies together. This requires a transformation that is neither fully controlled nor an event one undergoes passively, but rather a challenge that encompasses all dimensions of biological and social existence.

If *LB* criticizes phallocentrism, racism and speciesism, it is not a critique that dreams of a world without asymmetrical relations. In *LB*, an important factor in the asymmetry of species relations is that the Oankali seem to understand humans better than humans do themselves. Moreover, humans have great trouble fathoming Oankali modes of communication—spoken, pheromonal, tactile, neuronal and genetic—even if they do participate in these modes. The paradox is fleshed out in a sequence where an adolescent Akin quite suddenly finds himself in an intimate situation with an Olooi: “It was delicately controlling his nervous system, stimulating the release of certain endorphins in his brain-in effect, causing him to drug himself into

pleasurable relaxation and acceptance” (454). The encounter is almost traumatic in its perplexity, but simultaneously exhilarating and joyous. In his struggle to communicate in strange new ways, Akin ultimately resists resisting, accepting the “self-dissolving closeness” (455) and thus affirming his own singularity as a mixed species and a body-in-becoming.

On the one hand, the Oankali’s direct neuronal communication is reminiscent of scenarios of totalitarian biopower such as Huxley’s *Brave New World* and Orwell’s *Animal Farm*. Human beings find themselves in a highly artificial experiment that they have not chosen and from which they cannot escape. For example, when Lilith is first introduced in her Oankali family she is continually monitored and cannot even open doors, which makes her wonder: “How was a pet supposed to feel? How did zoo animals feel?” (58). But as Stacy Alaimo has noted, the pervasiveness of tactile and other non-verbal communication in *LB* can also be read as a feminist critique of *distance* in the dominant western traditions of optical epistemology: “the Oankali do not perceive the world through vision, which separates the knower from the known, but through sensory organs that, with a certain eroticism, taste and feel the world around them” (144). Furthermore, Oankali communication cannot be reduced to the expression of pre-existing plans and ideas by rational individuals. Rather, it reveals a regime of *machinic* (a-signifying) communication that connects bodies in immediate ways, expressing *affects* (capacities-in-relation) rather than pre-formed messages.¹³

Especially in Haraway’s recent work, feminist and Marxist critique smoothly merges into a critique of speciesism. In *When Species Meet* Haraway tries to imagine what a sequel to Marx’s *Capital* would be like if it would take into account animals as laborers and consumers. Haraway’s relationship with her dog Cayenne is her point of entry into dog biopolitics, where dogs are consumers of food, health care (physical, mental) and entertainment, subjects of training and learning, as well as workers in science, care, and the police force. Haraway rejects the trenchant habit of framing non-human animals as objects only capable of “reaction” (rather than conscious response) and only valuable from the perspective of humans. Marx’s categories of use-value and exchange-value, Haraway proposes, ought to be expanded with that of “encounter-value.” Rather than constructing a full-blown theory of “encounter-value,” Haraway offers it as an intuitive concept describing “relationships among a motley array of living beings, in which commerce and consciousness, evolution and bioengineering, and ethics and utilities are all in play” (46). For Haraway, a critical analysis of contemporary trans-species encounter-value would lay bare the “practices through which working animals (and their people) are rendered incompetent in order to render them valuable” (Azzaredo 4), thus pointing to new responsibilities. These responsibilities, for Haraway, are not reserved to human subjects—animals are also responsible, i.e. able to respond: “responsibility is a relationship crafted in intra-action through which entities, subjects and objects, come into being” (71). Butler’s trilogy, in which humans and Oankali’s literally work together to create a new viable society, can be seen as a literary version of Haraway’s views. I would argue that both authors suggest a shift from Marx’s historical materialism¹⁴ towards a posthumanist materialism (Braidotti, *Transpositions*; Van der Tuin and Dolphijn) in which change is simultaneously social and biological.

LB dramatizes the loss of autonomy of western man, not just in an allegorical encounter with its racial or sexual others, but by suggesting that other species have, in a sense, participated in

a *domestication of humans*. The invention of agriculture and stockbreeding gave rise to the city-state in which, according to Sloterdijk, people started cultivating themselves in a very broad, evolutionary sense of the word. This self-cultivation, paradoxically, involved a process of (intellectual) distancing from other animals, which according to the philosophers of the time did not belong in the polis (Ten Bos 19). This anthropocentrism was affirmed by Christian dogma and expanded on philosophically by Descartes, Kant and others. In the meanwhile, not only have nonhuman animals been directly involved in all kinds of practices such as food production, housing, surveillance and exploration, but their sheer closeness has affected human bodies genetically. In Haraway's description of her intimate relationship with her dog Cayenne in *A Companion Species Manifesto* (2003), genomics, biopolitics and love share a space of potential infection:

I'm sure our genomes are more alike than they should be. Some molecular record of our touch in the codes of living will leave traces in the world, no matter that we are each reproductively silenced females, one by age, one by surgery. Her red merle Australian shepherd's quick and lithe tongue has swabbed the tissues of my tonsils with all their eager immune system receptors. Who knows where my chemical receptors carried her messages or what she took from my cellular system for distinguishing self from other and binding outside to inside? (*A Companion 2*)

The almost erotic intimacy exhibited by Haraway is akin to the encounters in *LB*. Ultimately, as Margulis's theory of symbiogenesis shows, such encounters have an impact on the genetic level and may even lead to new species. Importantly, Haraway stresses that the mutually transformative relations between humans and other animals should not be seen through a New Age philosophy of final peace: "Symbiogenesis is not a synonym for the good, but for becoming with each other in respons-ability" ("Sowing Worlds" 9).

As in *LB*, Haraway's serious consideration of inter-species collaborations puts a different spin on common understandings of ethics and responsibility vis-à-vis nonhuman animals. Both authors discard any position of innocence: humans are not divinely or otherwise ordained to dominate other animals, and nonhuman animals are not "innocent" victims. Without providing a ready-made plan for the future of interspecies relations, they complicate trenchant ways of thinking about them and suggest possible directions for thinking otherwise. Here, domestication is neither wrong, nor good as in the Christian doctrine of stewardship. It also isn't a neutral fact, but rather a biopolitically and ethically asymmetrical practice. Haraway asks:

What if we do not regard or treat lab animals as victims, or as other to the human, or relate to their sufferings and deaths as sacrifice? What happens if experimental animals are not mechanical substitutes but significantly unfree partners, whose differences and similarities to human beings, to one another, and to other organisms are crucial to the work of the lab and, indeed, are partly constructed by the work of the lab? What happens if the working animals are significant others with whom we are in consequential relationship in an irreducible world of embodied and lived partial differences, rather than the other across the gulf from the One? (72)

This struggle to sustain asymmetrical relations without reverting to the simplified category of sacrifice is also prevalent in *LB*. The Oankali try at all times not to kill anybody, even if they are attacked. No life should simply be wasted. Nothing could be further removed from the Oankali ethos than the logic of sacrifice, the subordination of life to transcendental laws and goals—religious, scientific, or otherwise.¹⁵ Haraway and Butler demonstrate how the logic of sacrifice represents a blockage to thinking about shared suffering and mortality, sanctifying the slaughter of animals and, in the case of genocide, of human beings, as a kind of indisputable ritual, a precondition for the survival of an elect people.

WORLDINGS

LB's logic of immanence applies not only to interspecies relations, but to the story-world as such. Rather than a product of "vertical" causation within particular boundaries, the narrative develops in the manner of horizontal "infection" on a planetary, and ultimately cosmic scale. As Bruce Clarke puts it, the theme of Butler's fiction is "the interpenetration of individual, social and planetary changes" (162). *LB* exemplifies a nomadic or "minor" sf writing, continuously redrawing the narrative world through the unfolding problem of metamorphosis. To put it another way, the multiple migrations in Butler's trilogy, from earth to the Oankali's ship, from individual cells to the training grounds, and back to earth, are inseparable from the novum of metamorphosis. Instead of telling a narrative taking place *in* a world, the narrative *becomes* what Haraway calls a "wordling," a topological space for continuous mutual adaptation and transformation. Remarkably, Deleuze and Guattari already used this same term in their chapter in *A Thousand Plateaus* on becomings: "Becoming everybody/everything is to world, to make a world" (308). I would argue that Deleuze and Guattari's usage is not so very different from Haraway's, rather expressing its extreme consequence: an intimate relation to one's pet or garden is only the most ordinary instance of our connectedness to the entire cosmos.¹⁶ As I will show, an analysis of metamorphosis in *LB* is best suited with a combination of the mundane and cosmic versions of "worlding."

Haraway celebrates Butler's work along with other feminist bio-sf questioning autonomous subjectivity through literary worlding (the work of Vonda McIntyre, Joanna Russ, Marge Piercy, and others). Although in a recent interview Haraway calls worlding "an sf term" (Jeffrey Williams 148), it is not exclusive to literary texts. In fact, the origins of Haraway's term lay partially in her background as a biologist. From studying embryology, "the profuse development of topologically ever more complex things through time out of interaction," it became clear for Haraway that "you never have organism and environment" but rather "intra-actions that construct the entities all the way down" (Jeffrey Williams 148). Yet this kind of worlding in science is immediately related to *narratives* about relationality "that don't know how to finish" (Haraway, *Sowing Worlds* 9). Worlding conjoins action and imagination, technoscience and fiction, in a single gesture.

In a recent book chapter entitled "Sowing Worlds", Haraway presents her concept of "worlding" as an urgent task of redesigning the world in ways that are responsive to other species, ecosystems, and the planet as a whole. This endeavor requires new kinds of narratives that deal with relations rather than revolving around the feelings of protagonists, narratives which Haraway finds in particular in feminist science fiction. In the following quotation Haraway

refers to sf writer Ursula Leguin's trope of the "carrier bag" as a useful way to think about such narratives. I shall cite Haraway at length to catch the richness of her prose and to explicate the concept of worlding:

Tool, weapon and word: that is the word made flesh in the image of the sky god. In a tragic story with only one real actor, one real world-maker, the hero, this is the Man-making tale of the hunter on a quest to kill and bring back the terrible bounty. This is the cutting, sharp, combative tale of action that defers the suffering of glutinous, earth-rotted passivity beyond bearing. All others in the prick tale are props, ground, plot space, or prey. They don't matter; their job is to be in the way, to be overcome, to be the road, the conduit, but not the traveler, not the begetter. The last thing the hero wants to know is that *his beautiful words and weapons will be useless without a bag, a container, a net.* (...) How do such lowly things keep the story going? Or maybe even worse for the hero, how do those concave, hollowed out things, those holes in Being, from the get-go generate richer, quirkier, fuller, unfitting, ongoing stories, stories with room for the hunter but which weren't and aren't about him, the self-making Human, the human-making machine of history? The slight curve of the shell that holds just a little water, just a few seeds to give away and to receive, suggest stories of becoming-with, of reciprocal induction, of companion species whose job in living and dying is not to end the storying, the worlding. (2; my emphasis)

The carrier bag is a *worldly* metaphor: a figure for non-heroic, life-sustaining activities. It highlights the significance of the historical roles of women as caretakers, housewives, and gatherers and relativizes the dominant structure of narrative and myth revolving around (male) individuals. The carrier bag can also be seen as a metaphor for a home, a place where species gather, a worlding, or a body which lends itself as a habitat for other species.

For Deleuze and Guattari worlding is never a familiar experience taking place at home. This is not to say that their understanding of the term is incompatible with Haraway's, but that they locate it "elsewhere," namely in the realm of potentiality or "the virtual." When philosophers or artists reach the domain of the virtual, which precedes representational forms, they enter into a series of becomings that go beyond the "man" form—becoming woman, child, animal, etc.—a series that ends in a becoming-world.¹⁷ They explain this final, most intensive becoming as follows:

By process of elimination, one is no longer anything more than an abstract line, or a piece in a puzzle that is itself abstract. It is by conjugating, by continuing with other lines, other pieces, that one makes a world that can overlay the first one, like a transparency. Animal elegance, the camouflage fish, the clandestine: this fish is crisscrossed by abstract lines that resemble nothing, that do not even follow its organic divisions; but thus disorganized, disarticulated, it worlds with the lines of a rock, sand, and plants, becoming imperceptible. (Deleuze and Guattari, *A Thousand* 308-9).

As I understand it, here "elimination" refers to a molar entity, an organism, which becomes absolutely dependent on its environment through a mixture of "other pieces," producing zones

where a body is no longer discernible because it merges with its world. In this situation, there are no longer distinct forms but only abstract, molecular lines, a cosmic web.

Encapsulating in literary form Deleuze and Guattari's and Haraway's ideas, *LB* presents worlding as a continuous, non-linear process in which characters are embedded in a series of test-environments in which they come to endure the tensions of changing living conditions. However simulated these sites may appear, they constitute real ecologies.¹⁸ The early stages of the encounter can perhaps be best understood through Haraway's usage of worlding. I will limit my analysis to the stage when humans and Oankali descend from the ship to a tropical forest area in the Amazon basin. To the Oankali's disappointment, the majority of humans abandon them immediately and start building strictly human villages. Lilith and a small number of followers decide to stay with the Oankali, trying to make the situation *work*. They live in an animate village called Lo, a growing and developing super-organism akin to the Oankali ship Chkahichdahk, where everything that happens simultaneously affects the inhabitants and the place. Lo develops symbiotically, "according to the desires of its occupants and the patterns of the surrounding vegetation" (303). Everyone is dependent on everyone for their well-being. Compared to human society, Lo is deterritorialized: it has no rigid organization of biological, economic or social functions, no natural "ground" or socio-economic "base," and literally no fixed temporal or spatial horizon. As Butler's trilogy illustrates, worlding is a messy border-zone of imagination and knowledge, thought and action, biology and sociality.

The precariousness of the trade becomes most pertinent in the third part entitled "Imago" (a biological term referring to the final stage of a metamorphosis), and here Deleuze and Guattari's understanding of worlding becomes more apt. In this part, Jdaya discovers that Akin is becoming an Olooi, something he had not anticipated. Akin is renamed "Jodahs." The Oankali suspect that Jodahs is in the process of developing wholly new capabilities for genetic manipulation, capabilities which he will only master once his metamorphosis is complete and which could do great damage to Lo in the meantime. After his first metamorphosis, Jodahs's body has become highly plastic, continually adapting itself to new environments "like those chameleon lizards that used to change color" (501). At the same time, Jodahs's starts to inadvertently manipulate his environment, triggering cancerous growths. Jodahs himself suffers from the pollution he is causing. He decides to leave for a remote area, following his desire to be closer to humans yet keeping a safe distance as long as he is uncertain about his own powers. This balancing act, in which Jodahs literally loses himself in the dense, dark forest and in the disturbing process of transformation, without allowing himself or his environment to be destroyed, can be seen as an ultimate example of Deleuze and Guattari's worlding. In this episode of metamorphosis, Jodahs performs or "repeats" the symbiotic encounter as a whole, embodying a cancerous, infectious life that cannot be contained. It is this precarious situation of solitary wandering, vainly following his ill-understood desires and withstanding his frightening final stage of metamorphosis, that will make a new future for the Oankali and humanity possible. But at no point is the future sealed. *LB* exemplifies Margulis and Sagan's warning that "at any time the association may dissolve, the partners may change or even destroy each other, or the symbionts may be lost. Outcomes that involve very different live organisms are not fully predictable, and terms like 'cost' and 'benefit' are not very useful" (*Acquiring* 90).

NOMADISM

Despite the fact that influences from and resonances with bioscience are centrally important, *LB* does not recount a quest for knowledge. The metamorphosis is not a problem to be solved scientifically. Akin's adventures exemplify Deleuze and Guattari's claim that unscientific practices are constitutive of nomad science (*A Thousand* 413). In that sense, the preservation of narrative tension in *LB* is entirely different than, for example, in novels of the thriller genre, where the central organizing question suggests a clear and definite answer waiting to be found. The detective novel may be seen as exemplary: once a case is opened, the plot leads inexorably to its closure (while residual curiosity about the details of the case may linger on). In *LB*, some characters keep wondering about the truth behind the trade as if it were a kind of conspiracy, but they find no answers. As Oankali family member Kahguyah't assures Lilith, "Your children will know us ... You never will" (112). *LB* is not about knowing, or, for that matter, about science. Rather than having a special status, science sinks into existence, as in the Oankali's idea of "natural" genetic engineering. This means that the boundaries between self and world, subject and object, fade away—the whole universe becomes an experiment, and Jodah's is "both the scientist and the laboratory" (60).

In place of a transcendental logic of understanding and solving, Butler's trilogy operates according to an immanent logic of problematization that is foremost expressed in what Deleuze and Guattari call *affect*: "an ability to affect and be affected" (*A Thousand* xvii). Lilith explains the challenge of the trade to her son Akin exactly in terms of affect, or the capacity to affirm difference:

Humans persecute their different ones, yet they need them to give themselves definition and status. Oankali seek difference and collect it. They need it to keep themselves from stagnation and overspecialization. If you don't understand this, you will. You'll probably find both tendencies surfacing in your own behavior ... When you feel a conflict, try to go the Oankali way. Embrace difference. (329)

Although this challenge to "embrace difference" occurs at various moments in different individuals, it is never really an individual issue. In *LB*, the problem is raised from the level of a single "case" to the level of species and even the planet, thereby making the world itself unstable, problematic. Since the problem is unfolding, under construction, it cannot be traced, let alone isolated, and no one can be blamed for causing it.

Wallace has argued that the presentation of Oankali ideas and practices as "natural" is misleading, and mirrors capitalist ideology. Although Wallace's comparison between the Oankali and capitalism is rather convincing in many respects, she misreads the status of genetics in *LB* when she maintains that for the Oankali "there is no ambiguity in the coding of DNA" (96).¹⁹ One could even argue that, by the third part of the trilogy, the image of a scrupulously designed, controlled experiment turns out to have been a figment of the human imagination from the onset. The Oankali are driven towards migration, encounter and transformation, events that are simultaneously necessary, risky and pleasurable. As Slonczewski has argued, the Oankali are not superior beings who have gained control over life:

Paradoxically, because the Oankali are such successful genetic engineers, they tend to engineer themselves into an evolutionary dead end; losing all genetic diversity, they lose the ability to adapt to change. The only way they can recover genetic diversity is to interbreed with an entirely new species, which contributes new genetic strengths—and weaknesses. ("Octavia")

Therefore, while genetic engineering forms a critical aspect of Oankali life, and while the intent is certainly to try to preserve the human population for the sake of survival, the genetic trade becomes an open experiment, depending on unpredictable, contingent events. Rather than a particular issue to be solved, the science involved in the trade is directed at a nomadic, never-ending problem: How to become intimate with a life form whose appearance and conduct is so deeply disturbing? How to develop new ways of life based on mutual dependence and a shared habitat?

The vicissitudes of Akin reveal the untenability of explaining it as control science. What Akin's body is capable of was not programmed in advance, but rather emerges out of his contact with his family as well as other Oankali and human beings. Akin is able to speak and to understand many things almost immediately from birth, and he can use his tongue to retrieve genetic information from his surroundings. In the following sequence he "tastes" Lilith's flesh in pleasurable curiosity:

He investigated the DNA that made up the genes, the nucleotides of the DNA. There was something beyond the nucleotides that he could not perceive—a world of smaller particles that he could not cross into. He did not understand why he could not make this final crossing—if it were the final one. It frustrated him that anything was beyond his perception. He knew of it only through shadowy and ungraspable feelings. When he was older he came to think of it as a horizon, always receding when he approached it. (257)

I consider Akin's investigations as an example of nomad science's desire not just to *bear witness to*, but to *immerse in* the world, without ever reaching the "essence" of life. Apart from shattering the image of the genome as an ultimate source of identity, Akin's tactile perceptions obliterate the correlate vision of the independent, individual human subject: "He was Akin. Yet he came to know that he was also part of the people who touched him—that within them, he could find fragments of himself. He was himself, and he was those others" (255). Akin soon learns that to "read" his environment through touch is not an innocent operation, and that "he would share any pain that he caused" (257). To be immersed in one's environment means to participate in a worlding.

Contra Wallace, I would argue that Butler, in her creation of Lo as an organic landscape that merges the urban, the suburban and the natural, imagines the advent of a radical kind of bio-based economy, one that does not incorporate biological life into capitalism but adapts economics to co-evolutionary worlding.²⁰ At his first encounter with Lo, the resister Tino expresses grave disappointment to Lilith: "Except for your garden—which barely looks like a garden—you don't grow anything. Except for your shacks, you haven't built anything! And as for building yourselves, the Oankali are doing that. You're their clay, that's all" (282). He soon finds

out that Lo is not an a-biotic space populated by living beings, but a living entity adapting to its Earthly conditions and depending on a fine balance between itself, Oankali, humans, and other species. After a few decades Lo enters a new phase, able to “learn to incorporate Earth vegetation, sustain it, and benefit from it” (313). In Lo, literally nothing is wasted, and there is nothing that Lo cannot modify to make it function within its environs. The whole system functions in the mode of sustainability—its expansion is slow and non-violent. Lo stands in stark contrast to the wasteful resister settlements scattered across the Amazon basin, where resources are increasingly exhausted in an attempt to uphold a sense of human autonomy (implicitly based on masculinity).²¹ Whereas the resisters use the little technology they have in the service of producing and trading goods, fortifying their villages, and salvaging plastic figurines and other commodities from the ruins the old world, the inhabitants of Lo trade *themselves* in an evolutionary process that collapses nature and technology, subject and world.

As the Oankali explain to Lilith early on in the experiment, the difference between humans and Oankali is ingrained in their biological constitutions. The “human contradiction,” as they call it, is a flawed combination of two incompatible traits: the “entrenched,” “terrestrial” trait of hierarchy, and the more recently acquired, flexible trait of “intelligence” (39). Human inability to deal with cancer is symptomatic for this genetic contradiction. The role of cancer in *LB* can be understood along the lines of Brian Goodwin’s reflections on the subject in *Nature’s Due* (2007). Here Goodwin detects a tension in cancer research between a dominant view that understands cancer as a failure of certain genes to control mutation, and a holistic view “that sees it as a disturbance in a complex network of relationships within cells and with the body” (50). Goodwin favors the holistic approach that affirms the malleability and ecological connections of cancer cells:

A cell that has gone through the process of genetic destabilization and has arrived at a fully cancerous state of continuous cell division and invasiveness has effectively developed into a new type of cell. It has a unique genetic organization and specific protein markers on its surface, but it shares with all other cancer cells the ability to propagate its kind in a particular environment, that of its host. It has effectively become a new species of cell, a stable genotype with a corresponding cellular phenotype ... So we may see cancer as an expression of the innate tendency of the living process to explore the possibilities open to it and to express successfully new forms of life in available habitats. (53)

Of course, cancer’s “success” in destabilizing and transforming life is accompanied by death. *LB* is as much about evolutionary novelty as about a loss of the (perceived) integrity of the human species and human civilization. What matters in the light of Goodwin’s perspective is that the chief impetus for the trade is not a “power over life” (*potestas*), but a *desire for life* (*potentia*).²² By affirming flexible, nomadic intelligence and moving away from hierarchy and control, humanity is able to overcome its “contradiction.”

Jodahs’s metamorphosis, resulting from an experiment with cancer, leads to a potentially viable new species and a new society. Jodahs and his brother Aor succeed in gaining the trust of a community of humans that have spontaneously become fertile again, but whose offspring

are severely malformed (another proof that Oankali technoscience is fallible). From the “vast genetic memory” that Jodahs had received from Nikanj, he extracts a cell which has the potential “to divide and grow into a kind of seed” (744-5). Jodahs plants the special seed in a particularly fertile soil to grow a new town for humans and Oankali to live in—a literal instantiation of Haraway’s idea of “sowing worlds” (“Sowing”). Yet as Greenwald Smith argues, this outcome is far from utopian:

Replacing the logic of market liberalism with a logic of life, as *Xenogenesis* shows, is not to do away with pain, loss, inequality, and violence. To the contrary: the dynamism of life offers hope for change precisely because it destabilizes elements of the present that support the status quo. These structures, however, also offer security. The loss of that security carries with it profound danger even as it promises new ways of life. Butler’s trilogy is compelling in its capacity to portray the end of humanity as ethically and ecologically crucial, while at the same time emphasizing the pain of evolutionary usurpation. (561)

Butler’s audacity lies in aligning biology and politics in a radical way, but not, as Peppers notes, “in the way we usually think” (4). Her work prefigures how genomics and other sciences may play important roles in a biopolitics of control, but also reveals the potential of bioscience to affirm the nonhuman life pervading the human, and the necessity of transforming rather than merely surviving.

CONCLUSION

In their journeys in and toward new worlds, the protagonists of *LB* learn that there is no beginning or end point to life, no original home, and no essential humanity—time, space and subjectivity are infinitely folded. The past is ever present, and the present already past, arousing feelings of loss and nostalgia. At the same time, there is a continual sensation that a new world is actualized, under construction. The old returns in the new, embodied in Jodahs, for instance, and in the seed he plants. But this is not a new Eden. The initial title of the trilogy, *Xenogenesis*, means “strange beginning,” indicating that the result of the trade is hardly a secure or pristine world. *LB* is a strange event, a literary *introduction*. What Butler offers is the vision, neither utopian nor dystopian, of a turbulent world where biotechnoscience pervades life. While the impulse of control is there as a “fact of life” (overtly in humans and paradoxically in the Oankali), there is also a sense in which science is no longer a manipulative tool but a carrier bag, a practice of selecting and conjoining species and traits. For Butler and Haraway, what makes us happy and healthy, and what makes us transform, is our propensity to enter into relations with others, including nonhuman others. Living together, we trade traits, becoming—with one another. This becoming can be quite direct: for example, the smooth, playful and sensual movements of cats may help us to become more relaxed. But as Deleuze and Guattari warn in *A Thousand Plateaus*, the essence of becoming is not merely “becoming alike,” an operation of copying. The traits that are transferred from one species to the other are not pre-organized images or genes coding for specific traits:

It is no longer a question of the organs and functions, and of a transcendent Plane that can preside over their organization only by means of analogical relations and types of divergent development. It is a question not of organization but of composition; not of development or differentiation but of movement and rest, speed and slowness. It is a question of elements and particles, which do or do not arrive fast enough to effect a passage. (282)

In other words, becoming is not an interplay between material mutations and abstract selection leading to reproduction: selection and mutation occur in a single, ongoing movement, immanent to an emergent potentiality. Deleuze and Guattari's emphasis on the contingencies of fluctuations which determine the outcome of encounters resonates strongly with the contingencies of the human-Oankali trade. The Oankali arrived *just in time* to save small, scattered human populations from their doomed situations and possible extinction. In the end, Jodahs's discovery of the village with fertile humans occurs *just in time* to guide him through metamorphosis successfully and start a new society.

Butler's trilogy makes palpable that, paradoxically, humanity can only survive if it transforms. It shows that the dominant attitude of control over organisms, ecosystems and the planet will have to be abandoned if we want to live up to global problems. Nomad science in *LB* may be treated as intuitive cues for meeting the entangled challenges of deforestation, climate change, food crises, pandemic threats, massive diasporas, militarization, financial crises, and so on. This complex experiment is risky, but what is the alternative? Science needs the audacity of a nomadic explorer like Jodahs who becomes the lab and the experimenter at once. Interestingly, *LB* presents nomadism not just through the prism of individuals-in-becoming, but also in the guise of a hybrid "multiplicity," a meshing of populations. Paradoxically, it is this strange image of scientific experiment as simultaneously collective and nomadic, organized and disorganized—like the orderly chaos of a swarm of bees—that continually raises the specter of an imperialist governance of life. For most humans in the story, the wondrous capacities of the Oankali are diabolical, unnatural traits, and their messages are aimed at indoctrinating humans with the false belief that the end of humanity is inevitable.

Each committed to their own trade, Butler and Haraway offer repositories of stories and thought-experiments in which science comes alive as a force fully ingrained in human existence, destined to create new habitats, engage in new symbiotic relations, and spur new capabilities. Butler's narrative can be understood as the result of an epistemological trade between literature and science, where science becomes a vital ingredient for literature, and literature explicates tensions in science that usually remain under the surface. *LB* resonates with science studies à la Haraway in which critique-from-a-safe-distance is replaced by "thinking with." It is a kind of fictional ethnography of species encounter focalized through Lilith, an anthropologist, and later through the "posthuman" perspective of Jodahs. Likewise, throughout her work Haraway deploys posthumanist sf figurations such as the cyborg and the carrier bag as genuine perspectives rather than mere illustrations. Both authors perform an experiment with science from within—as symbionts, as it were. Their greatest strength is to connect intellectual and political dilemmas to the mundane, embodied existence of living creatures. Yet their strength inevitably also becomes their weakness: by focusing on human and nonhuman species, the

inorganic stratum fades into the background. Significantly, the new village planted by Jodahs is destined to leave earth as a "ship," because it overgrows and destroys the native organisms, and will need to migrate to other worlds to find new fertile grounds. In the following chapter we will explore a nomad science that fuses a concern for ecosystems with the evolutionary significance of light, gravity, soil and atmosphere, more thoroughly unearthing the planetary and cosmic dimensions of nomad science.

– 6 –

“TERRAIN IS A POWERFUL
GENETIC ENGINEER”:
CONSTRUCTIVE INTERACTION IN
KIM STANLEY ROBINSON’S
MARS TRILOGY

*Revolution is absolute deterritorialization even to the point
where this calls for a new earth, a new people.*

– Gilles Deleuze and Félix Guattari –

INTRODUCTION

In Kim Stanley Robinson’s acclaimed *Mars* trilogy¹, a group of one-hundred scientists is sent on a mission to Mars to explore the planet and build the first human settlements. Well before the scientists even reach Mars, they concoct a variety of plans that envision a much more intense and long-term presence on Mars than initially intended. Physicist Sax Russell, one of the key characters, unfolds a plan to modify the atmosphere of Mars in order to make it breathable by introducing genetically engineered, oxygen-excreting microorganisms. Covering a period running from the 2020s to the 2210s and counting over twenty-three hundred pages, the trilogy takes the reader through a metamorphosis of Mars from its familiar rocky surface (*Red Mars*) to a planet covered by plants, mosses, trees and even animals (*Green Mars*) and finally to a planet

with vast oceans not unlike the Earth (*Blue Mars*). Thanks to gerontology (life extension) and other biomedical innovations, scientists in *Mars* are able to successfully execute mass-scale projects—for example, excavating huge areas of land to prepare an intricate system of canals, lakes and seas, and bringing into orbit around Mars a “soletta”: a gigantic sail made of nano-materials that reflects sunlight to heat up Mars’s atmosphere. While the initial designs are based on experiences from Earth, the longer the scientists live on Mars, the more they become aware of a unique “spirit of place” that needs to be understood and cherished. What began as a more-or-less controlled process of terraformation (an attempt to create a copy of the Earth), gradually transforms into areoformation (*Ares* being the Greek name for Mars) in which the planet and humans themselves transform in unforeseen ways.

Most scholars have analyzed the *Mars* trilogy as a social experiment involving scientific, commercial and political agents. Jameson regards the *Mars* trilogy as a superb example of a “polyphonic”² work that “includes the struggle between a whole range of utopian alternatives, about which it deliberately fails to conclude” (410). A similar point is made by William Dynes, who praises Robinson’s ability to convey “the contingency of each character’s particular perspective on Mars and what is happening there” (Dynes 154). This sense of collective strife and cooperation in *Mars* also applies to its accounts of science, which is not a monolith, but a loose assemblage of scientists from many different disciplines, including biology, physics, geology, chemistry, medicine and psychology. However, what interests me here are not so much disciplinary and cultural differences, as fundamental politico-scientific attitudes of control and nomadism. The trilogy narrates a continuous battle between states and “transnationals” (corporations) over the mineral resources and carrying capacity of Mars in a time when societies on Earth are jeopardized by overpopulation and ecological disasters. Against this power play, various resister groups on Mars—mainly members of the first hundred and their children—attempt to build a Martian society from the bottom up. Under the scientific and spiritual leadership of the biologist Hiroko Ai, these nomad scientists work on an emergent, intuitive science of “areology” attuned to the unique circumstances on Mars. Epitomized by an unidentified narrator’s claim that “terrain is a powerful genetic engineer” (*Green* 13), areology is a science of interaction and transformation, tempering the hubris of terraformation and human enhancement. Hiroko’s underground movement can be analyzed as a “deterritorialization” of the terraformation project, refiguring the mission in terms of an ongoing historical-evolutionary transformation process in which human and nonhuman agents work together.³ As Robinson’s trilogy progresses, this nomadic perspective becomes more dominant, revealing that the key player in processes of transformation is not humanity but Mars itself (Markley 782).

In order to analyze the contours of nomad science in *Mars*, I will analyze it alongside evolutionary psychologist Susan Oyama’s concept of “constructive interactionism” (*Evolution’s Eye*). In congruence with Deleuze’s philosophy of immanence, Oyama’s concept points to a messy network of factors composing a system, or assemblage of systems, lacking a common ground or center. This spatio-temporal topology, I would argue, is not a scientific “solution,” but rather a nomadic mode of problematization, a weapon against claims in molecular biology that the “essence” of life inheres in a particular substance (DNA) or coded message (genetic instructions). As Manuela Rossini has demonstrated, Oyama’s constructive interactionism is also rel-

evant for the Humanities, showing how bodies are constructed not just socially and discursively but also biologically, without falling into biological determinism (“Coming Together”).⁴ In a similar vein, I want to demonstrate that Oyama’s concept helps to understand the processes of planetary and human transmutation occurring in the *Mars* trilogy in ecological terms, thus complementing the abovementioned analyses of social polyphony. After analyzing the central projects of terraformation and human enhancement as *control science*, and discussing the role of scientific content in scholarly analyses of *Mars*, I will introduce Oyama’s constructive interactionism as an adequate model for understanding the entangled processes of human and planetary transmutation in the trilogy.

TERRAFORMATION AND HUMAN ENHANCEMENT

In *Red Mars*, the central projects of planetary and human transformation are framed as more or less conscious attempts at control. The most significant alchemical experiment⁵ is the engineering of biomaterials by the terraformation group led by Sax, who believes that “the planet is the lab” (*Red* 263). His team disseminates all kinds of genetically engineered microorganisms over the surface of Mars, organisms that excrete oxygen, thus gradually modifying the atmosphere so that more and more terrestrial life forms are able to survive there. By the end of the twenty-first century Mars has attained a green look because of microorganisms, algae, mosses and plants living on its soil. By this time, even insects and animals, such as bees and moles, are introduced, reshaping the soil and creating ecoscapes akin to terrestrial tundras and savannahs. This sense of total control is expressed in the following passage (undoubtedly inspired by the Human Genome Project which was taking place when Robinson wrote the trilogy) in which the narrator describes how new organisms are genetically engineered:

The array of restriction enzymes for cutting, and ligase enzymes for pasting, was big and versatile; the ability to line out long DNA strings precisely was there; the accumulated knowledge of genomes was immense, and growing exponentially; and used all together, this new biotechnology was allowing all kinds of trait mobilization, promotion, replication, triggered suicide (to stop excess success), and so forth. It was possible to find the DNA sequences from an organism that carried the desired characteristic, and then synthesize these DNA messages and cut and paste them into plasmid rings; after that cells were washed and suspended in a glycerol with the new plasmids, and the glycerol was suspended between two electrodes and given as short sharp shock of about 2,000 volts, and the plasmids in the glycerol shot into the cells, and voilà! There, zapped to life like Frankenstein’s monster, was a new organism. With new abilities. (*Red* 205)

As in Craig Venter’s “artificial life” project (see chapter 3), the assumption is that life is a set of encoded traits made by “DNA software” (Venter “What is Life”). Once the operations of DNA software are understood, it is suggested, nature can be made “anew.” Robinson’s trilogy is partly based on genomics and on the scientific concept of terraformation, a line of research instigated by NASA in the 1970s which speculates about finding, and possibly creating, planets with Earth-like conditions.⁶

Following Deleuze and Guattari, the basic outline of the terraformation project can be characterized as control science: an attempt to take control over life, yielding new technological solutions that render the world habitable and predictable. If Mars potentially represents a "smooth space" open to novel experimentation, in *Red Mars* it is transformed into a *terrain* in its most literal sense: an earthly, human landscape subservient to the demands of states and corporations.

From the get-go it is clear that the mission to Mars is not innocent—it is a politically controversial experiment with finding new modes of living in a strange environment. Geologist Ann Clayborn is the most vocal representative of a "Red" group that is skeptical of any form of terraformation: "We'll all go on and make the place safe. Roads, cities. New sky, new soil. Until it's all some kind of Siberia of North-West Territories, and Mars will be gone and we'll be here, and we'll wonder why we feel so empty. Why when we look at the land we can never see anything but our own faces" (*Red* 158). For Ann, terraformation means destroying the native landscape and overcoding it with human ideas and values. Despite the Reds' concerns, the Martian landscape is transformed in rather drastic ways. The scientists build a nuclear reactor and several factories to produce building materials in the hometown of Underhill. In an area known as the Alchemist Quarter new materials are produced through "alchemical operations" such as making diamond out of carbon: "all their window glass was coated in a molecular layer of diamond to protect it from the corrosive dust" (*Red Mars* 220). These physical engineers are crucial for large projects such as the "Solleta"—a nano-sail built to heat up Mars's atmosphere—and the "space elevator": a nano-engineered cable guiding elevator cars between the surface of Mars and a small asteroid called Clarke just outside the orbit of the moons Phobos and Deimos. The purpose of the elevator is to speed up and lower the costs of transport between the Earth and Mars, allowing more people and materials to move back and forth. Yet the project of terraformation is stunted on various occasions by resisting groups such as the Reds, who try to liberate Mars from the straightjacket of terrestrial interests. As Daniel Cho has analyzed, all three installments of the trilogy work toward a revolutionary event, "each time taking on a different, more alien, form" (Cho 66), with the final revolution being completely nonviolent and so slow that it is even imperceptible (I will return to this gradual, imperceptible transformation below).

As in alchemical experiments, the scientists in *Mars* are part of their own set-up. While the planet is being modified, humans are biomedically enhanced to withstand low gravitation, extreme cold and increased exposure to ultraviolet radiation levels. Life under the harsh Martian conditions does not come easy: apart from physical hardship, the scientists are pestered by homesickness, estrangement, memory loss, permanent déjà vu, and depression. As biologist Nadia Chernyshevski realizes, it is not just a matter of a different physical environment, but also a different temporality: "human circadian biorhythms had been set over millions of years of evolution, and now suddenly to have extra minutes of day and night, day after day, night after night—no doubt had its effects. (*Red* 124). The development of an anti-depression drug by the mission's biotech team can only temper the consequences of living in a radically different environment. Apart from enhancing the quality of life, scientists also manage to increase its quantity through a gerontological (anti-aging) treatment, a genetic therapy developed by Ursula Kohl and Vlad Taneev's biomedical team:

Ordinary aging is mostly caused by cell-division error. After a number of generations, ranging from hundreds to tens of thousands depending which cells you're talking about, errors in reproduction start to increase, and everything gets weaker ... The division errors are caused by breaks in DNA strands, so we wanted to strengthen DNA strands. To do it we would read your genome, and then build an auto-repair genomics library of small segments that will replace the broken strands. (*Red* 288)

The gerontological therapy, which according to Ursula "had its origins in the genome project" (*Red* 289), can be seen as a radicalization of a central aim of the HGP—to understand, and thus potentially eradicate, all disease at the base. It intervenes in the very fabric of life itself, postponing or even stopping an inclination towards death. Thanks to the treatment, many of the characters presented at the beginning are still there by the end of the trilogy.

At its introduction, the long-term medical effects of the longevity treatment are still completely unknown; as Ursula makes clear to Sax, "We ourselves are the experiment" (*Red* 288). What is evident from the beginning, however, is that the treatment has revolutionary potentials and will seriously affect population growth. As Ursula explains, "It's very possible you could inoculate everyone on Earth. But the population problem down there is already critical as it is. They'd have to institute some pretty intense population control, or else they'd go Malthusian really fast" (*Red* 289). Ursula's premonition proves valid, for during the trilogy population density grows rampant on Earth. Access to the costly treatment, which is to be rehearsed every few years, is much more difficult in developing countries, and Sax fears "a kind of physicalization of class—a late emergence or retroactive unveiling of Marx's bleak vision—only more extreme than Marx, because now class distinctions would be exhibited as an actual physiological difference caused by a bimodal distribution, something almost akin to speciation ..." (*Green* 279). Genetic enhancement becomes the physical substrate of social status, but now possibly leading to de facto speciation as in H.G. Wells's *The Time Machine* (1895).⁷

SCIENCE AS POLITICS

As with the novels discussed in the previous chapters, the characters in *Mars* find themselves in a strange, problematic situation that refuses to stabilize. Sax Russell, the head of the terraformation project, has a rather simplistic understanding of the situation. His objective is to alter the atmosphere of Mars, without thinking about the wider political consequences for people on Mars or on Earth. For Sax and for many others, the vast space of Mars is a paradise in the sense that it allows them to conduct their experiments without any political interference or societal context. Politics occurs elsewhere—on earth. Even if Sax predicts that "being on Mars will change us in an evolutionary way" (*Red* 88), he does not see how this make the whole project political: "We're a scientific station ... It doesn't necessarily have much politics to it" (*Red* 60). On the other side of the spectrum we find the radical leftist Arkady Bogdanov⁸: "Everything is political ... Nothing more so than this voyage of ours. We are beginning a new society, how could it help but be political?" (*Red* 60). For Arcady, planetary and human transformation are inherently political:

"We have come to Mars for good. We are going to make not only our homes and our food, but also our water and the very air we breathe—all on a planet that has none of these things. We can do this because we have technology to manipulate matter right down to the molecular level. This is an extraordinary ability, think of it! And yet some of us here can accept transforming the entire physical reality of this planet, without doing a single thing to change ourselves, or the way we live. To be twenty-first century scientists on Mars, in fact, but at the same time living within nineteenth-century social systems, and seventeenth-century ideologies. It's absurd, it's crazy, it's-it's ... unscientific! And so I say that among all the many things we transform on Mars, ourselves and our social reality should be among them. We must terraform not only Mars, but ourselves." (*Red* 89)

What is significant about Arkady's statement is that it politicizes the situation *in scientific terms*. From his view, the political stakes are not an add-ons to an otherwise neutral scientific project—instead, on Mars, science rediscovers its practical *raison d'être*, namely changing the world (much in the same way that Marx in his eleventh thesis on Feuerbach declares that "philosophers have only *interpreted* the world, in various ways; the point is to *change* it"). I would argue that Arkady figures as a mouthpiece for Robinson in calling for a new science more attuned to social demands.

Jameson praises Robinson for his sophisticated use of scientific ideas, but still argues that "any first scientific reading of the *Mars* trilogy must eventually develop into a second allegorical one, in which the hard sf content stands revealed as socio-political" (396). In one sense, then, Jameson seems to echo both the character Arkady and Robinson himself in his emphasis on science as politics. Yet at the same time, Jameson's assessment allows him to neglect the content of science-as-politics and focus almost exclusively on the struggles between (cultural) groups. Given the essential role of technoscience in Robinson's narrative—not just socio-politically, but also biophysically—I would argue that scientific content deserves more critical attention. On the one hand, the *Mars* trilogy is unabashedly positive about science as such, "revitalizing," in the words of Carol Franko, "the myth of science and scientists as hero" (545). Yet importantly, Robinson's celebration of science is not a naïve stance—it is critical in at least two ways. First, as demonstrated above, scientists only become true heroes in Robinson's work when they deliberately plunge into the messy world of politics. In other words, for Robinson, political agency is *integral* to science. As Robinson argues in two recent interviews, the scientific method is "actually a way of praxis" (Robinson, "Kim Stanley Robinson" 89), making it "the equivalent of the most powerful leftist politics we have ever had" (Canavan, Sklarr and Vu 204). Scientists should be more aware of their power and dedicate their skills to transforming society for the better of all, including future generations as well as nonhumans. Second, even if Robinson evidently appeals to all scientists and to the scientific method as such, science in *Mars* "is not science as traditionally conceived and practiced" (Leane 99). Robinson seems to be convinced that great challenges require ambitious global experiments. As I will demonstrate, *Mars* promotes a more daring science, not just in the sense of creating even bigger geo-engineering projects, but by allowing itself to change under the influence of new insights, in particular insights about the unpredictability complex systems.

Robinson is critical of sf writers reproducing an instrumentalist view of science, in which science is corrupted by politics, leading to a loss of experimental control and hence disaster.⁹ In the *Mars* trilogy, introducing new technologies is never an easy feat. Projects like the space solleta and the space elevator prove extremely vulnerable to sabotage: they need to be continually modulated and reconsidered in the light of new developments in order to make them *work*. The various perspectives on terraformation amount to a scientific "polyphony," a radical interdisciplinarity. In an interview with the journal *Science Fiction Studies*, Robinson reconfigures biologist E.O. Wilson's idea of "consilience" between the sciences, which states that the human sciences are reducible to biology, and biology reducible to physics. Rather than following this reductionist logic, Robinson argues for systemic holism: "Sociology, anthropology, psychology and the rest of the human sciences are also consilient with biology, chemistry, and physics, and, though the questions are harder, the methods are the same and the answers, when achieved, are part of a whole system" (Canavan, Sklarr and Vu 212). This is exactly what is conveyed in the *Mars* trilogy: the image of a scientific continuum of interacting research fields, a process that is political through-and-through in the sense that it harbors possibilities for control *and* nomadism. Robinson's work can be regarded as a call to scientists to discover the revolutionary potential of their work and explore all kinds of connections to other disciplines. What kind of model could do justice to this radical interdisciplinarity, without risking to become a totalizing theory of everything?

CONSTRUCTIVE INTERACTIONISM

One possible route for thinking about interdisciplinarity and scientific content in the *Mars* trilogy is Oyama's Developmental Systems Theory (DST) first developed in *The Ontogeny of Information* (1985) and reworked in *Evolution's Eye: A Systems View of the Biology-Culture Divide* (2000). In her work Oyama asserts that the concept of information, as used in the biosciences, needs to be reconsidered in order to reclaim the primacy of the whole organism-in-development. Central to Oyama's work is a desire to think of the living as immanent to many entangled factors within and without the cell:

As the notion of centralized control of development gives way to the developmental system, the view of heredity is enlarged beyond the germ cell to encompass other developmental means or resources. (...) this increases the number of ways in which developmental influences can act transgenerationally, altering the relationship between developmental and evolutionary processes. (*Evolution's Eye* 207)

By including many environmental factors, Oyama suggests that the developmental paths of organisms and the long-term processes of evolution are much more profoundly related than the dominant neo-Darwinist/molecular paradigm allows. Denouncing the famous nature-nurture debate, Oyama argues that traits in organisms are never caused by nature *or* nurture, neither are they *partly* natural and *partly* cultural. This dichotomy, so Oyama argues, represents a failed attempt to determine the causes of life as if they were attributable to given substances

and/or learned habits, when causality is in fact a heterogeneous and emergent phenomenon pertaining to organisms and ecosystems (Oyama *Evolution's Eye*; "Terms in Tension").

DST has been developed by many other scientists working in the fields of evolutionary biology, developmental biology, and psychobiology. It replaces dualisms such as information-organism and genotype-phenotype with a topological model, i.e. a model of continuity and connection. As Rehmann-Sutter explains about DST, "the information which in-forms developmental steps, does not pre-exist the processes that give rise to it. Information, in the sense of developmentally relevant information, is produced in the course of the interactive processes of the cell, the organism and the environment"(43). Oyama calls this "constructive interactionism," distinguishing her approach from "weak interactionisms" prevalent in the biosciences and beyond, which stress the ways in which the environment has a role to play, but merely as an external (often distorting) influence (*Evolution's Eye*). Weak interactionism reaffirms the idea of a relatively stable natural essence (genetic information) that is only secondarily regulated or selected. Constructive interactionism represents a immanentist approach in which ecological systems are irreducible to genomes and cannot be measured against an environmental or evolutionary background. The environment and evolution are not external entities, not things we are "in"; space and time are parameters rather than conditions of systems. Oyama's immanentist approach to the living resonates strongly with Deleuze's work, in particular with the notions of "the virtual" and "the actual" which Deleuze takes from the biologist and philosopher Henri Bergson. In DST, the organism is never reducible to a past or present state: it is implicated in virtuality or potentiality. This potential cannot be pin-pointed—for example, it is not "internal," "biological" or "genetic." The notion of virtuality is exemplified by the embryo, an emergent body whose contours are highly vague and that has not yet developed into a self-sufficient organism. However, the same holds for ontogeny and phylogeny in general: as Bergson pointed out, even mature organisms are characterized by "the insensible, infinitely graduated, continuance of the change of form" (19).

The notion of constructive interactionism gives rise to an extended view of inheritance: organisms do not inherit just DNA, but a developmental system in which the genome plays one part (Griffiths and Gray 421-22). Important precursors of this extension are Von Uexküll's ethology and Lewontin's work on ecological niche-construction, which have demonstrated that organisms actively select and modify their environments rather than being passively selected by their environments. The relatively static opposition between organism and environment breaks down and is replaced by a nested ecology of systems (hormonal, neural, cognitive, social, etc.) that link individual stretches of DNA, proteins, organelles, cells, organs, organisms, and ecosystems. This epigenetic field determines what can be done with genes (Griffiths and Stotz). As Karola Stotz explains, "The fact that even the structural identity of a gene is created by genome regulatory mechanisms and its environmental conditions makes it very difficult to draw a clear boundary between 'gene' and 'environment'" (Stotz, "With Genes" 914).¹⁰ The idea of extended inheritance suggests a rethinking of the organism-environment dualism: rather than there being one neutral environment exerting influence on individuals, each individual uniquely expresses potentials that inhere not "in" its body or "in" the environment, but in embodied and enacted relations.

Where the work of Oyama pushes the boundaries of inheritance through philosophical and scientific argumentation, the *Mars* trilogy provides a literary scenario in which these ideas come to life, as it were. The genetic engineering of organisms and the chemical engineering of Mars's atmosphere effectuate a speeding up of processes, revealing that development and evolution are much more intimately related than neo-Darwinism allows them to be. In *Mars*, inheritance is not subdivided in the modern categories of nature and culture, but rather becomes a continuum of physical, biological, social, political, technological and psychological evolution. Ultimately, it is really the problem-event called "life on Mars" that evolves: apart from documenting the adventures of human individuals and populations, the trilogy is also a non-anthropocentric story about relations between systems. Thus history becomes infused with those biophysical processes that are so often pictured as mere decorum to human action, while simultaneously the meaning of human existence is placed in a planetary if not cosmological order of things. It is this entanglement of physical, biological and anthropomorphic processes that necessitates the collaboration of scientists in *Mars*.

As we shall see below, the connection between Mars and Oyama's work can be discerned on the level of (quasi-)scientific descriptions of transformation, but equally important is the dimension of a non-anthropocentric *ontology* that resonates with what Braidotti calls "a nomadic eco-philosophy of multiple belongings," which produces "an enlarged sense of interconnection between self and others, including the non-human or 'earth' others" (*Transpositions* 35). The trilogy recounts, and calls for, a transition from anthropocentric thought to an ecological paradigm.

FROM RED TO GREEN

In *Red Mars*, it is mission leader John Boone who is most aware of the fragility of the experiment in which scientists of various (cultural) backgrounds need to cooperate. He participates in rituals and celebrations of all the different Martian communities, exchanging ideas about the future of Mars. Like Arkady, John wants to think of the First Hundred as "a collection of friends" (*Red* 365) working with different sets of ideas but for the same goal: a viable Martian society. In a time when the UN has become a body dominated by super-states as well as transnational corporations, John is in search of a new type of political unity from the bottom up. He organizes a constitutional congress, which he provocatively describes as an occasion to determine "the genome of our social organization" (*Red* 379). His speech given at the advent of the gathering is relevant for my argument because it highlights a moment when the link between biology and sociality can only still be articulated in metaphorical terms:

Now I know I used to say we had to invent it all from scratch but in these last few years traveling around and meeting you all I've seen that I was wrong to say that, it's not like we have nothing and are being forced to conjure forms godlike out of the vacuum—we have the genes you might say, the memes as Vlad says meaning our cultural genes, so that it's in the nature of an act of genetic engineering what we do here, we have the DNA pieces of culture all made and broken and mixed by history, and we can choose and cut and clip

together from what's best in that gene pool, knit it all together the way the Swiss did their constitution, or the Sufi's their worship, or the way the Acheron group made their latest fast lichen (*Red* 379)

John is assassinated just before the break-out of revolutionary turmoil in which the space elevator is destroyed, separating Mars from Earth for decades to come. Many people are killed and a police force takes control; the revolutionaries flee into hitherto uninhabited regions. What was designed by John as a first, small step towards a new society, emanating organically from the people on Mars, turns out a vain attempt to impose the image of "a collection of friends" on a still immature Martian society. In *Green Mars* it will become clear that a true "cultivation" of Mars must be social *and* biological: based on a greening of the world and a new, transformed *Homo ares*. This new human being will not only be the result of biotechnological intervention and "social engineering" (the title of a chapter in *Green Mars*), but also of gradual, largely imperceptible transformations. As John's daughter Jacky will formulate it years later: "We terraform the planet ... but the planet areoforms us" (*Green* 457).

While William White typifies *Red Mars* as "a kind of prologue, the final failure of an old political paradigm" (585), I would add that it also demonstrates the dangers of control science and marks the birth of nomadic approaches to life on Mars. In the opening passage of *Green Mars*, which was also cited in chapter 1, the narrator opens up the neo-Darwinist paradigm to the agency inherent in the ecological environment:

Of course all the genetic templates for our new biota are Terran; the minds designing them are Terran; but the terrain is Martian. And terrain is a powerful genetic engineer, determining what flourishes and what doesn't, pushing along progressive differentiation, and thus the evolution of new species. And as the generations pass, all the members of a biosphere evolve together, adapting to their terrain in a complex communal response, a creative self-designing ability. This process, no matter how much we intervene in it, is essentially out of our control. Genes mutate, creatures evolve: a new biosphere emerges, and with it a new noosphere. And eventually the designers' minds, along with everything else, have been forever changed. (13)

After the disastrous events at the end of *Red Mars*, this introductory statement sets an entirely different tone. It indicates that a real transmutation of Mars will not transpire as a result of the "guided" terraformation initiated in *Red Mars*. What started as a statist and corporate mission develops into story about a new world, a situation in which Mars and its inhabitants are "constantly undergoing alchemical transmutations" (Markley 794). The birth of nomad science is obscure, occurring beyond the disputes between Greens and Reds that linger out throughout the trilogy. By the end of the *Blue Mars*, the two protagonists representing these antagonistic positions, Sax and Ann, finally come together as lovers and the debate appears to be resolved, synthesized in a new color for Mars: blue or purple. There is a weakness in this debate which sometimes makes it quite tiresome to follow it: from the beginning it is obvious that Ann's position—the preservation of Mars *as it was*—is simply untenable. Even just by participating

in the mission, Ann is acting against her own views. It is not surprisingly that her following is unable to become a constructive ally to the other groups, only able to say "no" and to destroy what is being built. There are two characters who, remaining outside this polemic, are able to perceive and construct a new, truly different Mars: Hiroko Ai and Desmond Hawkins.

Hiroko is a biologist working mainly on agriculture for the purpose of food production. From the beginning she is an intriguing outsider with a mystical bent, keeping mostly silent and occasionally outing statements such as "Mars will tell us what it wants and then we'll have to do it" (*Red* 115). During the political unrest, she flees with her team and remains under the radar of the mission leaders and the police. Hiroko had been responsible taking a stowaway on board, her former lover Desmond who on Mars becomes known as Coyote.¹¹ Coyote is not a scientist, but an adventurer scavenging Mars who falls in love with the planet. Both Hiroko and Coyote are nomadic figures whose lives remain largely unknown to other characters and to the reader. They are, however, hardly absent: Hiroko is the key figure in the birth of a native Martian underground, and Coyote becomes a crucial mediator connecting the myriad islands of the underground, building up a new "eco-economical" society on the principles of Hiroko's ideas. The ideas and actions of Hiroko's underground movement do not so much oppose the dominant order in the way Ann's red movement does, as modulate it.

The reader first learns about Hiroko's rather literal "underground" by the very end of *Red Mars*, when Coyote escorts a group of scientists fleeing the (anti)revolutionary violence. After a hazardous voyage to the Martian icecap, the party enters into a tunnel that leads them into a large dome "several kilometers in diameter" (572). The dome's floor is covered with a red soil, vegetation, and it accommodates an entire village made of bamboo as well as a big lake. In the dramatic last sentence of *Red Mars*, Hiroko greets the refugees with the words, "This is home ... this is where we start again" (572). In the underground village, named Zygote, the group not only encounters Vlad and Ursula's biomedical team and other members of the First Hundred, but also a group of children. The children are called "ectogenes": they were born through ectogenesis, that is, in an artificial uterus. During spirito-sexual ritual, Hiroko had collected the semen of many of the First Hundred, which she then used to give birth to her own children. Few moral questions are raised in the trilogy considering Hiroko's experiment.¹²

Hiroko's spiritual ideas are encapsulated in her concept of viriditas¹³, a "greening fructiparous power within" (*Red* 229). This is how Hiroko explains her concept to the children at Zygote through the example of a seashell:

The dappled whorl, curving inward to infinity. That's the shape of the universe itself. There's a constant pressure, pushing toward pattern. A tendency in matter to evolve into ever more complex forms. It's a kind of pattern gravity, a holy greening power we call viriditas, and it is the driving force in the cosmos. (*Green* 20-21)

Resisting the reductionist tendency to dissect the world into ever smaller units, the notion of viriditas expresses connectedness and continuity. In scholarship on the trilogy, Hiroko's ideas are often characterized as a mystical, for example by White who dubs Hiroko "the high-priestess of the areophany" (586), and by Jameson, whose argues that Hiroko "negates empirical

reality in the spirit of an ideal" (*Archaeologies* 405). This way, scholars have overlooked Hiroko's role as scientist. While acknowledging Hiroko's spiritual bent, I argue that Hiroko's ectogenetic experiment can be theorized as nomad science, for it escapes and simultaneously radicalizes the projects of human enhancement and terraformation. The creation of artificial wombs and of a large womb-like cavity in the ice may suggest that Hiroko is conducting a controlled experiment, but this is evidently not the case. Rather, Hiroko's exile is the only way to escape from the demands of governments and industries. Within the confines of the underground, both human enhancement and terraformation become de-instrumentalized experiments of *becoming* without a pre-set goal. Life on Mars is placed in the cosmological context of planetary evolution and spreading viriditas throughout the universe.¹⁴

Hiroko's nomad science can be further illuminated by juxtaposing it with the control science of Sax, who despite some significant transformations remains the quintessential representative of "ultra-reductionist scientism" (Leane 95). In a conversation with psychologist Michel he typifies science as "a system for generating answers" (*Green* 502): in the end, for Sax, anything can and should be understood by science. Sax is increasingly frustrated by the fact that the process of terraformation does not follow the trajectory he had calculated at its incipience. Michel, tells Sax that he is suffering from monocausotaxophilia: "the love of single causes that explain everything" (503). Undoubtedly inspired by Hiroko, Michel tries to persuade Sax to follow another line of thinking:

The scientist's job is to explore everything. No matter the difficulties! To stay open, to accept ambiguity. To attempt to fuse with the object of knowledge. To admit that there are values shot through the whole enterprise. To love it. To work towards discovering the values by which we should live. To work to enact those values in the world. To explore—and more than that—to create! (506).

Only after having been confronted with (anti)revolutionary violence, Sax experiences a partial conversion to a more nomadic mode of science, no longer able to neatly separate science and politics. He departs from his central position within the terraformation project, travelling about in search of new forms of ecological development and new ideas, open to what the planet might teach him.

I would argue that in Hiroko's case, spirituality is an integral part of nomad science, allowing her to think the planet itself as agential and thereby challenging the idea that terraformation can be controlled by humans. According to Hiroko's areology, Mars is not merely a site for colonization but rather the home of a new humanity. In some ways, Hiroko's ideas are actually more sober than those of Sax: DNA is not a holy grail leading to perfect knowledge and endless opportunities for control. Like Oyama's constructive interactionism, areology can be seen a form of thought that resists transcendental "hidden" truths, desiring openness. Oyama's plea to "reinsert ourselves into the world" resonates strongly with Robinson's literary experiment:

Can it be that if we really reinsert ourselves into the world, see our development, investigations, and technological control as actions within a network that we support

and alter and that supports and alters us, see freedom and responsibility not as denials of causality but as a particularly human acknowledgement of it, if we see nature, including our own, as multilayered and constructed in development, not prior to it, if we see the world as truly our home ... with all the loving reliance, multiple attachments, pride, and farsighted maintenance that "home" entails, is it possible that we will no longer need a mystical hidden message? Is it possible that the only message is our lives in our world and the life of our world in its universe? (Oyama, *The Ontogeny* 193)

Hiroko's areology is exactly a way of reinserting, *introducing*, humans—not in *the* world, but in *a* world—to discern the networks we participate in. Much more forcefully than the novels discussed in the previous chapters, *Mars* presents the idea of the planet, and even the cosmos, as a home and a laboratory, linking scientific, social, psychological, biological, physical and chemical processes.

GREENING POWER

The *Mars* trilogy can be read as a thought-experiment with planetary science and politics in which personal, historical, evolutionary and cosmic processes begin to coalesce. I agree with Markley that the cosmological aspect of *Mars* is presented not merely as an ideological sauce accompanying the technoscientific main dish, but as a matter-of-fact investment in "an eco-centric turn toward holism" (773)—or, as mission leader John Boone phrases it, "thinking seven generations back and seven generations forward" (*Red* 379). This concern with the long term also motivates Arkady—although as a Red, he seems to be more concerned with socio-political dynamics rather than with ecology:

Shortness of life was a primary force in the permanence of institutions, strange enough it is to say it. But it is so much easier to hold on to whatever short-term survival scheme you have, rather than risking it all on a new plan that might not work—no matter how destructive your short-term plan might be for the following generations. Let them deal with it, you know. And really, to give them their due, by the time people learned the system they were old and dying. And for the next generation it was all there, massive and entrenched and having to be learned all over again. But look, if you learn it, and then stare at it for fifty more years, you will eventually be saying: Why not make this more rational? Why not make it closer to our heart's desire? What's stopping us? (*Red* 340)

The "normal" human life cycle, Arkady suggests, is simply unfit for grappling with the dynamics of a rapidly developing technoscientific society. Human lives on Mars need to be synchronized with humanity's terraforming ambitions. The same type of argument is developed in *Green Mars* by members of the underground on a more ecological note: human society ought to be synchronized with long-term planetary dynamics, including climatological systems, water systems, and ecosystems, a process that cannot simply be modeled "in advance" but must be modulated in the midst of things.

In *Green Mars*, a new society and a new planetary ecology emerges, with its own native inhabitants. This transmutation of humans is largely epigenetic, in other words, induced by influences of the environment on the genome. As a narrator recounts, the difference between the generations is that the second one is truly *Martian*:

they were different, sharing interests and enthusiasms perfectly incommunicable to any other generation, as if genetic drift or disruptive selection had produced a bimodal distribution, so that members of the old *Homo sapiens* were now cohabiting the planet with a new *Homo ares*, creatures tall and slender and graceful and utterly at home. (592)

What was designed as a project expanding the reaches of humankind, turns out to be the advent of a "bimodal distribution"—the splitting of populations over multiple locations, resulting in genetic variations—a phenomenon already described by Darwin, most famously in the example of different variations of finches on the Galápagos islands. A narrator even suggests that novel variations are the beginning of a "new species" of humans (628). The rather immediate emergence of variations is also manifested on the level of behavior. For Martian natives, enormous projects such as creating a sea "the size of the Caribbean" are completely normal: "It was their work, their life—to them it was human scale, there was nothing unnatural about it" (593). While the scientific validity of Robinson's account of epigenetic transmutation can be debated, I am more concerned with a number of mutually constitutive assumptions undergirding his trilogy as well as Oyama's work: (1) species can and do change in response to their environments, (2) species and environments are interactively constructed, (3) acquired mutations in the genome are heritable.

The relevance of constructive interactionism for understanding the *Mars* trilogy is evinced in two key concepts evolving from Hiroko's experiment: eco-economics and ecopoiesis. The former term is an attempt to go beyond economic models that take the environment as a construction site and a reservoir of resources: ecology becomes an integral element of economy. Eco-economics involves a systems of gifts and barter, where value is expressed not in something as abstract as money, but in calories, and efficiency is measured by the input/out rate of calories (*Green* 463-66). In eco-economics, the value existing in the environment and the wastefulness of human behaviors can no longer be neglected. In eco-economics one never invests solely in oneself, a company or a nation—one invests in an ecology. As Markley has argued, eco-economics can only be a viable option because the barriers between behavior and being, sociality and biology, have been broken down in historical experience: "Viriditas, then, is not a simulation or thought experiment imposed on Mars but the embodied experience of participating in the evolution of green life on a red planet ... Conscious political intentions and philosophical positions are acted upon and sublimated by the land itself, fostering complex processes of ideational as well as genetic evolution" (786). Similar to the "trade" in *Lilith's Brood* discussed in the previous chapter, eco-economics is a nomadic practice which, rather than imposing a grid on the world, affirms the potentials for transformation inherent in the world—viriditas—allowing oneself to become part of a cosmic, evolutionary trade.

The aptitude and desire to live in a new Martian world is most evident in the character of Nirgal, son of Hiroko and Coyote. Nirgal is able to sense the temperature with incredible accu-

racy and, even more incredibly, has some kind of ill-understood control over temperature. During one of his trips, Nirgal is able to save Sax's life, who had become trapped in a blizzard while studying new mutant species, by raising Sax's body temperature—he "poured into Sax every bit of viriditas he could muster" (*Green* 354). Although in the trilogy the capacity to sense and control temperature is only exhibited by Nirgal, the entire native generation has become physiologically adapted to Martian gravity and more skilled at navigating the Martian landscape. This is evidenced in a new, unnamed sport that somewhat resembles the French phenomenon of *parcours* (a free run through the city ignoring designated paths and involving acrobatic maneuvers). First performed by Nirgal, the new sport is simply about reaching a particular place, typically hundreds of miles away, before the other contestants do. The matches last for days or weeks and require not only endurance and running skills, but an ability to choose the right routes, to read the landscape, and to survive. A quick comparison between Nirgal, Coyote, and Art (a terrestrial immigrant who joined the resistance) is revealing: "Coyote knew the land, and ran in short mincing dance steps, efficient and clean. Art bombed over the landscape like a badly programmed robot, staggering often as he hit wrong in the starlight, but keeping up a pretty good head of steam nevertheless. Nirgal ranged in front of them like a dog" (360). The narrator also compares Nirgal to a tiger, a cheetah-bear and a springbok (363). Living in the open as a nomad clearly requires being more attentive to one's surroundings than humans have come to be. It seems that Mars offers not so much a clean start as a trigger to actualize latent capacities for sensation and movement in a new ecological context. The match between Nirgal, Coyote and Art is emblematic for the relationship between the new generation and their terrestrial ancestors: there is a friendship, but differences produce a distance between the generations that is often experienced as painful by both. When Nirgal tries to bridge that distance by getting to know his father, and later on visiting Earth, he ends up disillusioned. On Earth he contracts a virus that makes him ill and his body aches from the change in G force. Coyote and Nirgal, whose relationship is one of dispassionate respect, lead their lives as nomads without a sense of belonging.

The eco-economic network of underground communities that emerges around Zygote, characterized by one ectogene as "a kind of Polynesia" (427), is by no means under centralized control by Hiroko, Coyote or anyone else. The network is, in Deleuze and Guattari's terms, deterritorialized: rather than uniting the community within certain legal, political and economic structures, it remains a "movement"—diffuse and incipient, but effective nonetheless. Eco-economics can be seen as a reframing of the "eco"/*oikos* in economics: a deterritorialized home, in which the human body is not primarily a consumption machine but rather constructive and transient, and where nonhuman bodies play important roles. In order to gain momentum for their utopian ideas, the Greens strike an alliance with a terrestrial supranational organization called Praxis, that wants to invest in Mars's ecosphere. As Praxis delegate William Fort explains, "Essentially it's infrastructure investment, but at the most basic biophysical level. Infra-infrastructure, so to speak, or bio-infrastructure" (112). Fort stresses that Praxis's model is non-capitalist, in the sense that it is not based on expansion, but an investment in communities and landscapes, and an effort to connect the two in constructive, durable ways: "We need to grow inward, to recomplicate" (480). The ideas developed by Praxis and the underground

are Robinson's own. In an interview he states that our capitalist economy is in many ways continuous with feudalism, and that economy as a discipline needs to be restructured in order to be "not just the astrology of the ruling class but actually a way of calculating costs and benefits" (Buhle 89).

In *Mars*, thinking "big" is complemented by local practices emerging from the underground and eventually proliferating in a climate that has become less oppressive. In *Blue Mars*, when Nirgal returns from his voyage to Earth he discovers to his joy that all over Mars, new agricultural native communities are flourishing, so-called "gardeners" toiling the land in innovative, sustainable ways not to make profit, but to make a living and to develop Mars: "They followed the inclination of the land, as they saw that some plants prospered, and others died. Co-evolution, a kind of epigenetic development" (*Blue* 91). The methods of gardeners are not claimed to be more "natural." What matters is that they nomadically "follow the inclination of the land," attending to the singularities of living systems rather than modifying the alleged "essence" of a particular species. The gardeners advocate the idea of "ecopoiesis," which, as one gardener explains it, is terraformation "redefined, subtilized, localized. Transmuted into something closer to Hiroko's areoformation. No longer powered by heavy industrial global methods, but by the slow, steady, and intensely local process of working on individual patches of land" (*Blue Mars* 91). Importantly, the gardeners' communities do not represent utopias in which all science has become nomadic. The spread of these local communities was made possible by the terraformation project, which had led to the partial melting of Mars's icecap, creating new oceans and seas and more wild life, and the engineering of the atmosphere, which has become breathable for human beings and other animals. But the role of biotechnology has been modified, much in the way that Vroom, Ruivenkamp, and Jongerden have argued for the need to "endogenize" (22) agricultural biotechnology according to local circumstances.

CONCLUSION

Although the romantic joining of Ann and Sax in the final part of the trilogy seems to symbolize a new balance, the prospects for Mars are neither comfortable nor clear. Martian society has been able to pass through episodes of revolutionary fervor, negotiating the terms of governance and the status of Mars vis à vis the Earth, partly because immigration of terrestrials has been restricted. Eco-economic living on Mars is still inchoate and vulnerable, and it is unclear what will happen if terrestrials start pouring in, now that the Red resistance to terraformation has waned. Mass immigration of terrestrials is a real option, since the political and physical climates on Earth are radically destabilized. Nirgal, cultural icon of the new Mars, is in favor of an open attitude toward Earth. For him it is clear that, just as the experiments of the underground resistance flow over into Martian society as a whole, the Martian adventure as such is a "simulation" whose lessons must be applied on Earth to save its societies and ecologies from collapse. The two worlds cannot be separated. The utopian "moment" in Robinson's trilogy is nomadic: open and in becoming, a problematization that cannot be framed as a problem in/of Mars or the Earth, nature or culture, the sciences or the Humanities. To cite again the words of Deleuze and Guattari at the beginning of this chapter, in *Mars* revolution is "absolute deter-

itorialization," effectuated not by the oppositional politics of the Reds, but through Hiroko's radicalization of terraformation, her experiment-in-an-experiment, that gives birth to "a new earth and a new people" (*What is Philosophy* 101). To put it in Nietzschean terms, absolute deterritorialization cannot be achieved by saying "no" or by clinging onto an original Martian identity: it means saying "yes" in the manner of a risky transmutation of values and of humanity itself, an affirmation of nonhuman life pervading the human.

Immensely enthusiastic and critical about the potentials of science, Robinson puts a nomadic spin on E.O. Wilson's notion of "consilience," deterritorializing the sciences as well as the divisions between the sciences and the Humanities to establish non-hierarchical, experimental relations. This leads to hybrids such as eco-economics, which goes beyond atomistic (individualist) models, pointing towards a new *relational* economics that takes the community and the environment as primary (Daly and Cobb). Implicated with eco-economics, another mode of bioscience emerges in *Mars* that studies organic life as an open system, in continuous constructive interaction with the physical and anthropomorphic strata. Robinson's meshing of scales and dimensions, while uprooting modern divisions between personal, historical, spiritual, evolutionary, and cosmic temporalities, never ends up in either chaos or a theory of everything. Instead, the event of transformation becomes the locus of a new, socially robust biotechnoscience as well as a new "biohumanities" (Stotz, Bostanci and Griffith 5) endowed with the challenge of rethinking human affairs within expanded planetary and temporal horizons. Reinserting biology into the world and connecting evolution to history, Oyama's and Robinson's constructive interactionisms constitute calls for nomadic interdisciplinarity, a call much needed in a time when interdisciplinarity has become a norm.

PART 3

A NEW PEOPLE
AND A NEW EARTH

NOMAD SCIENCE AND COSMIC LIFE

Today we live in an evolutionary universe, where change is endemic to how we see the universe and ourselves.

– Dorion Sagan and Eric D. Schneider –

INTRODUCTION

More than ever before, science is becoming a collective enterprise, increasingly organized in interdisciplinary and international research consortia and networks. Yet there are still individuals and small scientific communities who operate relatively independent from such structures, and it is these scientists who are more apt to produce truly nomadic ideas beyond the immediate goals of control science. Like nomad writers and philosophers, nomad scientists are, to a certain extent, what Deleuze calls “private thinkers” as opposed to “public professors” (*Difference* 7-8). Paradoxically, it is this privacy that is the precondition for cultivating new forms of belonging. Referring to Kafka’s short story “Investigations of a Dog,” which recounts one dog’s relentless questioning of his surroundings and experiences, Deleuze and Guattari write, “If the writer is in the margins or completely outside his or her fragile community, this situation allows the writer all the more possibility to express another possible community and to forge the means for another consciousness and another sensibility; just as the dog of ‘Investigations’ calls out in his solitude to *another science*” (*Kafka* 17).¹ If the task of individual thinkers is to invent a new world and create the conditions for another “possible community,” then this can be translated in biological terms as creating new *modes of relating* (desires, attitudes, practices, ideas) to the human species and its ecological environments. As the previous chapters have demonstrated, this reinvention of biology crucially involves

a planetary and, ultimately, cosmic perspective, decentering the role of the human as well as the genome.

The crucial role of individuals in science is foregrounded in the sf novels discussed in this thesis. In *DR*, genomicist Kay Lang and archaeologist Mitch Rafelson are expelled by their scientific communities, pursuing the problem of retroviral activation (SHEVA) in secret. Their scientific intuitions and encounters lead to the birth of a different human being with new cognitive capabilities, adapted to a world radically transformed by technoscience. In *LB* the prospect of a viable (post)human future also, ultimately, depends on individual efforts. If the extraterrestrial Oankali seem to shift between control science and nomad science, carefully monitoring yet deliberately leaving open the experiment of species merger, a real break-through is reached by the human-Oankali hybrid Akin, who becomes the pioneer of a new community. Robinson's *Mars* trilogy finally, moves toward a sustainable planetary system mainly due to the controversial yet much admired biologist Hiroko Ai, who disappears to become the biological and spiritual mother of a new underground community of *Homo ares* raised on principles of sustainability. To understand nomad science and its relation to life, it seems logical to zoom in on the practices and attitudes of these protagonists, seeing how they affect the future of human populations and their environments.

It should be clear, however, that the analysis of individual actions is not intended to imply individualism—the mythic image of a genius who single-handedly transforms science—or an attempt to rigidly categorize scientists as either nomadic or collectively organized. Scientists working within institutions and disciplines can be propelled by nomadic desires. As observed in the discussion of Craig Venter's work in chapter 1, the image of the scientific pioneer often presented in popular accounts of science has clear nomadic features, but it all too often amounts to a reterritorialization on state interests, profit, or personal gain. As Stengers argues in *Cosmopolitics II*, nomadism and control need to be evaluated *in particular contexts*:

It is not a question of identifying "nomadic" and "sedentary" individuals but of identifying them only in relation to a given interaction, of creating a contrast whose scope does not exceed that interaction. Those who appear as sedentary on the basis of a given interaction may well take risks in an elsewhere foreign to the "nomads" who judge them. Within such spaces, these nomadic judges may seem as hopelessly sedentary, desperately tied to a territory that assigns limits and conditions to the risks they boast of. (364)

What Stengers conveys here is that the nomad-sedentary distinction is not a simple opposition, but an asymmetrical, paradoxical pair that applies to dynamic "interactions." In the light of this dynamic understanding of nomad science, it is undesirable to use the concept of nomad science in a mode of (self-)identification. Control and nomad science are not simply labels, but tendencies that can be seen in various degrees in individuals and groups. Accordingly, nomad science and "nomad scientist" should not be read as universal types nor as (personal) identities, but as a assemblage of desires, attitudes, practices and ideas.

The present chapter draws together and expands on observations about nomad scientists and nomad science in the previous chapters. It is not my ambition to provide an exhaustive list

as if Deleuze and Guattari's concepts perfectly map onto the works of the writers and scientists discussed. Because of its fluid and vague nature, nomad science resists attempts at neat delineation or synthesis. Rather, I assemble associated notions in clusters that capture certain aspects of nomad science. For example, the series "following—opening up—interacting" conveys various ways in which nomad science stays intimately close to its objects of study, while remaining open and responsive to them.

In the first part of this chapter I gather *desires, attitudes, and practices* of nomad science from the literary texts. Nomad science, here, is first of all a style or *way of doing science*. Minor sf dramatizes the desires, attitudes and practices of nomad science through the adventures of its protagonists, who investigate and participate in a complex transformation of humanity and its world. Rather than trying to survey and control the situation, these protagonists become implicated in the unfolding problem-event, roaming a no-man's land between knowledge and the unknowable. The second part of the chapter goes on to analyze the *fundamental ideas* of nomad science particularly on the question of life. Here I shift the focus to the contributions of scientists analyzed in the previous chapters, for whom life is inherently creative, not just reproducing its conditions of production but exploring new possibilities for recombination and transformation. In making a distinction between desires, attitudes and practices on the one hand, and fundamental ideas on the other hand, I do not mean to suggest that these aspects are separable in an absolute sense. It would be interesting to see if and how the nomadic desires, attitudes and practices in the novels also exist in real scientists; this would require biographical, ethnographic and other types of research that transcend the scope of this thesis. The reason for the present chapter structure is entirely pragmatic: the sf novels appear to be especially useful for gaining insight into the *ways* of a nomad scientist, while science writing provides thickly described scientific content. The conclusion to this chapter will reflect on the differences and contradictions between the different texts.

PART I: WHAT IS NOMAD SCIENCE?

Mobility — Encounter — Disappearance

Deleuze and Guattari argue that if nomad scientists obtain a certain independence from (state) power, this independence is ephemeral because the state is continuously looking to bind them to their goals: "Ambulant procedures and processes are necessarily tied to a striated space—always formalized by royal science—which deprives them of their model, submits them to its own model, and allows them to exist only in the capacity of 'technologies' or 'applied science'" (411). Yet nomad science is not always containable. As the novels show, nomad scientists' unquenchable thirst for problematization takes them beyond the confines of institutions and research communities. In *DR*, Kay and Mitch are expelled by their scientific communities for pursuing scientific questions that are politically sensitive. They travel around the country, trying to remain invisible to the authorities while looking for alliances with scientist, journalists and others who are willing to support their research. Kay places their journey in a scientific tradition, comparing it with the struggles of Darwin and Margulis (88). Scientists in the *Mars* trilogy

are equally mobile—the mission itself can be seen as a great scientific field trip without return. The prospect of a new society on Mars founded on scientific principles spawns a myriad of utopian plans. On Mars mission leader John Boone travels between the various research teams, trying to create a sense of conviviality in the Martian colony by promoting the idea of a new, truly Martian society uncontaminated by terrestrial politics. In the revolutionary turmoil Boone is assassinated. The mission, which first seemed to veer away from immediate terrestrial concerns, reterritorializes. However, a small group of scientists under the leadership of Hiroko manage to disappear and set up an underground community under the ice, invisible to radars.

In Butler's trilogy the motifs of mobility, encounter and disappearance attain hyperbolic status. *LB* offers a glimpse of the mobile existence of the Oankali, who on their animate "ship" *Chkahichdahk* look for new life forms that will allow them to recombine, transform and disseminate. The Oankali's encounter with humanity can be seen as an "evolutionary experiment" that is scientific, but never fully controlled. They proceed carefully, exposing themselves to humans in a sequence of simulated environments. This leads to many (attempts at) escape by humans, including Lilith, who eventually acquiesces in a life with the Oankali. Her hybrid son Akin also passes through various environments and disappears several times. Akin's flexibility, which exceeds that of the Oankali, is crucial for his experimental field work that will take him through several stages of transformation and towards a (precarious) new beginning.

Following — Opening up — Interacting

Closely related to mobility is the notion of following, which is important in Deleuze and Guattari's description of nomad science. In *A Thousand Plateaus* Deleuze and Guattari propose that nomad science has a special sensitivity to the singularities of matter. In the case of working with materials such as wood, "it is a question of surrendering to the wood, then *following* where it leads by connecting operations to a materiality, instead of imposing a form upon matter" (451; my emphasis). I would argue that the idea of following is not just applicable to materials, but to any phenomenon. Thus in *DR*, Kay and Mitch *follow* the unfolding of SHEVA without immediately reaching conclusions, faithful to its complexity and open to any possible consequences. This practice of opening up to the object of research is also prevalent in *LB*. Although it sometimes appears that the Oankali are orchestrating the encounter, the success of the experiment depends on all participants' ability to open up to the other. Humans are not simply repositories of genetic material for Oankali science, but active partners in co-evolution. The necessity of opening up becomes most intense with the adventures of Akin, who disappears from Lo and starts following human settlers. In a series of metamorphoses, Akin's body becomes increasingly malleable, adapting to his environments in chameleon-like ways. When coming near human beings, Akin's body attains a more human, less repulsive form. Akin is finally able to break the "terrestrial characteristic" of hierarchy that kept humans in their oppositional and doomed positions (39). Butler's narrative is a utopian narrative not in the sense of offering a synthesis, but in showing the importance of coping with differences in a non-hierarchical manner.

The same kind of interaction with the environment is found in *Mars*. The mission is an incredible challenge for its participants in terms of adapting to the circumstances on Mars—climatic,

gravitational, social and so on. Hiroko is the architect of areoformation, a social and scientific model akin to what Oyama calls "constructivist interaction," which is placed against the dominant model of terraformation based on controlled (genetic) modification. Hiroko's son Nirgal becomes a symbol of Martian identity and the prime mouth piece of her ideology. He has strange capacities including the ability to sense and control temperature, which supposedly emerged as response to Martian climate (although such explanation is not given in the trilogy). In a speech he dramatizes the physical and emotional impact of place: "Our bodies are made of atoms that until recently were part of the regolith ... We are Martian through and through. We are living pieces of Mars. We are human beings who have made a permanent commitment to this planet. It is our home. And we can never go back" (*Green Mars* 739-40). The concept of areology, which will give rise to sustainable modes of relating to the Martian environment ("ecopoiesis"), instantiates Deleuze and Guattari's idea that nomad science has a great sensitivity to the singularities of matter.

Risk — Secrecy — Resistance

The novels under scrutiny arguably reveal that nomad science entails risks on the part of scientists and whole populations. The nomad scientist is an adventurer, choosing, in Isabelle Stengers words, to "detach herself from her beliefs in order to challenge them and to follow a problem wherever it may lead" (*Cosmopolitics II* 363). In comparison, the experiments of control science are organized in such a way that (health) risks are minimized. In *Mars*, the work of psychologist Michel, the development of enhancement drugs and the introduction of the genetic longevity treatment all contribute to the health and stability of the Martian communities. Likewise, in *LB* the Oankali carefully prevent the diminished human population from succumbing to disease or social conflict. In both trilogies, individuals arise who, often in secret, radicalize the experiment, creating nomadic ways of living and allowing life to transform without top-down control. Thus Hiroko takes her ex-lover Desmond ("Coyote") on board the *Ares* as a stowaway. Coyote will become a vital element in the resistance, a messenger and pioneer in eco-economics and "guerilla climatology" (*Green Mars* 321). In Butler's trilogy, Akin's secret life in the forests around Lo, wandering the environs in search of humans, is also an act of resistance against the Oankali. As the only human-born Oankali-human hybrid, Akin's life is vital to the success of the species trade, and the Oankali are afraid that he will get hurt or even killed during this vulnerable stage of his metamorphosis.

In *DR*, Kay and Mitch's choice to conceive a child, an *in vivo* experiment of sorts validating their evolutionary explanation of SHEVA, is an act of resistance against the US government's biopolitical control. Another example of resistance against containment in *DR* is a scene in which virus specialist Christopher Dicken suddenly climbs over the barricades set up around the Task Force's headquarters and ventures into the surrounding crowd of protesters: "It was time to catch this fever and understand the symptoms. Better to be one of the troops on the front line, part of the mass, ingest its words and smells, and come back infected so that he could in turn be analyzed, understood, made useful again" (318). If there is something irrational and pathetic in Dicken's rush towards the infected masses, it also expresses audacity.

His perilous act forms a necessary step in the scientific struggles over what SHEVA really is: not a virus to be “hunted” but an unfolding event that is not just biological, but also social. Against the background of massive health problems, forced abortions, and increasing violence against infected women, these acts of purposeful contamination become signs of a profound sanity. Moreover, like *LB*, *DR* exemplifies the idea foregrounded by Deleuze and Guattari that disease and contamination, while threatening existing life forms and ways of living, can also be thresholds toward evolutionary change (see chapter 2 of this book).

Fascination — Imagination — Intuition

Nomad science is closely connected to a moment of strong “affect,” of being engrossed by the grandeur of the cosmos—experienced not as a peaceful, symmetrically ordered unity, but as chaosmos. Yet nomad science would be hopelessly unproductive if it did not somehow *act* on this fascination. In other words, if fascination is a moment of being overwhelmed by something greater than human, then nomad science is a pragmatic, active response to this experience, which prevents the situation from ending up in stasis. In control science, I would argue, fascination is manifested quite differently. Firstly, when nature is experienced in its astounding complexity, control science is quick to retreat to the steady grounds of institutions and received knowledge. Consequently, control science’s fascination with the world remains rather superficial, expressed in semiotically dense images and metaphors such as “the book of life” that mysteriously *stand in* for complexity (Roof). Secondly, when invoking a sense of wonder about life, control science inevitably rechannels this feeling so that what emerges is not the grandeur of life, but of *science itself*. This is an example of Kant’s idea of sublime experience: being engulfed by the powers of nature, the subject regains a sense of autonomy in the act of rationally reflecting on these powers. With control science fascination retains its etymological layer of *hardiness*: the Latin *fascis* means a bundle of wooden rods, which in Roman times was a symbol for unity and power. In nomad science, fascination denotes a much more flexible mode of attachment that refuses to cling onto subjects, objects or signifiers, something that might be called “fluid fascination.”

The concept of fluid fascination can be clarified by looking at how bewildering events in the novels spark practices of scientific intuition.² Kay and Mitch’s scientific response to SHEVA is manifested in brain-storm sessions in which they creatively imagine the evolutionary and historical significance of SHEVA and its future potential. Their intuitions are informed by vivid dreams and epiphanies through which they become emotionally, affectively attached to SHEVA-infected people and to the event of species transmutation as such. The primitive people in Mitch’s dreams, castigated for their SHEVA-triggered physiological differences, seem to call upon Mitch for help. Kay’s epiphanies feature a “caller” whose spiritual presence seems to forebode great change. These intense experiences work to open up the scientists to the psychological, social, and spiritual dimensions SHEVA. In *Mars* the intuitive thoughts of Hiroko constitute a similar practice of opening up to the outside of science, the great unknown. Her vitalist ruminations on the planet Mars and the role of humans allow the underground to imagine another Mars, beyond the short-term interests of states and corporations. Hiroko in-

vents new rituals in which humans become attached to the Martian landscape, thus lending a cultural and even spiritual aura to the mission. Her fluid fascination can be contrasted not just to the concept of terraformation, but also to the position of the Reds, who stick to the idea of preserving the original Mars, a kind of sanctification of the red rock. Ann, leader of the Reds, is a prime exemplar of the fact that scientific resistance can be just as rigid as control science. As Michel, the mission’s psychologists explains to Ann, “I think you’re afraid. Afraid of attempting a transmutation – a metamorphosis into something new ... You will never stop loving Mars. After metamorphosis the rock still exists” (257). By the end of the trilogy, oppositions have weakened due to what Hiroko describes as a “symbiotic” relation between terraformation and areoformation (*Green Mars* 37).

Fluid fascination, imagination and intuition also play significant roles in *LB*. As the Oankali Nikanj explains to Lilith and her mate Joseph, “A partner must be biologically interesting, attractive to us, and you are fascinating. You are horror and beauty in rare combination. In a very real way, you’ve captured us, and we can’t escape” (154). The mutual dependency of humans and Oankali is often painful and restricting, but it is also a source of joy and new possibilities. Successful species encounters come with fluid fascination and require soft skills—notably careful verbal and tactile communication. What the Oankali seem to be lacking is an imaginative plan for the future. It is Akin, the first human-born hybrid, who designs such a plan and tries to convince others to follow him. Having no scientific or social scenarios at his disposal, Akin follows his intuition. As the creator of a new society and a new world, Akin conjoins the role of the scientist with that of the artist and the philosopher, but also the mystic, the prophet, and the shaman.

Problematization — Cooperation — Introduction

Nomad science is described by Deleuze and Guattari as a science of problems, but is it not true that science *as such* revolves around problems? What distinguishes a nomadic mode of problematization, I would argue, is that the problem becomes a kind of cancerous growth that keeps returning and dissipating. Rather than isolating a problem in a controlled environment, nomadic problematization is a desire and a practice that pushes the researcher far into complexity. While Deleuze and Guattari stress the nomadic potentials of individual journeys, their joint writings are evidence that cooperation is a crucial element in problematization. Hence in *Mars*, interdisciplinary collaboration in conferences and congresses is vital in the development of a new society. These gatherings are sites of deterritorialization—open experimentation with ideas—but they also reterritorialize on new solutions and plans. Nirgal describes well the disenchantment felt when such meetings come to an end: “The future becoming the past: there was something disappointing in this passage through the loom, this so-sudden diminution from infinity to one, the collapse from potentiality to reality which was the action of time itself” (*Green* 159). Continual questions, problems, and discussions: this is what drives nomad science as well as Robinson’s trilogy itself, which does not want to end. The danger of this desire speaks from the various failures of scientists to come to a workable plan for Martian society. The complexity of the discussions sometimes tips the scales toward pure chaos.

Although the nomad scientist's desire for complexity verges on the pathological and often culminates in unpolished ideas that lack immediate use-value, interdisciplinary brain-storm sessions may also produce veritable leaps of understanding. We can see this happening in *DR*, where the problem of SHEVA is problematized when Kay and Mitch combine their biological and archaeological findings and ideas. This critical moment introduces a story that is much richer than the official account promulgated by the government task force: a story of planetary and evolutionary proportions. Although these insights instill a sense of victory on the part of Mitch and Kay, the repercussions are neither clear nor comfortable. A similar kind of complexity and open-endedness characterizes the scientific experiments in *LB* and *Mars*, which take life not just beyond the human, but beyond the planetary. The Oankali are conducting a long-term experiment whose dimensions are impossible to fathom for humans. In spite of their pervasively genetic discourse on life, the Oankali's experiment is holistic, encompassing all aspects of species encounter. In *Mars*, Hiroko's vitalism surpasses common scientific and social theories, representing the mission as a true evolutionary step for humanity, other species *and* for Mars. For Hiroko, the mission does not end on Mars; life is destined to reproduce and disseminate into the cosmos in a series of introductions.

Immersion — Self-experimentation — Becoming

Holistic images of life confront researchers with the impossibility of an "objective" scientific process purged of social, political and ecological aspects. Nomad scientists are acutely aware of their own (humble) role in these processes. Moreover, they *immerse* themselves in the problematic events they are exploring, returning from thought-experiments not with fitting solutions, but with insights that may transform their fields of research and even science as a whole. In *DR*, the question is not Where can SHEVA be located? (on the genome, in populations, in history), but rather Which new ideas about human beings and evolution does the *event* called SHEVA (retroviral activation) provoke? In *LB*, Akin's strange encounters generate a feeling of "self-dissolving closeness" (455) that testifies to a kind of escape from coarse self-identity, a moment of becoming. I argue that in place of an epistemology of spatial distance between subject and object, nomadism produces becomings in which *difference* is affirmed, creating the conditions for another science and another humanity.

The most obvious example of self-experimentation is Kay and Mitch's decision to have a child, which results in the first SHEVA-newborn. Kay and Mitch use their bodies as laboratories. This is not just a personal event; after Kay and Mitch publicly announce that SHEVA babies will be born alive when the mother is not anaesthetized, a new future opens up for a new type of human being, who in the sequel *Darwin's Children* develop their own means of communication and social order. In *LB* and *Mars* organic and planetary bodies become laboratories for (co-)evolution. The name Oankali literally means "traders," but in an unusual sense of the word: they trade themselves, their bodies (24). In *Red Mars*, geophysicist Nadia notes that as soon as the scientists will land, micron-sized dust will be "getting into everything, our lungs, our blood, our brains" (104), implying that there will be no way to escape the influence of their new environment. Later, Sax's plans for terraformation lead him to the conviction that "the planet is the lab" (263).

If this idea is born from state and corporate-driven control, in the course of the trilogy Sax drifts towards a more nomadic mode of science, restlessly roaming the Martian landscape studying new life forms and putting himself to the test, almost freezing to death. Sax's desire to immerse in the planetary lab becomes greater than the will to control.

For Deleuze and Guattari, all escape from identity through becoming must pass through becoming-woman (*A Thousand* 306). This conviction may sound unnecessarily restricting, but in the present context it does resonate with the central role of female scientists. I argue that all three works portray a becoming-woman of science. In *LB*, Lilith is the first to cooperate in the Oankali experiment and becomes the first mother of a new race of hybrids. Lilith's joyous as well as painful exchange with the Oankali stands in stark contrast to the male-dominated human villages which keep an oppositional, violent stance towards the Oankali and other human settlements. As an anthropologist trained to be critical of her own culture, Lilith is motivated by the idea that "there must be saner ways of life" (132). Her ordeals make her an exponent of what Nietzsche called "great health": the health of an active affirmation rather than the health of reactive (defensive) life. A similar analysis can be made for Hiroko's role in *Mars*. As Coyote notes in his own crude way, Hiroko is the founder of a "proto-Minoan matriarchy" promoting feminine values such as compassion and care, as well as a feeling for materiality.³ Finally, in *DR* the main protagonist is a woman who diverges from the male-dominated science of control. Kay's theory suggests that species metamorphosis is triggered by an evolutionary "radio" in the mitochondrial DNA, receiving stress signals caused by a fast-changing environment (overpopulation, explosion of communication streams). Her expertise shows that the maternally inherited mitochondrial DNA, floating around in the cytoplasm, is crucial to the evolution of species, more important perhaps than the DNA in the cell's core.⁴ Moreover, Kay's research and her pregnancy are motivated by a compassion for women around the world facing denial and persecution, and express a desire to transcend the short-sightedness of a control-obsessed scientific elite dominated by men. The important roles of women in the novels reflect a relatively recent historical development in which women begin to participate in science, and even outnumber men in some instances (albeit mostly in the lower ranks). What will happen to the male-dominated sciences once women participate in its remaking?

Apart from becoming-woman, there is also a persistent becoming-child of science in the novels, at least in the case of *Mars* and *LB*. In the Martian underground the children of Hiroko ask questions all the time. In a science class given by Sax they keep asking "Why Sax, why?" until he can no longer provide explanation (*Green Mars* 25-6). With their unrelenting curiosity the children challenge Sax's science that proclaims to know the world. Against this backdrop Nirgal's nomadism can be understood as the yearning for a knowledge that resists the urge to control and fully understand. When one has no steady territory, the alternative is becoming: "His home was crushed under a polar cap, his mother had disappeared without a trace, and every place since then had been just a place, and everything everywhere always changing. Mutability was his home" (192). Nirgal's non-identity or becoming keeps him flexible, youthful. His favorite sport—skillfully running through the Martian landscape for days on end—can be seen as an exemplar of what Deleuze and Guattari see as the ultimate form of becoming: merging with the land and "becoming-imperceptible" (*A Thousand* 308-9). Braidotti has defined

becoming-imperceptible spatially as “the point of fusion between the self and his or her habitat, the cosmos as a whole” and temporally as “an eruption of desire for the future” (*Transpositions* 261). The same intense awareness of the environment and desire for the future can be detected in the meanderings of Akin in *LB*, whose sensibility and flexibility affirms the nomadic aspects of his parents and is vital for the advent of a new people and a new world.

PART II: WHAT IS NOMAD BIOLOGY?

Nomad science, rather than being the privilege of minor sf as a kind of discursive exile, is present in contemporary science as well. Indeed, minor sf on the one hand and the biosciences on the other should not be seen as opposites, but rather as interlocking endeavors that challenge one another. Therefore I will now shift my focus to contemporary bioscientific discourse, notably to point out possible *ideas* of a nomad biology as a counterpoint to control science. Apart from discussing ideas from Margulis, Haraway, and Oyama, I will add a number of key insights from the biologist Stuart Kauffman which, in my view, neatly illustrate the nomadic preference for *becoming*. Concise references to the sf novels under study make clear that these scientific ideas can function as (components of) literary novums, bringing science to life.

Multiplicity — Immanence — Nested Scales

One obvious way to begin to distinguish nomad bioscience from control science is by its resistance to contemporary reductionist approaches to life such as Craig Venter’s idea of “DNA software” (“What is Life”), which proposes that biological life can be translated into a digital code and reproduced (see chapter 1). Usually the reasons for reductionism are entirely pragmatic. As biologist Richard Lewontin puts it in his foreword to the 2000 edition of Oyama’s *The Ontogeny of Information*, “when the wrong question is being asked, it usually turns out to be because the right question is too difficult. Scientists ask questions they can answer” (vii). Reductionism allows science to arrive at solutions and to gain a degree of control over bodies and environments, but it can also lead to oversimplified, premature or even wrong conclusions that impede nomadic thinking. Nomad science counters reductionism not by merely criticizing control science, but by carefully unfolding ever new factors in a web of life that ultimately cannot be controlled. Nomad science prizes the fact that nature is excessive, something that is readily perceivable in the astonishing diversity of organismal forms, but also becomes apparent on the molecular level, where the “redundancy of genetic and molecular pathways” allows for “great flexibility and adaptability to unexpected environmental changes” (Capra, “Complexity” 40).

Oyama’s Developmental Systems Theory, first formulated in the *Ontogeny of Information* (1985), articulates the idea that biological life must be approached as a set of interlocking systems that are continually constructed in interaction with one another. The title of Oyama’s book is meant to suggest that the idea of information as pre-programmed in the genes is mistaken: information “neither preexists its operations nor arises from random disorder” (3). Oyama intends to remove the focus in biology from a bottom-up molecular approach to a

multi-scalar systemic one. The genome is displaced, but only in order to purge its transcendental status as an “unmoved mover”; it remains a crucial factor in the developmental system (*The Ontogeny* 156). Oyama’s idea that nature is nothing other than the development of forms (phenotype) effectuates a move towards immanence: “Seeing natures as developmental products, and thus as phenotypic rather than genotypic, turns us away from the search for transcendent reality and back to the processes and products of development” (*Evolution’s Eye* 66). As Alberto Toscano has pointed out, Oyama’s conception of information as a developmental process resonates with Simondon’s theory of individuation, which had a major influence on Deleuze’s (bio)philosophy of difference.⁵ Deleuze and Oyama share a reluctance to articulate genes and environments as limitations on what a body can do; rather these are enabling elements of developmental systems. As Oyama argues, there is no opposition between nature and nurture, biology and history, or genes and environment, where the first denotes something internal, determined and constraining and the second something external, contingent and developing. Instead, all traits are acquired *and* inherited, environmental *and* genetic, in equal manner (86).⁶

Oyama’s systems view concords with Deleuze’s philosophy of immanence –thinking “a life” without transcendent cause or telos. It suggests a flat ontology of interlinked processes across micro, meso and macro scales, without thereby invoking a classical notion of cosmic order as composed of *symmetrical* scales. What returns at each level is not the same structure, but difference itself. The principle of immanence steers away from questions of sameness and resemblance and towards difference and connection. Moreover, it curbs the desire to find central control or causality in a particular location towards a view of nature as an abstract process of creation: a machine. In a world that is connected at multiple levels like a giant, all-encompassing machine, nomad science wants to reveal how seemingly disparate phenomena relate to one another. In conformity with Deleuze’s principle of immanence, Oyama qualifies her Developmental Systems Theory as a style of thinking that “moves with a certain fluidity among scales and measures” (*Evolution’s Eye* 209). Oyama’s work suggests that the environments of cells and organisms are not passive “backgrounds,” but active components of developmental systems.

One of the most potent images to date of the interlinkage of processes at multiple scales is the Gaia hypothesis, which Margulis co-developed with James Lovelock during the 1970s. Here the earth is envisioned holistically as a living thermodynamic system in which the biosphere regulates the composition and temperature of the atmosphere. Although human technologies have the ability to affect the planet in unprecedented ways, for Margulis, neither humanity nor technology should be placed on some kind of meta-level. In analogy to Haraway’s analysis of the cyborg as a cultural figuration for the contemporary entanglements of silicon-based technologies and living systems, Margulis and Sagan argue that technology is entirely natural, immanent to one and the same world:

On a sensual level it is easy to imagine a conception of the human environment as beginning with the fingernails, hair bones, and other substances no longer considered to be body parts because they are bereft of sensation. Conversely, technological introjection exemplified by devices such as tele-vision (video, movies, et cetera) and tele-portation (automobiles, airplanes and so forth) suggest a topological extension of the human into

what formerly would have been considered the environment. Therefore the body, the material or corporeal basis for “self,” has no absolute time-independent skin-encapsulated topological fixity. (“The Uncut Self” 19)

One consequence of this view is that, in Deleuzian terms, there is nothing inherently “organic” about life: an organism is merely one actualization of life’s potential. Technology is an extension of an organism’s capacities (perceptive, motoric, and so on), and these abilities evolve and proliferate throughout the natural world, so that now humans wield the bacterial ability of gene recombination. Another important consequence of this view is that human interventions through science and technology should always be assessed as part of, and limited by, conditions that are not human-controlled. This view is exemplified by the literary novum of terraformation in *Mars*, where transformation is produced by biotechnological enhancement and bioengineering in interaction with non-human process, making the project ultimately uncontrollable.

Relation — Interaction — Co-evolution

Margulis’s theory of endosymbiotic evolution is an alternative to genocentrism as well as to a neo-Darwinist understanding of evolution as the gradual accumulation of random DNA mutations subject to natural selection. In *Acquiring Genomes* Margulis writes that the genesis of new forms out of existing ones cannot be explained by examining genomes or species in isolation: “Animal evolution resembles the evolution of machines, where typewriters and television-like screens integrate to form lap tops, and internal combustion engines and carriages merge to form automobiles. The principle always stays the same: well-honed parts integrate into startling new wholes” (172). Margulis’s work examines the ways in which symbiotic relations between animals, for example bacteria living in the guts of mammals, are often useful, thus offering counterweight to the dominant idea of a *competition* between species. Radical transformation of species is simply unthinkable in neo-Darwinism, which focuses too much on vertical transmission and thereby “misses the symbiotic forest for the genetic trees” (201). Margulis’s work on symbiotic co-evolution resonates strongly with Deleuze and Guattari’s concept of the rhizome, which instantiates the primordially of *relations*. In other words, the elements of a system are entirely immanent to the relations that compose it.

Oyama shares Margulis’s concern about individualist approaches in biology, such as the paradigmatic ideas of competition and natural selection, which lead biologists to treat relations as secondary to identities. Criticizing dominant science’s “obsession with detachment, isolation and independence,” Oyama looks for “metaphors of engagement, connection, and interdependence,” ways of knowing with a preference for “mutuality over domination, systems of influences over single causes, openness over closure, loops over lines” (151–52). Her way out of the conundrum of individualism is “constructive interactionism”: a mode of interaction that moves beyond the idea of an external influence on (or, worse, “perturbation” of) an internal essence. All interactants are on equal footing, and “internal” and “external” are but epistemological, political, and, if we follow Barad, ontological effects of interactions. The instability of inner

and outer worlds is expressed in Bear’s novel with the novum of infected genomes, and in the novels by Butler and Robinson by the continuous (re)construction of organisms and worlds.

While Oyama and Margulis reach far into micro and macro-levels, none has gone further than Haraway in analyzing the lived experience of relations between humans and other species. Haraway’s ethnographic work on interaction between species in science (primatology, medical genomics), animal agility sports, as well as agriculture and bio-industry, render concrete the idea that species evolve *together*. For Haraway, domestication is a mutual process in which humans and animals influence one another: the realms of anthropology and ethology converge in human-animal ethnography (“Multispecies”). Human-animal relations are cultural, in the sense of being embedded in and mediated by discourse and technology, but they are also biological, leading Haraway to invent hybrid terms such as “material-semiotic” and “naturecultures.” She amplifies the ethico-political dimension of co-evolution also present in Oyama’s and Margulis’s work, arguing that science should nurture “the capacity to feel and think with other mortal beings, not just *about* them” (6). Calling research animals “significantly unfree partners” (*When* 72), Haraway reveals the problematic nature of binary oppositions such as human-animal—without letting go of these terms altogether, for that would obfuscate the existing asymmetries existing between them. For Haraway, who is an ardent reader of Margulis’s work, it is clear that her relation with her dog Cayenne affects their lives *and* their genomes: “sympoiesis displaces autopoiesis and all other self-forming and self-sustaining system fantasies” (9). In her latest works on species encounters, Haraway’s ideas reverberate strongly with Deleuze’s philosophy of difference and his insistence on the ontological primacy of relations: “The relation is the smallest unit of analysis, and the relation is about significant otherness at every scale” (*The Companion* 24). While the relations between species are made palpable by all three of the novelists, the intimacy of such relations is most explicit in the encounter between humans and Oankali in *LB*.

Embodiment — Fluidity — Folding

Geneticists mostly investigate exons (the bits of DNA that code for proteins) and until recently, introns (non-coding DNA) were referred to as junk-DNA. This practice illustrates a desire in control science to eradicate redundancy and noise, leaving only clear and clean bits; notions of “good data,” “elegant theories,” and “beautiful results,” all imply this sense of cleanliness. The desire for order ultimately results in a binary opposition between polished essences and messy materiality. In the genocentric view, the genes are solely responsible for generating form and function (Fox Keller, “Beyond” 292). The idea that biological life can be captured in a digital code, substituting wetware for dryware, may be one of the most extreme examples of producing a polished essence and disregarding the messy body. In this light, Oyama criticizes the notion of “substrate neutrality” proposed by thinkers such as Daniel Dennett, where “programs can be instantiated in brains, silicon, or tin cans” (*Evolution’s Eye* 283). This critique can be placed in a tradition of feminist critiques of science of which Donna Haraway is a key figure, which shows that in science and Western culture as a whole, the body has consistently been coded as impure, deceptive, and so on.⁷ In Butler’s trilogy, the Oankali strangely entertain a symbiotic-

developmental view *and* disembodied genetic essentialism. However, genetic manipulation by the Oankali is merely an aid, not a means to *control* co-evolution.

Nomad bioscience, rather than seeking solid causal essences, looks for fluid connections. Jesper Hoffmeyer argues that bioinformation is not a genetic blueprint or program but an active *process* in which “the cell interprets the DNA” (156). In other words, the cell as a whole is the doer. Instead of acting solely on the membrane of the nuclear DNA, on which most geneticists focus, the cell’s activities are “topologically connected to the membranes of mitochondria, chloroplasts, the nuclear envelope, the Golgi apparatus, ribosomes, lysosomes, and so on” (165). Instead of a mechanistic movement from genotype to phenotype, gene expression is a complex event dispersed over an “extended membrane,” which, for Hoffmeyer, becomes “the principle locus of life itself” (165-6). The notion of an extended membrane is a clear example of a nomadic approach to the body as topology: a fluid entity for which notions of inside and outside are unstable. For Oyama, too, the body is a fundamentally open structure:

If we follow our skin to its transition to the mucuous membrane of the mouth and throat and beyond ... we can ask whether our gut symbionts are inside or outside us. A particle of food could be considered inside once it has been absorbed into the bloodstream or into a cell, but one of our cells similarly resolves, if we look closely enough, to a maze of structures, channels, and pores, constantly changing their configurations and traversed by frantic traffic. (“Boundaries” 279)

In a similar vein, Margulis and Sagan emphasize that the membrane is “a self-maintained and constantly changing semipermeable barrier” that allows them to “jump organizational levels, from intra-organismic cell to cellular organism to organismic ecosystem and biosphere” (“The Uncut Self” 17).

Of all three novels, perhaps *DR* most vividly imagines the body’s openness to the outside. Here, evolution does not occur merely as a result of selection from the outside, but through an internal “radio” receiving signals from the environment. As Oyama argues in *Evolution’s Eye*, we are not unities but multiplicities: “Many natures (“organisms-in-transition”) constitute a species, rather than some single species essence, and an organism has as many natures as it has situational and developmental moments” (181). Organisms are not merely selected, but they select and co-create their own environments. Furthermore, many organisms can offer food and shelter for a great number of other species. Margulis and Sagan identify a tendency in life to “literally incorporate more and more of its environment into itself” (“Welcome” 81). Translated in Deleuzian terms, this means that the inside is merely a fold of the outside (*The Fold*) and that organisms are temporary forms in a fluid world. The idea of biological *multiplicity* (derived from the Latin word *plicare*, meaning to fold) affects psychological, sociological and philosophical conceptions of self, which attain a non-anthropocentric stature; as Margulis and Sagan put it, “we are composed of smaller selves, and we form parts of the more inclusive selves” (“The Uncut Self” 28). Haraway looks to Margulis’s endosymbiogenesis as a source for thinking a “paradoxical individuality,” another mode of subjectivity beyond the model of liberal humanism in which the human individual is pictured as autonomous (“Otherworldly” 146). For Haraway,

embodiment and materiality are keywords for going from an abstract individuality (implicitly based on standards created by and for white heterosexual males) to the multiplicities of our bodies and our material and spiritual connections to (non-)human others.

Instability — Nonlinearity — Transformation

Nomad science is attracted to complex problems, and the phenomenon of transformation is perhaps the most enigmatic problem thinkable. As philosopher François Julliens has recently argued, although transformation is everywhere, it eludes measurement:

Between the moment when it has not yet reached the visible and that in which it will henceforth be too widely distributed and confused in the midst of the visible still to be discerned, the transformation offers only a narrow chink of perceptibility; this is why it is necessary for it to be “examined” with so much vigilance. (80)

What better phenomenon is there to be relentlessly “followed” by nomad science than a transformation that never really begins or ends, that is neither here or there? This is what the novels by Butler and Robinson express most forcefully, by creating novums of species encounter and constructive interactionism: a sense of ongoing development, proliferation and change. Transformation is everywhere, but it is not “neutral” or random: it is an achievement, a solution to problems. As Haraway argues in *When Species Meet*, evolution is not a neutral or blind process of natural selection, as neo-Darwinism has it, but a straining, creative exercise of “becoming with” (16). The novels analyzed in this thesis illustrate that species transmutation can occur when an organism, symbiotic assemblage, or ecosystem is under extreme pressure and becomes unstable, for example because of food shortages or changes in climate. The literary event of transmutation and the struggles it entails double Margulis and Sagan’s argument in *Acquiring Genomes* that “most genetic takeovers and acquisitions, mergers and fusions ensue under conditions of environmental hardship” (42). Evolutionary and developmental problems are inherently nonlinear, unpredictable: they can bring catastrophe, but also trigger innovation, creativity, and cooperation. Often destruction and creation coincide. For example, when about 2.4 billion years ago oxygen produced by cyanobacteria through photosynthesis began to accumulate in the atmosphere, nearly all anaerobic organisms on earth were wiped out, while, simultaneously, the conditions were created for the arrival of life forms that still thrive today.

Instability is a key concept in the biological systems theories of Stuart Kauffman and Brian Goodwin, where the units of development and evolution are not genes, organisms or species, but the systems which coincide with particular bodies. From this perspective, the expression of genetic material is highly contingent on systemic conditions that are unstable and, thus, unpredictable. Any particular body is overdetermined by a host of factors that embed it, connect to it, move through it. For example, in spatial terms, the development of an ant is constituted by its insides (genes, cells, gut symbionts, etc.) and outsides (the colony, other animals, plants, climate, and so on). This inside-outside topology is forever changing: the outside is incorporated

(for example through food consumption and learning) while the inside is extended or externalized (through technologies such as building and writing). Moreover, time becomes nonlinear. A living system's development at a particular moment depends on an accumulated history of developments that still have a relative bearing on the present and that co-constitute the possibilities for future developments. Yet the virtual potentials for becoming are not given in the present—as if there were fixed repositories of futures—but emerge in a feedback loop with actual conditions. Systems dynamics can be periodic (hormone cycles, migration patterns, and so on), gradual (growth, learning), or they can approach a bifurcation point where the system makes a phase transition (reaching puberty, metamorphosis, death). These systems dynamics have been deployed beyond biology, and can be virtually applied to any given system (Delanda, *Intensive*). The discovery of nonlinearity at the heart of matter marks a crucial threshold in which science is forced to abandon, as Ilya Prigogines argues in *The End of Certainty* (1997), the search for final causes.

The problem of thinking life as nonlinear and nonrandom becoming is explored by Kauffman, who argues that complex systems are permanently poised at “the edge of chaos” (*At Home* 209), and therefore continually undergoing transformation. This means that nonlinearity and instability are not synonymous with random chaos: they are aspects of complex systems that are exceptional on a cosmic scale, but entirely normal for our biosphere. Doing battle with chaos, life is forced to be creative, and the external force of natural selection is insufficient to account for this creativity in evolution. Life is neither reducible to parts (mechanism) nor an omnipresent, mysterious force (vitalism) but, as Kauffman phrases it, a series of co-evolving, self-organizing systems or “ways of making a living” operating in some yet to be understood relation to natural selection (*Investigations* 134-35). Kauffman argues that self-organization is a feature of life as such and applies to everything from physical to economic systems. While the idea of self-organization was first conceived within the context of living organisms, theorists have shown that it conceptualizes *mechanism-independent processes* that apply to complex systems in general (Delanda, *Intensive*; Goodwin, *How the Leopard*; Kauffman, *Order*). It is clear that Kauffman's introduction of the colloquial notion of “making a living” into the non-human sphere is neither a mere metaphor nor a gesture of anthropocentrism. Kauffman's idea of systemic “ways making a living” is a scientific transmutation of the original saying that results in a decentering of the human, making life and work immanent to the universe in ways similar to Deleuze and Guattari's idea of nature as machine or “process of production” in *Anti-Oedipus* (3). Kauffman's idea that the future emerges unpredictably as process of selecting “adjacent possibles” resonates strongly with Deleuze's ontology of the virtual and the actual.⁸

Most of Kauffman's career has been at the service of discovering underlying laws of self-organization or “emergence” in evolution using mathematical models such as Boolean networks, as if trying to fuse control science and nomad science. Recently, however, he seems to have taken a more radical nomadic turn. Together with mathematician Guiseppe Longo and biologist Maël Montévil, Kauffman has argued that the desire to discover “entailing laws,” originating predominantly in physics and mathematics, has been erroneously forced upon the other sciences. In biology, evolution has no foundational causes or laws, but rather operates through regimes of “enablement” which are inherently nonlinear and hence unpredictable (“No

Entailing”). The authors state that while in physics the default state is inertia, in biology it is “the never identical iteration of a morphogenetic process, by proliferation and mobility,” and that, in this evolutionary process, “an organism, a species, does not need a cause to be active, e.g. to proliferate and occupy a new niche” (“No Entailing” 1388). If we follow this line of reasoning, molecular biology's often unquestioned assumption of natural selection as a kind of *law* as well as its fixation on the genome as a primary *cause* become highly problematic. Moreover, Kauffman's work suggests that whilst during the Nineteenth and Twentieth centuries the law-based thinking of physics strongly influenced biology and the social sciences, biology's recent investigations of self-organization and co-evolution will transform other sciences as well. For example, Kauffman perceives the economy as a system “forever becoming, burgeoning with new ways of making a living, new ways of creating value and advantages of trade, while old ways go extinct ... The economy, like the biosphere, is about persistent creativity” (229). Apart from drawing an *analogy* between economics and biology, Kauffman's work also shows that economies are *de facto* parts of human and planetary evolution.

Whereas Oyama and Haraway are, perhaps, *earthly* biologists in search of “a hardy, soiled kind of wisdom” (Haraway, “Sowing Worlds” 1), in the work of Margulis and Kauffman, the whole cosmos becomes a theater of life. Margulis's son Dorion Sagan, whose father Carl Sagan happened to be a world famous astronomer and author of a bestselling alien contact novel, moves even further in this direction. In an essay entitled “The Pleasures of Change,” Sagan and physicist-biologist Eric Schneider argue that thermodynamics and the evolution of life are “part of a single process of cosmic change” (231).⁹ Transformation, for them, is what links human beings to the cosmos, and, from this observation, becomes an existential goal: “the pleasures and challenges of life, both personally and cosmically, are not in achieving some sort of final stasis, some steady-state heaven or nirvana of eternally solved problems, but in dealing with energy flow and the change it inevitably entails” (233). These intuitive visions, which resonate with Hiroko's cosmic vision of spreading life in the *Mars* trilogy¹⁰, exemplify a key idea in nomad biology: life is a process of dissemination and creative becoming that science cannot control, but in which it participates nonetheless.

CONCLUSION

This chapter has traced a myriad of overlaps and resonances between various nomadic scientific practices, ideas, attitudes and desires in different genres. Whereas control science seeks to find rigid and reliable organization in life and to create new forms of life that respond to the wish for utility and predictability, nomad science confronts life in its a-personal and inorganic dimensions: life as becoming without origin or end. Open, explorative experimentation is the basic practice of nomad science, which is more concerned with tracing new problems and unforeseen possibilities than with a final truth. It asks: which are the complex problems that make a difference, that will enable us to see, understand and create life anew? Which connections between the disciplines are required by these complex problems? How many variables can be considered without falling prey to chaos? And how do these problems, variables and connections transform science and humanity itself? This relentless desire and exhaustive prac-

tice does not lead to some kind of synthesis: nomadic elements do not join in one coherent system, and nomad science will never be at peace with control science. At all times elements of nomad science can be incorporated into control science, but scientists can also escape the regime of control on lines of flight.

The key observation about the novels analyzed in this thesis is that they all bring to life, in a narrative mode, a fundamental vision of nomad biology: the profusion, redundancy and unpredictability of life. In none of them an ultimate merger of nomadism and control is brought about, or a utopian world in which humans are finally at peace with (which usually means: in control of) nature. Instead, they produce a plurality of forms and voices. But there are also divergences, the most salient ones existing between Bear's *DR*, on the one side, and Robinson's *Mars* and Butler's *LB* on the other. On the one hand, Bear's novel seems exceptionally clear in its depiction of an extensive series of nomadic practices, which encompass the protagonists' whole existence, in contradistinction to the control science of the Task Force. On the other hand, this clear distinction may obscure the ambiguities of nomadism and control—the way one scientist can move from one position to the other—that the other novels portray so well. Secondly, Bear's novel points to a Body without Organs—not our genome but the economy of transversal gene exchange through which the genome is always already "infected" —but he does not follow the past and future becomings of this state of "being infected" quite far enough. Bear's focus is *inwards*: on the genome, on the human, and on the US. Questions about which changes in the environment, and what kinds of human relations to environments, may have triggered human transmutation, are hardly worked out. In this way, Bear's work partially reterritorializes on human subjectivity and on the state: narrative tension inhere mostly in the fear of and desire for an "other" that is always already part of the self/nation. Instead, *Mars* and *LB* narrate continually evolving human-nonhuman relations, thus more thoroughly leveling criticisms at anthropocentrism and genocentrism.

Similar kinds of overlaps and divergences can be traced in the analyses of nomadic ideas in biology. Apart from the recurring reliance on notions of relationality, nonlinearity and other ideas, there is also a shared attraction to other modes of thought: each of the scientists displays tendencies toward philosophy and art. Notably, all insist on the importance of stories as meaning-making devices that can help to flesh out the relational, transformative, and cosmic dimensions of life. Haraway stresses the need for "richer, quirkiest, fuller, unfitting, ongoing stories" where life is unfolded beyond the paradigm of human autonomy ("Sowing" 2). Similarly, Oyama argues that "the organism's ontogenetic story needs its developmentally relevant environment" ("Boundaries" 284). Nevertheless, the various elements and thinkers of nomad science do not cohere in any organized sense. Rather than forming a unified nonreductionist camp, Oyama sees relations of friendship as well as discord between her Developmental Systems Theory and the works of Maturana and Varela, Kauffman, Goodwin, and others ("Friends"). Haraway has problems with systems thinking *as such*, arguing that it is too much dependent on discourses of control and autonomy.¹¹ Then there are different levels of analysis, and different ways of connecting those levels. In her research Margulis is mostly focused on the cell as a unit of analysis, but also considers the connections between organisms and the planet as a whole; Oyama wants to promote analysis across scales, with a recurring preference

for niche-construction; Haraway explores relations between human, animals and machines in messy "natural-cultural" situations; finally Kauffman takes biological systems thinking to a cosmic level, while also showing its relevance for the technosphere, the econosphere, and so on. Undoubtedly, there are many other lines intersecting with and diverging from the ones analyzed here, including the lines of nomad *science studies*—a subject to which I shall tend now.

— 8 —

BRINGING SCIENCE TO LIFE

Good stories reach into rich pasts to sustain thick presents to keep the story going for those who come after.

— Donna J. Haraway —

Gripping stories entail a migration, a risky adventure into another world. Writers of minor sf dwell in science at the risk of losing themselves in a forest of findings and hypotheses. It is only when they return from such voyages with a consistent set of ideas, or even just a single idea, that these writers are able to tell “good stories” in the sense that Haraway alludes to above: sustainable narratives that touch not only “our lives” at present but the lives of our ancestors and progeny, the lives of other species, and the lives of ecosystems and planets. Why are such stories relevant at all? Why should we care? If we follow Deleuze and Guattari, these skeptical questions concern the birthright of literature as such. As Deleuze and Guattari maintain in *What is Philosophy*, *doxa* (opinion) reigns supreme in today’s media saturated society. Incessant acts of communication divert us from thinking, from connecting with the past and the future. We need to engender a healthy “resistance to the present” (108). This is exactly what sf’s task, according Samuel Delany, amounts to: to produce “significant distortions of the present” (*Starboard Wine* 26). Resistance to the present means imagining things otherwise, seeing the strangeness and artificiality of life, looking into the face of a monster. Sf is able to achieve this in two important ways: it explores the actual limits and virtual potentials of science—its attitudes, desires, ideas, and practices—as well as of life in its biological, social, physical and abstract nature.

As this thesis shows, sf is able to produce rich stories about science—but also *with* science—stories that bring out the implicit desires of scientists for control and chaos. By construing narratives

on the basis of a novum or problem-event, the sf novels analyzed in this thesis map the dynamics of control and nomad science, while at the same time pushing the sciences to their limits, thus affirming their nomadic potentials without ever offering simple predictive extrapolations. Experimentally testing the limits of human understanding and sensation, these narratives manage to escape stereotypical feelings and opinions. Bringing science to life, in this respect, means two things: showing how science is a theater of dynamic and at times antagonistic forces, but also prompting science to escape reductionist axioms, to dare to encounter an untamed and even cruel, inhuman life whose excess perhaps only the writer and the artist are willing to submit to.

How successful are Bear, Butler and Robinson's novels in thinking science and life together? The writers who are most versed in scientific discourse, Bear and Robinson, may seem to provide a more thorough grounding of the narrative in contemporary technoscience as well as a clearer image of what nomad science may amount to. However, I would argue that Butler's trilogy produces the most intense account of human transmutation, and the most sophisticated investigation of the ethical, biopolitical and epistemological ambiguities and tensions animating this event. Butler's text is more on the side of thinking *with* science than thinking *about* science. All three authors invent what Deleuze and Guattari in *What is Philosophy?* call affects and percepts: compounds of sensation in which "we are not in the world, but become with the world" (169). Affects, or "nonhuman becomings of man" (169), occur in sf in the form of disrupting events in which characters intuit or sense life as a raw force opening up bodies to their insides and outsides, their potential for transformation. More than the other writers, Butler has been able to extend affect throughout the text, as if the problem-event is expressed in every thought and every action as a continuous vibration. Perhaps Robinson is least concerned with creating affects, and more with creating "percepts," or "nonhuman landscapes of nature" (169). These are not images of a pristine Mars before humans arrived, as desired by the ideologue of the Reds, Ann Clayborn. Rather they are images of Mars *as becoming* in which humans participate but which they cannot predict or dictate. The strongest percepts are those in which humans become-Mars through new ways of living, such as Nirgal's playful, athletic maneuverings during which he merges into the Martian landscape, becoming imperceptible. The trilogy as a whole can be seen as a percept in which Mars-as-becoming is sensed in the subtle, gradual changes of its landscape, as well as in bifurcation points such as the introductions of humans and microorganisms, or the moment when the atmosphere becomes breathable for humans and other animals.

Chapter 2 introduced the idea of "minor sf" as a literary form that thinks nonhuman, planetary, and cosmic life *with* science, thus opening up space for the joint readings of science and sf in the case studies. Building on these reading experiences, we may now once again pose the question raised in Chapter 2: What exactly is minor sf? And what exactly is the relationship between literature and science in sf from a Deleuzian perspective? I would argue that the three sf works analyzed here create affects and/or percepts of the scientific ideas of symbiogenesis, species encounter, and constructive interaction. They give a sensible form to these ideas through novums, narratives, and other aspects. We may extend this idea to other minor sf novels to see if and how, from a Deleuzian perspective, such novels constitute a transmutation of literariness. This thesis can only be the beginning of such an expedition through the minor sf landscape.

Sf's intersection with the sciences has been the key interest of this study. It has become clear that the sf writers whom I have studied do not wish to evoke an image of science as a supreme caretaker of truth. While the tales of transmutation under analysis all crucially involve biology, it is the developing connections between different elements—biological, technological, social, physical, etc.—that make the metamorphosis into a "sustainable" narrative event in the sense evoked by Haraway above. Some of the characters (and perhaps also some readers) may be inclined to emphasize the biological origins of the metamorphosis or to determine its evolutionary purpose, but such understandings are problematized by the complexity and open-endedness of the narrative and the problem of life that informs it. Minor sf creates capricious narratives that resist rigid emplotment by a center of control, whether scientific heroes or "genetic programs," affirming a life of becoming, in which there is, in Oyama's words, "no centralized repository of 'information'," rather only *relations* that are "part of the developmental story" (*Evolution's Eye* 118). In minor sf, biology becomes a trigger for transformations affecting all the dimensions of existence, from the social to the cosmic, thus creating a literature that is no longer "about" any particular aspect of (human) life. Here humanity's future is not a matter of controlled design or engineering, but of participation in evolutionary assemblages.

Minor bio-sf novels can be placed in the wider context of contemporary artistic engagements with biology, biotechnology and ecological crises in film, gaming, and bioart. Minor artistic engagements with biotechnoscience are able to bridge the social and the biological realms without reducing one to the other. As such, they are deeply involved in an epistemological movement within the bio(medical)sciences in which, as Fausto-Sterling argues, the social and biological become intertwined:

We need to develop the habit of thinking about genes as part of gene-environment systems, operating within networks that produce new physiologies in response to social conditions. In this view, bodies are not static slaves to their biology. Rather, it is our biological nature to generate physiological responses to our environment and experience. We use genes to produce such responses. This understanding of the relationship between the social and the biological gives us new epistemological set points that would drive us to seek social solutions to health disparities, using technology as an aid but not as the motor. (31)

As due to developments such as epigenetics the social environment is increasingly being regarded as a key factor in determining our biological constitution, all social developments and reforms potentially attain evolutionary significance. From this perspective, one can understand why biologist Fritjof Capra, in his pioneering study *The Turning Point: Science, Society and the Rising Culture* (1982), contends that feminism as a social movement "will have a profound effect on our further evolution" (11), a speculative argument that resonates strongly with the novels analyzed in this thesis. Female scientists, artists, writers and philosophers are teaching us how to think and live differently. Sociality is epigenetic, involving feedback between genomes and internal as well as external environments, a process in the course of which both bodies and environments are reconfigured. Although the radical transformations narrated in bio-sf are highly speculative, they do serve as potent demonstrations that the social and cultural phenomena

studied by scholars in the social science and the humanities are, in fact, much more closely connected to the objects of the natural sciences than most academics tend to acknowledge. They also provocatively suggest that, from an epigenetic perspective, all politics is biopolitics.

This brings us to the question of how both (minor) sf and (minor) sf studies can become involved in science studies and even take science studies into new directions. I see two obvious ways in which this can transpire. First, minor bio-sf can bring science studies to life, as it were, by presenting radical examples of *thinking with science*. Artists and writers are especially well-disposed to accomplish this, because they are not bound by disciplinary rules in the way academics are. Science studies itself becomes nomadic, I would argue, when it stops thinking exclusively “about” science as its disciplinary object, and starts thinking *with* other sciences about common problems and developments. This is exactly what Caspar Bruun Jensen implies when he proposes to define science studies in a Deleuzo-Guattarian vein as “a following science dedicated to following science” (“Anthropology” 1). When we follow science, whether in the field or in discourse, we become implicated in the questions that science asks, just like a writer like Robinson writes himself into discussions about terraformation and sustainability. Life can no longer be stratified into the social (science studies) and the natural (science), but becomes a shared space between academic disciplines as well as the arts, a crossroads of “non-metaphorical transport” (Mackenzie 50) where one element becomes the milieu of another. Of course this does not mean that science studies asks the same questions or applies the same methodologies as other fields. What it means is that there is an overlap, a moment of coincidence or linkage.

In this cooperative endeavor of science studies, is it still possible to be critical? As Latour formulates it, science studies needs a rather specific notion of critique: “The critic is not the one who debunks, but the one who assembles. The critic is not the one who lifts the rugs from under the feet of naïve believers, but the one who offers the participants arenas in which to gather” (“Why” 246). Critique thus stops being external and becomes participatory, constructive. This practice of assembling is political, epistemological *and* ontological, for it means thinking, and otherwise creating, the conditions for new worlds. The creation of spaces is intrinsically a matter of architecture, design, art, and activism: to transform the way things are made and done. In this temporalized understanding of space, according to Tim Ingold, scientists can come to *inhabit* the world rather than occupy it: “A world that is occupied, I argue, is furnished with already-existing things. But one that is inhabited is woven from the strands of their continual coming-into-being” (Ingold 1797). The critical task of science studies thus comes down to being responsive to environments, to “inhabit” a transdisciplinary milieu rather than survey it from outside or from above.

However, being critical in this different sense does not imply a harmonious, efficient cooperation. A second aspect that needs to be emphasized is the need for science studies to “slow the problem down” (Stengers, *Cosmopolitics II* 361), to *problematize*, in ways that run counter to the interests of control science. In seeking to slow science down, science studies can benefit from engagements with philosophy and art. For example, bio-sf novels may problematize molecular biology’s relation to life, opening it up to ever other factors and unexpected becomings.

Art and philosophy provide meandering, nomadic “detours” that slow down science’s descent toward the actual, tempting it to stay with the virtual chaos for as long as possible. I am hesitant to argue, as some scholars do, that these interferences will lead to a kind of transmutation of thought in the near future, reconciling the sciences and the humanities, the East and the West, the masculine and the feminine (Capra, *The Tao*; Goodwin, *Nature’s Due*). In any case, such a utopian prospect cannot be simply deduced from the nomadic tendencies discussed in this thesis.

A third and final element of nomadic science studies enriched with aesthetic ingredients is *dramatization*: bringing science to life through narratives, scenes, and songs. This is in fact what the popular science texts analyzed in this thesis do when they unfold the adventure that is science, mixing the scientific, the personal, and the imagination. But at the same time that science becomes a drama, *life itself* also becomes dramatic. The famous ethologist Von Uexküll saw the biosphere as a symphony. Genomics pioneer Susumu Ohno suggested that life is a music drama and that DNA is more aptly understood as a musical score, performable in multiple ways, than as a “blue print” (Zwart, *De filosofie*). Recently, Zwart, following thinkers as distant as Pythagoras, Hildegard Von Bingen, and Schopenhauer, has proposed that the whole universe *is* music (*De filosofie* 335). The world is not a mere passive background for human action and representation, but rather is itself creative expression, perception, and desire. This idea of epistemological and ontological dramatization enters science studies, for example in Stengers’s depiction of embryology as “field science”:

The field in this case is the amazing “causal choreography” associated with processes of development that had been characterized by both finalists and neo-Darwinists as directed by a cause (the final cause or the program). The characterization of the continuously self-redefining developmental entanglement mobilizes all the words we have to describe encounters that affect the very fate of the encountering terms. From infection or mobilization to hijacking, seduction or reciprocal induction, the common feature of these narratives is that any simple relation between “cause” and “effect” is lost without regret. (*Cosmopolitics II* 231)

The embryo’s continuous movements are not “effects,” but an emergent *staging* without a fixed script. Although, as Deleuze maintains, the embryo is a hero of sorts, since he “lives the unlivable,” (*Difference* 267), this is a heroism devoid of any notion of autonomous subjectivity. It concerns a “larval subject” (267), an assemblage of potentialities that does not correspond to the notion of an organism or species. It is on the level of interacting particles, bodies and environments that the drama of life really unfolds. In the light of this “causal choreography,” Shakespeare’s famous line “All the world’s a stage” attains a new meaning, pointing towards an eco-aesthetics of existence, where humans perform or play together with others—notably with other species—as inhabitants of a plethora of merging habitats.

As a child I loved a specific exercise at school in which the pupil was offered a brief written sketch of a more-or-less problematic social situation, and was asked to “finish the story.” The point, of course, is that one does not need to be faithful to the obvious pedagogical intentions

of those who designed the exercise, and may suddenly shift to a wholly different situation (“in the meanwhile, on Antarctica, Richard was ...”) or introduce new elements (“unfortunately, he had not seen the giant rooster ...”). Creative writing multiplies possibilities that make it impossible to bring the story to a closure except by a blunt, arbitrary stop. It opens new worlds and ways of living. As a child I experienced that the joy of writing lies in this excess, although I was incapable of giving consistency to it. With the waning of the grand narratives of the West, we are in desperate need of Harawayan “good stories” that lack beginning or end, intuiting our worlding and becoming-with other species, which are at the same time Deleuzian stories that express becomings exceeding the human form. Perhaps one of science studies’s important tasks is to weave itself into stories of science and life. *Become woman, become child, become animal, become molecular*—such is the alchemical formula whose echoes bring science to life.

NOTES

NOTES CHAPTER 1

- 1 For an analysis of the human-induced migrations of plants, see Laura Marks.
- 2 I use the denomination “science studies” as a shorthand to cover a rather wide area that includes science and technology studies (STS), social studies of science (SSS), philosophy of science, anthropology of science, cultural studies of science, science and literature, and related fields. In lumping all of these fields together, I do not wish to deny the genealogical differences between them.
- 3 The predominantly US-based academic field of literature and science, which has existed as a subdiscipline of literary studies since the 1920s but only really came to fruition as a field in its own right in the mid-1980s, studies the manifold entanglements between science and literature as well as the arts. Rather than being solely or primarily a field for literary scholars, its practitioners come from fields including science studies, STS, philosophy, gender studies, anthropology, art history, as well as the medical and natural sciences. Scholars of literature and science are organized in the US-based Society for Literature, Science and the Arts (SLSA). In 2008, a European branch of the SLSA was launched.
- 4 Deleuze’s philosophy was greatly expanded in his joint work with Guattari, with whom he wrote four books: *Anti-Oedipus* (1973); *Kafka: Toward a Minor Literature* (1975); *A Thousand Plateaus* (1980); and *What is Philosophy?* (1993). Nevertheless, throughout this thesis I will refer to Deleuze alone, unless citing one of the joint works.
- 5 Robinson has won a number of prestigious sf awards, including the Nebula award and the British Science Fiction Award for *Red Mars*, Hugo and Locus awards for *Green Mars* and *Blue Mars*, and a Locus award for his alternative history novel *Years of Rice and Salt* (2003).
- 6 Noosphere is generally used to refer to the sphere of human thought. It was probably coined by the mathematician-philosopher Édouard Le Roy and developed by his colleagues

- the Soviet geochemist Vladimir Vernadsky and the French philosopher Teilhard de Chardin in the 1920s.
- 7 While the prospect of living on other planets may seem fantastic, the reality is that terraformation is a *scientific* concept thoroughly developed by NASA in the 1970s. Moreover, in 2012, the Dutch entrepreneur Bas Lansdorp announced a manned mission to Mars to take place in 2023, in which all participants are expected to permanently stay on Mars, with new participants joining them every two years. The project is supported by a host of expert advisors from science and industry.
For information on the Mars One mission see <http://mars-one.com/en/>
 - 8 The term “anthropocene” denotes the era in which man becomes a major determinant for planetary systems such as weather systems, climate and ecosystems. The term was coined by biologist Eugene Stoermer in the 1980s, only to be developed in the 2000s by Dutch chemist and Nobel laureate Paul Crutzen.
 - 9 Margulis and Sagan’s statement that evolution is “everybody’s story” is backed by evolutionary psychologist Susan Oyama, who suggests that the vision of evolutionary existence is not just *scientific*, but a new “origin myth” for humanity in an era of globalization, “a narrative that characterizes the present as it names the past” (*Evolution’s Eye* 171).
 - 10 Eva Neumann-Held and Christoph Rehmann-Sutter define the molecular paradigm as “the study of developmental processes through the analysis and manipulation of molecular interactions at the level of gene regulation” (3). See their wonderful edited volume *Genes in Development: Re-Reading the Molecular Paradigm* (2006).
 - 11 For example, the archetype of the explosion in chemistry is also a radical process of transformation. I would argue that often the archetype is a concrete image that *stands in* for an otherwise unimaginable event of transformation, for example the image of the monster in biology reminding us of life’s mutability. This is illustrated by Zwart’s observation about two images of “Hiroshima” engraved in the cultural imaginary, which represent the imperceptible event of the explosion either through its trigger or cause (the atom bomb) or, more commonly, its “result” (the mushroom cloud). The transformation *as such* appears unimaginable.
 - 12 For a comparison between Western and Chinese thought about transformation, see Jullien.
 - 13 Deleuze and Guattari seem to borrow the term fabulation from Bergson’s *Two Sources of Morality and Religion*, where Bergson argues that fabulation is an ancient faculty at the root of art and other forms of creativity. For a useful elaboration of Bergson’s idea of fabulation in the context of film, see Mullarkey.

- 14 As Paul Patton has argued, Deleuzian philosophy is utopian in the sense that it seeks the virtual conditions, the immanence, behind actualized states of affairs in history and in the present (112-3).
- 15 A key example of collaboration in science studies is the methodology of “midstream modulation,” where social scientists test ethical, social and other issues in the midst of scientific research (for example, in the laboratory) with the intent of incorporating of those issues in the daily practices of scientists and fostering mutual learning-experiences (Fisher, Mahajan and Mitcham). I would argue that a similar kind of boundary-blurring approach can be found in philosophical science studies. I am thinking particularly of analyses that mix scientific, philosophical and literary ideas, for example in the work of Isabelle Stengers and Donna Haraway. Before coming to science studies, Haraway earned her PhD in Biology and Stengers in Chemistry. In my view, these scholars are particularly well-equipped to address complex problems that demand insights from multiple disciplines.
- 16 The tendency in contemporary science discourse to replace “biology” with “life sciences” is telling. In the 1950s biology becomes a molecular science that gathers all the sciences (not only biology and its various sub-branches, but also physics, mathematics, informatics, chemistry and so on) around “life” as the key object (the object of objects, as it were). As is indicated by the omnipresence of the prefix bio-, virtually all the sciences become oriented towards understanding, controlling and enhancing life, from the molecular up to the cosmic scale (exobiology). While the idea of “life sciences” suggests interdisciplinarity, it also binds all these sciences to a particular, genetic understanding of life. If life, as biologists like Stuart Kauffman maintain, is something irreducible, more akin to notions such as “world” or “cosmos” than with particular field of knowledge, then the term “life sciences” makes little sense. I shall therefore use only the terms biology and bioscience.
- 17 Compared to previous developments in biology such as the biotech revolution, genomics is extraordinary in that it has an auxiliary discourse attached to it in the form of ELSA genomics (ethical, legal and social aspects of genomics). ELSA research explores the knowledges, technologies and practices of genomics and their societal repercussions. The same is being done in fields like science and technology studies, the social studies of science, the cultural studies of science, literature and science, and the medical humanities. Scholars from these various fields not only critically analyze how genomic knowledge, data and technology function in particular contexts, but also evaluate the tenability and desirability of certain ambitions in genomics.
- 18 Indeed there are a few exceptions to the rule: the so-called monogenetic diseases (such as Huntington’s disease and cystic fibrosis).
- 19 As Alison Pilnick explains, determinism can be attractive for scientists and policy makers alike, because it “offers a way of viewing social problems as discrete and controllable, arising

as a result of problematic individuals, rather than more widespread societal problems" (36). In the same vein, evolutionary psychologist Susan Oyama discerns a hope in biology, shared by the wider public, that "an immutable natural 'core' will stabilize an increasingly relativistic and uncertain world" (*Evolution's Eye* 23).

20 This thesis uses MLA style in-text referencing, which does not include the year of publication. However, when the title of an article or book is mentioned in the text, this title is followed by the original year of publication (which need not coincide with the version listed in the list of references).

21 Barad describes intra-actions as "causal (but nondeterministic) enactments through which matter-in-the-process-of-becoming is sedimented out and enfolded in further materializations," stressing that the environment should never be posited as mere background, because "'environments' and 'bodies' are intra-actively constituted" (170).

22 Cary Wolfe, who coined the term Posthumanities and is the editor of a book series under that name (published by Minnesota University Press), argues that "the blunt theoretical instrument of humanism, which divides the world of the living along the axis of 'the human' and everything else, actively prevents our understanding, for instance, that humans and the great apes have far more in common with each other than apes do with most other 'animals,' or that a blind person and a guide dog form a third, prosthetic kind of subjectivity whose experience of the world cannot well be explained by reference to the traditional hierarchy of human vs. animal, which belies the complex forms of communication, trust, and mutual dependence entailed in such a hybrid relationship" (page). As I see it, a major consequence of Wolfe's vision of the Posthumanities is that the queries of genomics and synthetic biology cannot be bracketed as mere objects of cultural or social analysis; rather, scholars need to *think with* new understanding and technologies from the New Biology. Moreover, in opening up to the natural sciences, Humanities scholars ought to consider the possibility of confronting life as something that exceeds the provinces of discourse, history, culture, and human subjectivity.

23 Paul Griffiths and Karola Stotz have coined the name Biohumanities for a field of study aimed at four goals, "deepening our understanding of biology itself, engaging in constructive science criticism, creating alternative visions of biology, and achieving critical science communication" (44). Analyses of literary texts can contribute to these goals in a way that is complementary to work done in the philosophy and history of biology. Sf texts in particular offer fictional ethnographies of science (scientists' dynamic relations to each other, institutions, procedures, etc.), meeting Griffiths and Stotz's aim of communicating to a wider audience "something of the complexity of the scientific process and the contestability of its findings" (38). They also *think along* with science, exploring various ways of doing biology.

24 In *The Body Multiple: Ontology in Medical Practice*, science studies scholar Annemarie Mol analyzes her experiences as an ethnographer in a Dutch hospital following doctors, patients and

researchers Her story about atherosclerosis is "not about social causes and consequences of the disease, nor about the way patients, doctors, and whoever else involved perceives it. But about atherosclerosis itself. What it is" (53). Mol argues that science studies should quit focusing on multiple epistemological and social *perspectives* and become involved with ontology: how reality is *enacted*. In deemphasizing epistemology, Mol emphasizes that "the question of what it 'is' does not infer some transcendent truth, but a relational, situated, local, enacted reality" (54-5). The point of Mol's argument is to demonstrate "the permanent possibility of alternative configurations" (164): the disease is enacted through various practices, which can and do change.

25 Scholars of science and technology like Caspar Bruun Jensen, Andrew Pickering, Isabelle Stengers and Eugene Thacker all draw heavily from Deleuze and Guattari's work. One of the founders of STS, Bruno Latour, argues that his theory of actor-networks, assemblages of human and nonhuman actors, could have been named "actant-rhizome ontology," because it instantiates Deleuze and Guattari's idea of the often invisible connections between assemblages ("Technology"). Recently, the relevance of Deleuze's work for science studies has been brought to academic attention more explicitly in a number of volumes on science and technology: *Deleuze and science* (edited by Marks); *Deleuze and New Technology* (edited by Poster and Savat); and *Deleuzian Intersections: Science, Technology, Anthropology* (edited by Bruun Jensen and Rödje). Studies relating Deleuze's work to contemporary biology and biotechnology include Ansell-Pearson's *Germinal Life: The Difference and Repetition of Gilles Deleuze* (1999); John Marks's *Deleuze: Vitalism and Multiplicity* (1998); Luciana Parisi's *Abstract Life: Philosophy, Bio-Technology and the Mutations of Desire* (2004); Eugene Thacker's *Biomedica* (2004); and the volume *Deleuze/Guattari and Ecology* (2009) edited by Bernd Herzogenrath.

26 Patricia Ticineto Clough perceives the problem of thinking technologies and futures as follows: "What technology is unfolding thought anew? Or in what technology are thought and its subjects, objects and processes presently enfolded? Such an approach would shift criticism from the ongoing attempts to limit technology, to control it, or *anticipate* the future that technology is purported to bring with it. Instead criticism would *precipitate* the future, setting off mutation in the complexity which technology is giving up to thought" (312). In Deleuzian terms, this means becoming implicated in a becoming, and allowing thought to transform in the process.

27 Contemporary authors of biologically inflected sf include Greg Bear, Paolo Bacigalupi, Andrea Barrett, Octavia Butler, Michael Crichton, Paul Di Filippo, Gwyneth Jones, Nancy Kress, Marge Piercy, Richard Powers, Kim Stanley Robinson, Joan Slonczewski, Bruce Sterling, and Karen Traviss. Although Jameson's assessment about the rise of bio-sf seems pertinent in the period from the late '70s until the late '90s, I have doubts whether this trend is still ongoing today. It seems more likely that the biological is being inserted as an element in the new space opera (especially in Britain) and new mixtures of sf and fantasy (for example China Miéville's work).

- 28 Sf novels and other literary texts are increasingly becoming the object of literary analyses that emphasize nonhuman forces and actors. See for example Stacy Alaimo's *Bodily Natures: Science, Environment and the Material Self* (2010); Wai Chee Dimock's *Through Other Continents: American Literature Across Deep Time* (2006); and Mark McGurl's article "The Posthuman Comedy" (2012) in the journal *Critical Inquiry*.
- 29 The qualification of the "world wide lab" as *performative* can be extrapolated to any lab situation if we follow Barad's "posthumanist performativity" in *Meeting the Universe Halfway* (2007), but also on the critique of representationalism in Bruno Latour's *Science in Action* (1987), and Andrew Pickering's *The Mangle of Practice* (1995). From the perspective of these theorists, the lab is never merely a place for representing or simulating reality, but rather a transformation of the world, actually or virtually (in terms of what can be done, perceived, understood, or what can happen).
- 30 Examples of analyses of sf by scholars in science studies and allied fields include Donna Haraway's *Simians, Cyborgs, and Women: The Reinvention of Nature* (1991), Colin Milburn's *Nanovision: Engineering the Future* (2008), Susan Squier's *Liminal Lives: Imagining the Human at the Frontiers of Biomedicine* (2004), Priscilla Wald's *Contagious: Cultures, Carriers, and the Outbreak Narrative* (2008), and Hub Zwart's *De waarheid op de wand: Psychoanalyse van het weten* (2010).
- 31 For a sophisticated discussion of the sf genre and its limits see Freedman.
- 32 In Hindu religion Sheva is the Goddess presiding over life and death.

NOTES CHAPTER 2

- 1 I use the term "biophysical" to refer to the continuum of biological and physical phenomena (including chemical processes), and should not be confused with the scientific field of biophysics, which uses methodologies and ideas from physics to study biological systems.
- 2 In *A Thousand Plateaus* Deleuze and Guattari refer to the work of Asimov in relation to the becomings explored in sf, but refrain from reference to a specific work or from further explanation.
- 3 The connection between science studies and sf studies is a relatively recent and underdeveloped one. See Bould, *Science Fiction* (2012); Luckhurst, *The Invention of Telepathy, 1870-1901* (2002) and "Pseudoscience" (2009); Bould and Vint, "Learning from the Little Engines That Couldn't: Transported by Gernsback, Wells, and Latour" (2006); and Vint, "Science Studies" (2009), and "Archaeologies of the Amodern" (2012).
- 4 The novel *Blood Music* was based on a short story by the same title published in the sf journal *Analog* in (1983), for which Bear won Hugo and Nebula awards in the category "best novelette."

- 5 Ernst Bloch develops the concept of the novum, an unanticipated event or idea that enables the imagination of a new future, in *The Principle of Hope*. In his landmark study *Metamorphoses of Science Fiction* (1979), Darko Suvin argues that good sf novels essential work by introducing such a novum—a technology, a disease, an extraterrestrial life form—which functions as a device that sets the narrative in motion. This novum is not something static, but something productive: it performs something new. The mere presence of extraterrestrials, for example, is not sufficient; these beings have to *make a difference* in the succession of events, for example through (bio)technologies that reconfigure human bodies and social relations.
- 6 Moore's *Utopia* imagines an island on which new and more perfect society has come to fruition, while in *Island of Dr. Moreau*, a medical professor who has been expelled from his scientific community seeks refuge on a deserted island to continue his controversial work, creating a hybrid of human-animals, an experiment that ends up in a massacre.
- 7 Here Jameson is especially indebted to Adorno's *Aesthetic Theory*, where Adorno insists on the preeminence of literary form and artistic autonomy.
- 8 The problem of realism or cognitivism in sf has been discussed widely. Recently, Carl Freedman has argued that sf does not produce stories that are inherently "cognitive" (logical, plausible), for this would imply that there is a way to assess such a qualification objectively, which is impossible, for what counts as "true" in science is up for debate and subject to changes in time. Instead, Freedman argues, we can observe in sf a "cognition effect" which is not explained through external judgment but through "the attitude of the text itself to the kind of estrangements being performed" (18). However, I agree with China Miéville that even in this conception, the pretention of "scientific accuracy ... sneaks in through the back door" (236). The whole idea of cognitivism, which seems to boil down to some appeal to mimesis, should be left behind in order to do justice to the power of experimentation, whose merits should not be sought not in logic, correspondence, or plausibility, but in text-immanent consistency.
- 9 For Jameson, all libidinal energy that goes into artistic and intellectual work must flow in the direction of class struggle; there is no viable alternative. When other interests take hold of this shallow reserve of the utopian imagination, for example in the name of feminism or racial politics, Jameson suggests that this only amounts to one other ideological trap. He argues that, unfortunately, under postmodernity (or "late capitalism") the possibility of class consciousness has been lost. Referring to feminist literary and philosophical utopian writings in the US in the 1970s, Jameson comments that "the gender turn of the Utopian imagination is the sign of a waning of the Utopian imagination in the post-Cold-War period, in which the socialist model seems to have been discredited by Stalinism and the excesses and dysfunctionality of the newer global capitalist system have not yet begun fully to appear" (140). In spite of Jameson's ongoing interest in feminist sf authors like Ursula Le Guin, such a position amounts to an imposition of his Marxist framework on politics as such (Stengers,

Cosmopolitics II 408). Furthermore, Jameson's bleak image of postmodernism, which he argues has brought about a loss of coherent subjectivity, denies the fact that the de/reterritorialization of cultures and economics systems also yields possibilities for new forms of identity and belonging (Sandoval 34-5).

- 10 The modulation of language is not exclusive to literature. As Deleuze and Guattari note, the same type of linguistic experimentation can be found in the elaboration of accents and slang by African-Americans (*Kafka* 17). An even better example, perhaps, is the profusion of "Spanglish" (a hybrid of English and Spanish) in the US.
- 11 A common form of experimentation with language in sf is neologisms describing new place, beings, and artifacts. There are also sf novels that explore the very concept of language, but they are scarce. Carl Malmgren mentions Samuel Delany's *Babel-17* (1966), Jack Vance's *The Languages of Pao* (1958), and Ian Watson's *The Embedding* (1973) as examples of sf that "deal with the invention of languages with the power to transform social reality" (78). Fredric Jameson singles out Philip K. Dick's work as a site of experimentation with language itself (*Archaeologies* 363-383). A more radical statement comes from Samuel Delany, who has argued that the genre of sf as such invites different "reading protocols": the meaning of an ordinary sentence can change significantly when it is transposed from a mainstream literary text to an sf text ("*Dichtung*"). For Delany, what is unique about sf is "the occurrence of unusual, if not downright opaque, signifiers" on the level of single terms, sentences and plots ("To Read" 256). I am hesitant to assert that any of these examples correspond to Deleuze and Guattari's idea of the deterritorialization of language. In reference to Kafka's work, Deleuze argues that "the creation of words or neologisms is worth nothing apart from the effects of syntax in which they are developed" (*Critique* 5). Delany's more bold statement about the genre of sf as an "inmixing" ("To Read" 259) of unexpected signifiers seems to me a problematic identification of Derrida's *différance* with the genre of sf as such. As I argue in this chapter, what sets sf apart is an introduction of scientific ideas, practices, desires, and attitudes in literature.
- 12 Émile Zola's notion of the "literary experiment" supposes a kind of rapprochement between literature and science. Writing in the 1880s, Zola compared literature with bioscience (notably the work of the French physiologist Claude Bernard), stating that "naturalistic" novels aim to test and build upon scientific views under various conditions.
- 13 Deleuze and Guattari want to circumvent the trap they see in dominant critical paradigms such as psychoanalysis and Marxism, where too often reading becomes the mere reification of one's own theory at the expense of the unique properties of a literary text (a point that has been usefully elaborated by Colebrook and Lambert). They denounce all forms of interpretation, the method that aims to extract meaning from literary texts. For Deleuze and Guattari, the interpreter is a statist thinker, a "priest" or a "bureaucrat," who blocks the flow of thought (*A Thousand*, 126). In place of interpretation they present a pragmatic approach based on analyzing the way a text *functions*: not what it signifies, but what it does and how

it can be put to use. While many scholars read Kafka with a preset arrangement of "contents" in mind whose occurrence they will recognize instantaneously in the text (the challenge is always to get to the "hidden" contents: this or that pathology, fetish, or archetype), Deleuze and Guattari attempt to follow Kafka's experiments "freed from his interpreters" (Bensmaïa, xxi) and to distill philosophical concepts from this reading exercise. The notion of minor literature is in fact one of these concepts: first coined as an off-hand idea in Kafka's diaries, Deleuze and Guattari have made it into a full concept intuiting what literature can do, substantiating their theory on the basis of Kafka's oeuvre.

- 14 My Deleuzian approach to sf relies on science, but not, as in Jameson's work, as a source of "cognitive" authority. In a similar vein, speculative fiction writer China Miéville has argued against the Jamesonian "cognitivism" and the concomitant skepticism about the genre of fantasy. According to Miéville, sf writers should be devoted to "the development of a radical, aesthetically estranging and narratologically rigorous literature of literalized metaphor and alterity" (244).
- 15 The concept of historical *a priori* was coined by Husserl in his essay "Origins of Geometry" as a phenomenological alternative to Kant's transcendental *a priori*. Foucault, in chapter 5 of *The Archaeology of Knowledge*, changed the meaning of the concept in order to emancipate his archaeological method from phenomenology, which for him relied too much on the notion of the subject. For a comparison between Foucault's understanding of "historical *a priori*" and Husserl's initial usage of the term, see Oksala 67-9.
- 16 Baudrillard argues: "The point when prostheses are introduced at a deeper level, when they are so completely internalized that they infiltrate the anonymous and the micro molecular core of the body, when they impose themselves on the body itself as the body's 'original' model, burning out all subsequent symbolic circuits in such a way that every body is now nothing but an invariant reproduction of the prosthesis: this point means the end of the body, the end of its history, the end of its vicissitudes. It means that the individual is now nothing but a cancerous metastasis of his basic formula" (119).
- 17 Delanda has argued that it is not the genome, but "the more or less free flow of genes through microorganisms" that constitutes a Body without Organs ("The Geology" 11).
- 18 Hansen argues that although Deleuze and Guattari's biophilosophy has a lot in common with contemporary approaches to organic complexity in fields like systems biology and Developmental Systems Theory, there is a fundamental mismatch between their philosophical ideas and the workings of biological systems. Hansen's critique hinges on two points. Firstly, Deleuze and Guattari portray higher levels of organization such as biological organism as "an exclusively negative limitation of life, one that does not express so much as restrict its expression" (35), focusing instead on populations and the relations between populations as the site of development. Secondly, according to Hansen, Deleuze and Guattari see transversal (horizontal) molecular processes—which they call involution—as the exclusive domain

where novel traits are produced, rejecting the theory of evolution by natural selection. Hansen argues that Deleuze and Guattari ignore the irreversibility of developmental processes (path dependency). He accuses them of “confusing the flexibility attributable to organisms on an evolutionary timescale with the far more narrow flexibility characteristic of developmental processes” (58). I feel that Hansen exaggerates his point, which is in contradiction with his own convincing comparative analysis of Deleuze and Guattari’s biophilosophy and contemporary biosciences. Although Deleuze and Guattari admittedly go too far in denouncing the organism in favor of experiment and becoming, throughout *Anti-Oedipus* and *A Thousand Plateaus* they are at pains to stress that there are limits to experimentation and to what a body can do. As I see it, Deleuze and Guattari’s aim is to “reverse” evolutionary theory, arguing that variation on the level of transversal communication (gene transfer through viruses and other vectors) is primary, rather than a secondary phenomenon, an insight that has been given scientific form in the work of biologist Lynn Margulis. The conundrum of how flexible organisms really are has partly to do with epigenetic factors which the biosciences are only beginning to come to grips with.

- 19 Hayles, building on Hansens critique, argues that Deleuze and Guattari’s body without organs has a “lack of internal structure” (153), and thus cannot do justice to highly patterned developmental processes which are always constrained by environments. She goes on to argue that the mistake Deleuze and Guattari make is to take on biological terms as metaphors and then claim to use them literally. Like Hansen, Hayles seems to take Deleuze and Guattari’s statements about going beyond the organism at face value, disregarding the fact that they also stress the limits to and dangers of such experimentation. However, the greatest problem I have with Hayles’s critique is that it fails to take into account Deleuze and Guattari’s distinction between science and philosophy. When Deleuze and Guattari state that they are using terms literally, this does not mean that they use them in a mimetic way or as a proposition, as in science (see *What is Philosophy?*).
- 20 See in particular chapter 6 of *A Thousand Plateaus*, “November 28, 1947: How Do You Make Yourself a Body without Organs?”
- 21 For an interesting elaboration of Deleuze and Guattari’s notion of the molecular and its connection to contemporary modeling of swarm behavior, see Eugene Thacker’s “Swarming: Number versus Animal?”
- 22 Deleuze and Guattari analyze Kafka’s *The Trial* as an effort to dismantle the Law: to reveal, in a Foucaultian way, the machinery of power. What from a distance looks like a solid machine for making judgments, on closer look is a complex and amorphous assemblage of individuals, groups, institutions, rules, customs, and so on. Deleuze and Guattari argue that in *The Trial*, the goal of authorities is not to pass judgment once and for all, but precisely to suspend judgment and to wallow endlessly in desire for truth and justice. Power is revealed as an immanent field of desire: not the desires of human subjects but the “polyvocal” desire

of bodies and of the assemblages humans are part of (49). For this idea of polyvocality in literature Deleuze and Guattari seem indebted to Michael Bakhtin who coined the term in *The Dialogic Imagination*.

NOTES CHAPTER 3

- Pickering’s assessment that State science includes “classically modern sciences like physics and sociology” (“Cybernetics” 155) seems to me problematic; I would rather argue that all science is dominated by the State science model, and that nomad science is everywhere present as potential (perhaps some fields have historically developed to be more hospitable to nomad thought than others).
- According to Deleuze and Guattari, the state is a form of “interiority” or capture, while the war machine is a form of “exteriority” or freedom: “The State is sovereignty. But sovereignty only reigns over what it is capable of internalizing, of appropriating locally. Not only is there no universal State, but the outside of states cannot be reduced to “foreign policy,” that is, to a set of relations among States. The outside appears simultaneously in two directions: huge worldwide machines branched out over the entire *ecumenon* at a given moment, which enjoy a large measure of autonomy in relation to the states (for example, commercial organization of the “multinational” type, or industrial complexes, or even religious formations like Christianity, Islam, certain prophetic margins or messianic movements, etc.); but also the local mechanisms of bands, margins, minorities, which continue to rights of segmentary societies in opposition to the organs of State power” (397).
- Besides these examples, Deleuze and Guattari do not go much further in explicating the concepts of State and nomad science than simple enumeration: “Democritus, Menaechmus, Archimedes, Vauban, Desargues, Bernoulli, Monge, Carnot, Poncelet, Perronet, etc.: in each case a monograph would be necessary to take into account the special situation of these savants whom State science used only after restraining or disciplining them, after repressing their social or political conceptions” (*A Thousand* 401).
- Jackie Leach Scully has even argued that “the deterministic program model of gene action is currently the only one available for popular discourse on human nature” (354).
- In each institution, Deleuze discerns processes of deterritorialization: “In the *prison system*: the attempt to find penalties of ‘substitution,’ at least for petty crimes, and the use of electronic collars that force the convicted person to stay at home during certain hours. For the *school system*: continuous forms of control, and the effect on the school of perpetual training, the corresponding abandonment of all university research, the introduction of the “corporation” at all levels of schooling. For the *hospital system*: the new medicine ‘without doctor or patient’ that singles out potential sick people and subjects at risk, which in no way attests to individuation—as they say—but substitutes for the individual or numerical

body the code of a 'dividual' material to be controlled" ("Postscript" 4). Deleuze here adopts a polemical style and a mode of future telling almost unique in his oeuvre. In spite of its speculative features, scholars have found this text useful in trying to fathom the directions in which biopower is heading.

- 6 As the work of environmental philosopher Sanne van der Hout shows, it remains to be seen what the research fields of metagenomics and ecogenomics do to address environmental complexity and whether they lead to more sustainable ways of coping with nature.
- 7 In one of his experiments, Venter water marked a "synthetic cell" with several sentences transcoded into the four-digit code of DNA, one of which was a famous sentence from cybernetician Richard Feynman "What I cannot create, I do not understand" (Venter, *What is Life*). Indeed, this seems to be the dictum of Venter's work.
- 8 As Kay has pointed out, in *The Human Use of Human Beings* (1950), Wiener already argued that the possibility of transmitting a living human being in coded form and then reconstructing the body was theoretically possible. A similar statement was made by Nobel laureate Walter Gilbert (89, 327). However, Kay argues that there is also historical discontinuity: Schrödinger in *What is Life* "did not think of DNA or information; in fact, epochal distance separated his voice from its distorted echoes" (66).
- 9 On the potential of tissue engineering to generate endless wealth, see Cooper's *Life as Surplus*, in particular p. 120.
- 10 For a very similar argument see Kay, in particular p. 54.
- 11 Mayeri qualifies Venter as narcissistic (76, 80), referring to Venter's decision to use his own DNA for the sequencing of the human genome. After sequencing his genome, Venter learned about his health risks, and immediately took action, increasing body exercise, changing his diet, and taking certain drugs (Venter, *A Life* 85).
- 12 James Williams's guide to *Difference and Repetition* is highly recommendable, clarifying aspects of Deleuze's philosophy through a myriad of examples. As Williams explains, "things acquire fixity, that is, they acquire parts and hence boundaries through repetition. These parts and boundaries then allow us to see the individual as a member of a class or species. For example, the boundaries of an animal's territory come from the repeated prowling and marking of its perimeter. Or we acquire an accent by the repetition of particular intonations. Neither the actual territory nor the accent exist prior to the repetitions" (11-12).
- 13 Deleuze's fascination with embryology is salient in the context of contemporary alternatives to the molecular paradigm. As Griesemer argues, whereas in (post-)genomics "process is pushed into the methodological background," a field like embryology "foregrounds devel-

opment and backgrounds hereditary transmission" (222). Evelyn Fox Keller even goes as far as to argue that the dominant focus on genes has led to the "eclipse of embryology" and, thus, a situation where the "problems of development, still unresolved, lay dormant" ("Beyond" 298). Deleuze's argument in *Difference and Repetition* about the neglect of "difference-in-itself" in Western thought, I argue, serves as a general framework for understanding the neglect of embryology and other fields that foreground process.

- 14 In his study of Deleuze's biophilosophy entitled *Germinal Life*, Ansell-Pearson traces Deleuze and Guattari's concept of the rhizome, as well as Deleuze's idea of an embryological life that stays part of the organism, back to Bergson: "Although Bergson is close to Weismann he does not wish to locate the vital principle in something as specific and self-contained as a germ-plasm, since this would reduce the scope within 'creative evolution' for invention and innovation. For Bergson what is transmitted is not imply the physic-chemical elements of the germ-plasm but also the vital energies and capacities of an embryogenesis and morphogenesis that allows for perpetual invention in evolution" (40).
- 15 Reflection about science often occurs outside science departments, and many scientists regard exercises of philosophical reflection as impediments to their work-flow. Biologists Richard Levins and Abha Sur explain this lack of philosophical interest within the contemporary biosciences by pointing to the pressure to increase academic production levels "in an era of neo-liberal economics": "Commodification of science and its institutional organization works against self-reflectivity and produces contempt for philosophy. This contributes to the narrowness of contemporary science even when there are pleas for complexity, interdisciplinary methodologies, and wholeness. So far the appeals to complexity tend to live in the introductory chapters of books, while the main text is still fragmented and narrowly focused. Scientists are evaluated mostly by their contributions within the bounds of their department's definitions" (37).

NOTES CHAPTER 4

- 1 SHEVA stands for "Scattered Human Endogenous Retro Virus Activation." It is not the virus itself, but the process of activation. In Hinduism, Shiva is the eight-armed god of creation who destroys and transforms life at will.
- 2 *Darwin's Children* explores the consequences of a transmutation of humanity, when new humans have to live in a society where they are looked upon as anomalous and threatening. Since in the sequel, the actual transmutation has already transpired, it is less relevant in the context of this thesis.
- 3 In a book review of *DR* in *Nature*, biologist Michael A. Goldman even concludes that "hard scientific evidence tells us that the scenario is possible" (15). As Goldman concurs, "there is some basis for speculating that something other than a grossly random mess would result

from a massive mobilization of transposable elements ... it is possible that simple insertion of a retroviral element in the vicinity of a gene could result in an alteration in the timing or positioning of its expression in early development. The result could be a different, yet perfectly viable, organism" (15-6). Although Goldman does confess that the idea of species change within a single generation "might be a little too radical at the moment," he points to the fact that Bear has based his speculation on scientific studies on fruit flies, which have revealed that exposure to certain environmental pressures can cause radical mutations in only a few generations.

- 4 In the epilogue to *Darwin's Children*, Bear indicates that Niles Eldredge and Stephen Jay Gould's theory of punctuated equilibrium had been "one of the key stimuli" for his thoughts on evolution (490). An extension of Ernst Mayer's notion of "genetic revolutions," punctuated equilibrium uses discontinuities in fossil records to show that evolution is characterized by long periods of very slow change and short episodes of rapid transformation (the latter covering hundreds or even thousands of years).
- 5 In an article on his web site entitled "The New Biology," Bear reveals his familiarity with Koestler's work, stating that Koestler "fought reductionism in psychology and biology from the 1950s to his death."
- 6 The evolutionary role of transposons was first described, against the scientific grain, by Barbara McClintock in her research on corn genomes. See Evelyn Fox Keller's biography *A Feeling for the Organism: The Life and Work of Barbara McClintock* (1983).
- 7 Zwart's term "genomics novels" emerges out of his readings of Michael Crichton's *Jurassic Park* (1991) and *Next* (2006). Priscilla Wald and Jay Clayton have also discussed genomics in literature, visual arts and culture, although their understanding of genomics here seems extremely broad, encompassing genetics as well as eugenics. For analyses of genomics in film, see Kirby; Kirby and Gaither.
- 8 Margulis' idea that creativity and change, before they can be selected from the outside, must first emanate from the inside, ring with the work of Koestler, but more importantly, with the work of C.H. Waddington who coined the term epigenetics to point to the complex regulation of gene expression by factors other than the DNA itself, factors that are important for the actual development of organisms.
- 9 Consider, for example, the resemblances between Bear's description of biofilms and the following description from *Acquiring Genomes*: "In the protocist world, the first engineers and designers created structures like delicate silica boxes or calcium bonate hunting platforms. Others invented agriculture. Single-celled foraminifera, representing some 60,000 distinctive species, and comprising relatively huge cells, farmed and trapped algae they expelled along body tracks and stored in stalls in their cells. The well-trained algae take in the

sunlight and manufacture the food for everyone nearby during daylight hours. Then, snug inside the foram shells at night, the algae breathe in oxygen that they produced during the day. Some fussy relatives of these foram farmers make their new shells from a multicolor mix. These "agglutinators" plaster tiny stones to their bodies. Other forams even pack minerals together to construct look out towers. They climb atop the towers and hunt, preying on animals such as rotifers and crustaceans far larger than themselves" (86).

- 10 In *DR*, men whose SHEVA retrovirus has become activated can laterally transmit the virus to women through sexual intercourse. Once infected, pregnant women first miscarry an extremely malformed fetus. Then, without having sexual intercourse, the women become pregnant again and miscarry a fetus that reveals regular embryonic development. It is only by the end of the novel, when obstetricians have learned that it is the anesthesia that kills the fetuses, that "second-stage births" become successful.
- 11 Bear's idea of a global "neural network" on the level of the species closely resembles Howard Bloom's ideas presented in *Global Brain: The Evolution of Mass Mind from the Big Bang to the 21st Century* (2000). A useful book for understanding Bear's discourse on networks and its relation to neo-Darwinism and the Modern Synthesis is Steven Shaviro's *Connected: Or What It Means to Live in a Network Society* (2003). A recent novel that combines the themes of evolution and the brain is Joan Slonczewski's *Brain Plague* (2000).
- 12 Jean-Baptiste Lamarck (1744-1829) was one of the first biologists in the modern sense of the word. Today he is most often remembered for his theory of the inheritance of acquired traits. According to this theory, organisms pass on to the next generation traits that they have acquired throughout their life time. This theory, sometimes referred to as Lamarckism, has been rejected widely in modern molecular biology. According to a dominant idea known as the Modern Synthesis, the DNA is protected from outside influences by a membrane, so that the DNA is inherited without being altered.
- 13 For a fascinating exploration of these issues in American literature and culture see Priscilla Wald's *Contagious: Cultures, Carriers, and the Outbreak Narrative* (2008).
- 14 The biopolitical themes in *DR* are manifold. The novel plays on the concerns for global epidemics and, in the long run, the need to find alternatives to antibiotics, which are increasingly losing the battle against new viruses. It examines the power games played by the pharmaceutical industry, scientific institutes such as the Centers for Disease Control, and the federal government in times of crisis. Furthermore, Bear's story resonates with the biopolitics of sexual reproduction and sexuality in the US: the politicization of birth, the fetus, AIDS, and homosexuality. It raises questions about the ways in which people with a sexually transmitted disease are tagged as threats to the family, the State and to the cultural logic of what Judith Butler has called "the heterosexual matrix": the organization of society in exclusively heterosexual terms (Butler).

- 15 The term “molar” is used by Deleuze and Guattari to denote actualized, organized entities, while the “molecular” concerns the field of particles that interconnect, forming assemblages that are not actualized in a complete, functional body.
- 16 This was a critique of several students in the MA course Science and literature I taught in 2009 at the Faculty of Science of Radboud University, The Netherlands.
- 17 The pioneering molecular biologist Bruce Lipton argues that human evolution can be controlled through meditation and other techniques. The way we think and how we perceive the world, Lipton suggests, impacts immediately on our brains, which in turn influences our immune systems and our genomes. The corollary is that we can cure ourselves, release new superhuman powers, and transform ourselves as a species. See *Spontaneous Evolution: Our Positive Future and a Way to Get There from Here* (2009).
- 18 According to Margulis and Sagan, all symbioses begin with what Ivan Emmanuel Wallin (1890–1967) called “prototaxis,” a set of inherited motivations: “Examples include the tendency of the mouse to flee from the cat, the shark to swallow the fish, the rabbit to dine on lettuce, or the fly to lay its eggs on the bloody muscle tissue of a recently dead boar” (*Acquiring* 98).

NOTES CHAPTER 5

- 1 One famous exception is Arthur C. Clarke’s sf classic *Childhood’s End*, in which humanity is destined to merge with extraterrestrial “Overlords,” who turn out to be mere messengers of a central “Overmind,” a pure disembodied abstraction controlling the Universe, incorporating everything into itself. While this narrative reaches a kind of immanence, critiquing modern science’s division between body and mind, it can also be read as a cybernetic fantasy of transcendence, reaching a state of energy and information independent of matter. In this sense, it differs from *LB*, in which the merger of subject and world is nonlinear and non-totalizing.
- 2 In the majority of alien encounter films, such as the *Star Wars* series (dir. George Lucas) *Starship Troopers* (dir. Paul Verhoeven 1997,) and *Independence Day* (dir. Roland Emmerich), the prime strategy for preserving autonomy is warfare. Stories about “alien love” such as *E.T.* are exceptional in the sense that they relinquish violence, but here too, there is a humanist core that sets humans apart from its “others” (Badmington 6, 63).
- 3 The trilogy was formerly known as *Xenogenesis*, which means “strange beginning.”
- 4 Biologist and sf writer Joan Slonczewski has praised Butler’s account of genetic trade for its biological viability, arguing even that it is “remarkably consistent with modern molecular biology, even predicting developments that have occurred since the novels were written” (“Octavia” 1).

- 5 Bruce Clarke and Cathy Peppers have asked Butler respectively through e-mail and in person about her scientific sources. Butler indicated that she was introduced to the work of Margulis and Lovelock through the PBS television show *NOVA*, titled *Gaia, the Goddess of the Earth* and featuring expert commentary from Stephen H. Schneider and Richard Dawkins (broadcasted on January 28, 1986). See Clarke 168–69.
- 6 The possible consequences of liberal eugenics are sketched in other contemporary fictions such as Nancy Kress’s sf novel *Beggars in Spain* (1993), on the struggles for recognition and autonomy of a minority of enhanced “sleepless” people, and the sf film *Gattaca* (1997), in which an “ordinary” citizen manages to take on the identity of a member of the genetically enhanced upper class, and thereby manages to fulfill his childhood wish of becoming an astronaut.
- 7 As Robert Mitchell has pointed out to me, the name Akin refers to the fact that the son is like his mother in many ways, but not quite the same.
- 8 Perhaps the name “Ooloi” is a reference to the androgynous “Eloi” of H.G. Wells’s *The Time Machine* (1895).
- 9 Jorgensen, in a critique of Jameson’s approach to sf, repetitively states the need of reading “literally” rather than metaphorically. In a brief reference to Ursula Le Guin’s novel *The Left Hand of Darkness*, which experiments with a world purged of “compulsive heterosexuality” (Rich), Jorgensen asserts that Le Guin’s novel “can be taken as a concrete, scientific suggestion to engineer a human society that is not warped by libidinal investments. In looking to the limits of a world of ideological production, Le Guin engineers the shock and disgust of actual difference, and its possibility in the science of genetics” (209). Le Guin’s novel, in other words, makes it possible to think the future of human gender relations and sexuality in the light of new possibilities in molecular biology. A crucial point is that reading literally does not mean taking the text at face value, or treating it as one-dimensional and programmatic.
- 10 For example, in *Francis Bacon: The Logic of Sensation* Deleuze argues that the painter does not start with a blank slate: first he has to “empty” the canvas from the clichés and images projected from his own mind (71). In other words, the painter should not re-present something that is already there, but rather clear his mind from workaday experiences, in order to invent something new.
- 11 Although these philosophers go beyond Heidegger’s technophobia, they continue Heidegger’s idea of “*lichtung*,” a unique human space created through language and other externalizing technologies. It seems that Stiegler’s philosophy of technology and the post-phenomenological field of Object Oriented Ontology (Harman, Bryant and others) carry a residual anthropocentrism not found in the work of Deleuze and Whitehead. For a discussion of the convergence of Deleuze and Whitehead see Steven Shaviro’s *Without Criteria: Kant, Whitehead, Deleuze, and Aesthetics* (2009).

- 12 In Mexican-Amerindian mythology, Malinche is the woman who became the translator and concubine of conquistador Hernán Cortez. The figure of Malinche symbolizes the downfall of the native American cultures. Her name literally means “the fucked one” (Anzaldúa).
- 13 For Deleuze and Guattari, “machinic” does not mean technological or mechanistic but rather *abstract* (*A Thousand* 562). The communication of the Oankali is abstract because it precedes a division into concrete organs of perception and frames of understanding: it is an expression of affects, which are relational and transformational, not formal or substantial.
- 14 In *The German Ideology*, Marx and Engels attribute a unique “species-being” to humans: unlike animals, humans are free and conscious beings producing their “means of subsistence” and thereby, indirectly “their actual material life” (42). According to Marx and Engels, religion, the state, and capital try to conceal the reality of material production by representing life as an unchangeable, natural form, thus estranging man from his material needs and capabilities. Their theory of historical materialism, although accepting that there is such a thing as human nature, is a plea for man to purposefully change the course of history. Natural forces play no role in this project: “Of course, we cannot here go either into the actual physical nature of man, or into the natural conditions in which man finds himself—geological, orohydrographical, climatic and so on. The writing of history must always set out from these natural bases and their modification in the course of history through the action of men” (42).
- 15 For a lucid analysis of the relations between the logic of sacrifice, genomics, and contemporary biocommerce, see Mitchell’s article “Sacrifice, Individuation, and the Economies of Genomics” (2007) in the journal *Literature and Medicine*.
- 16 I do not mean to argue that Deleuze and Guattari’s ideas about the nonhuman, and animals in particular, are wholly compatible with Haraway’s work. In *A Thousand Plateaus* Deleuze and Guattari ridicule the relations between humans and pet animals, proclaiming that “anyone who likes cats and dogs is a fool” (265). Haraway condemns Deleuze and Guattari’s comments, which illustrate that while they have interesting things to say about co-evolution, they never really show any regard of mundane human-animal relations and the responsibilities that come with them. Similar criticisms on this remark by Deleuze and Guattari have been outed by Susan McHugh in *Animal Stories: Narrating Across Species Lines* (2011) and George Gessert in *Green Light: Toward and Art of Evolution* (2010).
- 17 The concept of becoming is one of the most difficult and controversial ones in Deleuze’s oeuvre. For useful reflections on becoming, see the works of Braidotti and Grosz.
- 18 Butler’s narrative ontologies touch on Baudrillard’s notion of “hyperreality,” a postmodern state in which there is no longer a steady reality behind the simulated environments of technological media. A crucial difference is that Baudrillard’s term denotes a social and se-

miotic implosion of reality, effacing meaningful mythologies, while Butler *rewrites* mythologies based on the endless embeddedness of biological life.

- 19 The inapplicability of genetic determinism becomes apparent very early on in the story, when Jdaya explains to Lilith the complexity of cancer: “It isn’t simple, and it isn’t a gene or two. It’s many—the result of a tangled combination of factors that only begins with the genes” (39).
- 20 For a lucid argument about the inadequacy of existing economic models for understanding transformation, and the potential for non-Darwinist evolutionary theory to explain economic dynamics, see Kauffman’s *Investigations* (2000), specifically the chapter “The Persistently Innovative Econosphere.”
- 21 The situation in resister villages can be explained by what Latour has defined as a distinctively modern “purification” (*We Have*) of the categories of nature and culture, and a tendency to privilege the latter, whereas the Oankali way of life is a worlding that exceeds such categories.
- 22 For an explanation of Spinoza’s opposition between *potentia* (an inner potential) and *potestas* (an external imposition or framework), see Braidotti’s *Transpositions*, 49.

NOTES CHAPTER 6

- 1 Robinson has won a number of prestigious sf awards, including the Nebula award and the British Science Fiction Award for *Red Mars*, Hugo and Locus awards for *Green Mars* and *Blue Mars*, and a Locus award for his alternative history novel *Years of Rice and Salt* (2003).
- 2 Robinson himself uses the concept of polyphony in dissertation, published as *The Novels of Philip K. Dick* (1984).
- 3 Mark Bould and Sherryl Vint have argued that while Robinson’s *Mars* trilogy at times offers a complex image of technoscience in the sense of a Latourian actor-network, even “allowing the landscape to become a powerful actant with which all others must negotiate,” the work does tend to gravitate towards human “heroes, villains, bureaucrats and politicians” (140). My aim here is two-fold: to analyze this tension in the trilogy and to bring out the “minor” element of human-nonhuman entanglements.
- 4 In an analysis of Paul Di Filippo’s transmutation novel *A Mouth Full of Tongues* (2003), Rossini argues that “The politically and ethically relevant potential of DST consists primarily in the proposition that system and environment, inside and outside, are mutually determining; in other words, power, control and agency are neither here or there, neither attributed to the self-subject nor to the other/object but are seen as multiple and distributed. A second important implication of DST is that we cannot legitimately define information as a binary

- code of ones and zeros, as a blueprint, fixed programme or stable representation of what a living organism will inevitably become and then eternally *be*" (249).
- 5 In the tradition of alchemy the practitioner exposes himself to obscure knowledges, substances and conditions in order to produce transmutations of matter and of the self (Zwart, *De Waarheid op de Wand* 183-86).
 - 6 Recently, the concept of terraformation has been elaborated by engineers Martyn Fogg in *Terraforming: Engineering Planetary Environments* (1995) and Robert Zubrin's *The Case for Mars: The Plan to Settle the Red Planet and Why We Must* (1996). For a convincing analysis of the connections between these accounts of terraformation, capitalism, and the American frontier hypothesis, see Markley (779-81).
 - 7 In Wells's *The Time Machine* a time-traveler discovers that in the year 802701 the human race is divided in two biological types, the feeble Eloi who live on the surface and the brutish Morlocks who, like rodents, live underground and only come out after dark.
 - 8 Robinson's choice of Arkady's surname Bogdanov seems to refer to a Bolshevik intellectual who in the 1920s experimented with blood transfusion as a means of achieving rejuvenation.
 - 9 In an interview with the journal *Science Fiction Studies*, Robinson laments the production of a "consensus future" in sf: a usually bleak and generally indifferent future based on present conditions as portrayed in "cyberpunk, or American-Imperial Heinleinism, or the 'future-war' subgenres" (Szeman and Whiteman 186). The sf author Robert Heinlein is one of the classic authors writing in a tradition celebrating American imperialism during the Cold War. In some ways, cyberpunk novels such as William Gibson's *Neuromancer* (1983) and Bruce Sterling's *Schismatrix* (1985) can be seen as postmodern, bleak versions of this imperialism, celebrating (male) aggression, fetishizing cybertechnology and neglecting non-anthropomorphic (ecological) processes. For critical discussions of cyberpunk see Bruce Clarke's *Posthuman Metamorphoses: Narrative and Systems* (2008), Catherine Hayles's *How We Became Posthuman* (1999), Eleaine Graham's *Representations of the Post/human: Monsters, Aliens and Others in Popular Culture* (2002) and the volume *Beyond Cyberpunk: New Critical Perspectives* edited by Graham J. Murphy and Sherryl Vint (2010).
 - 10 The idea of extended heredity is associated with C.H. Waddington's theory of epigenetics and Gottlieb's idea of the bidirectional influence of genes and environment.
 - 11 Desmond's nickname is a reference to Amerindian myths where the coyote represents a dweller and messenger. See Anzaldúa.
 - 12 In some ways, Hiroko can be seen as a cult leader exploiting her biotechnological skills to create a following. At one point Ann wonders: "To conceive so many children, without

- the fathers' permission, without control over the genetic manipulations; it was a form of insanity, really, divine or not" (*Green* 169). As most of the ectogenes are left-handed, rumors circulate that Hiroko "tweaked their genes" with left-handedness as side-effect, but this rumor is never confirmed (*Green* 33, 64). In spite of its artificiality and clandestine nature, there is an air of rightness and inevitability about Hiroko's experiment, not just for Hiroko but for most scientists. Although Hiroko is highly influential, I would argue that she is not an authoritarian guru, and that the success of her ideas depends on a network of underground settlements.
- 13 Robinson borrows the term *viriditas* from the Christian thinker, composer, and mystic Hildegard von Bingen (1098-1179). Von Bingen saw *viriditas* as a nourishing life force that "greens" the world (*viride* meaning green in Latin), a force that can be found not only in plants and trees, but also, for example, in celestial bodies. Humans gain *viriditas* mainly through eating and drinking (Von Bingen was also interested in medicine). It would be interesting to further explore the connections between Von Bingen's *viriditas* and the nomadic, ecological approaches analyzed in this thesis. For an overview of Von Bingen's life and work, see Flanagan.
 - 14 In an interview with Rjurik Davidson, Robinson argues that Buddhist modes of contemplation are in congruence with the scientific method: "Science has an attitude towards the universe that can be described as devotional: there's an intensity of interest, and an attempt to understand how it works, that is not dissimilar to the way that Buddhism intends to pay attention to the reality that we're in right now" (Davidson 40). Fritjof Capra has argued for the parallels between Buddhism and modern physics (*The Tao*); more recently, John Tresch has studied the multiple links between Buddhism and neuroscience ("Experimental Ethics").

NOTES CHAPTER 7

- 1 It seems feasible that the idea of "*another science*" points in the direction of Deleuze and Guattari's concept of nomad science although it is uncertain whether this concept was already conceived at the time they wrote *Kafka*.
- 2 As Deleuze and Guattari note, nomad science is a mode attuned to "the sensible conditions of intuition and construction" which continually lead it to encounter new problems, while royal science tries to "isolate" its operations from these conditions, acquiring a position of autonomy (*A Thousand* 412).
- 3 As Coyote notes, "the feminine was instinct, the body, and nature; the masculine was reason, mind, and law. And the law ruled ... On Mars it may be that the ego ideal is shifting back to the maternal. To the Dionysian again, or to some kind of post-Oedipal reintegration with nature, which we are still in the process of inventing. Some new complex that would not be so subject to neurotic over-investment" (*Green Mars* 53).

- 4 Kay's ideas do not only resemble those of Lynn Margulis, but also show affinities with the work of Barbara McClintock on gene transposons or "jumping genes" (genes that can change their position on the genome) for which she received the Nobel prize in 1983. Both of these female scientists had to fight for recognition by their (male) colleagues. For a fascinating analysis of McClintock's trials, see Evelyn Fox Keller's *A Feeling for the Organism: The Life and Work of Barbara McClintock* (1983).
- 5 Toscano shows how there are a number of resonances between Simondon's theories and systems theory, based primarily on their use of the term "information." However, as Toscano notes, for Simondon's conception of information is different from its usage in cybernetics and information theory, where it functions as a discrete entity carried along a channel. For Simondon, information rather constitutes the entire system of sender, receiver, message, and channel (this is what Simondon calls "first information"). In short, information is the ontogenic production of the system itself, rather than that which is produced within that system. For another discussion of Deleuze, Simondon and the concept of information, see Eugene Thacker's *Biomedica*.
- 6 For recent elaborations of the idea of extended inheritance, see Gilbert; Jablonka and Lamb; and Stotz.
- 7 See for example the work of Catherine Hayles, Luce Irigaray, Elizabeth Grosz, Sarah Franklin, and Rosi Braidotti.
- 8 Kauffman's idea that the emergence of order occurs as life moves in the direction of ever new "adjacent possibles" (*Investigations* 151) resonates with Deleuze's concept of the virtual, although Deleuze does separate virtuality sharply from possibility, the latter being discrete and the former continuous. Manuel Delanda, however, has explicitly linked the idea of evolutionary strategies or "searching devices" ("Virtual Environments") that explore possibilities to Deleuze's understanding of the virtual, which he calls "the machinic phylum." As Delanda argues, science itself is one of those "searching devices," we must realize that by its very nature, systems governed by nonlinear dynamics resist absolute control and that sometimes the machinic phylum can only be tracked, or followed (17). This statement shows a great affinity between Delanda's work and the concept of nomad science. For a concise discussion of nomad science by Delanda, see his chapter "Material Complexity" in the volume *Digital Tectonics* edited by Neill Leach, David Turnbull and Chris Williams.
- 9 Schneider and Sagan provide a fascinating explanation of Schrödinger's paradox—how it is possible for complex living systems to evolve in a universe whose guiding principle of entropy dictates the progressive annulment of differences. In *Into the Cool: Energy Flow, Thermodynamics and Life*, Schneider and Sagan argue that living matter on Earth has created a biosphere that is relatively cool, extracting matter and work from solar energy and sending

heat into space, thus producing entropy. In other words, if life diminishes entropy locally, it nevertheless produces entropy regionally.

- 10 Hiroko and the Oankali in *Mars* embody the "panspermia" idea, which was also held by one of the key figures in genetics, Francis Crick: life on earth may have originated through "infection" from the outside, either deliberately or by coincidence (Zwart, *De Waarheid* 173-4).
- 11 Haraway deplores Margulis's support of the theory of autopoiesis as formulated by Maturana and Varela, arguing that "symploysis and autopoiesis are incompatible" because organisms develop and evolve in interaction (*When* 33). In a conversation with Haraway in 2011, I learned that she is generally skeptical about systems thinking in biology.

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SUMMARY

This dissertation provides an analysis of contemporary biosciences through the lens of bio-sf novels (biologically oriented science fiction). The point of departure is that novels can be useful tools for understanding not just the psychological and social dimensions of science, but also the tensions between different scientific ideas, practices, and attitudes. Bio-sf novels usually revolve around radical events such as encounters with extraterrestrial species. This dissertation analyzes how such fictional events can shed light on tensions in contemporary biosciences. In the novels under study humans "transmutate," sometimes even resulting in a new, posthuman species. What makes these novels exceptional is that they narrate transformations that are not of human design. Rather, these are spontaneous events emerging from the interplay between humans and their new and/or changing environments. In the novels, certain scientists vainly attempt to stop or control the process of transformation. The protagonists, instead, realize that the event is too complex to be controlled. They seek to understand the transformation, adapting their own ways of thinking and living along the way. In short, these novels picture human beings, and scientists in particular, as *participants* rather than masters of their environments.

In this dissertation the scientific aspects of bio-sf novels are analyzed through the purview of Deleuze and Guattari's concepts "State science" and "nomad science." State science is epitomized by a focus on orderliness, clarity, hierarchy, and solutions, while nomad science has a preference for fluidity, processes of becoming, open spaces, and problematization. Whereas State science wants to map and control nature, nomad science is concerned with *following* the unpredictable movements and transformations of matter. These concepts should not be regarded as mere labels that define particular scientists. Rather, they refer to basic tendencies that may occur in one and the same person. This dissertation argues that in a time of large-scale transformations such as globalization and climate change, nomadic modes of thinking are vital. Nomad science is better equipped to understand such complex transformations. Moreover, it can contribute to the development of new, more sustainable ways of living adapted to our changing environments. In this dissertation the potentials for nomad science are not just explored in bio-sf novels, but also in (popular) scientific texts. Through this cross-reading it aims to contribute to the scholarly fields of science studies, literature and science, and sf studies.

This dissertation looks at how bio-sf novels write themselves into debates about the nature of life, with a special emphasis on the question of the roles of genes and genomes. Roughly since the 1950s, the biosciences have been dominated by a “molecular paradigm”: a focus on the structure and function of molecules such as DNA and proteins. Contemporary research fields such as genomics (the study of the complete DNA-set of a particular organism) bring forth a range of insights and technologies that are extraordinarily significant in the sense that they elucidate and intervene in organic life at the molecular level, making it increasingly recognizable, predictable and pliable. Such research fields have laid the foundations for new ways of treating and possibly curing disease, and promise revolutionary possibilities such as *in-vitro* meat or clearing pollution with microorganisms. Yet the implications of such developments are ill-understood as long as we see them as rational and unambiguous solutions. Instead, they should be understood as *biopolitical*—as part of a historical reconfiguration of how humans influence themselves and their environments. Moreover, many biologists argue that the centrality of genes and genomes in contemporary biology too often hampers a comprehensive, nuanced understanding of how life works. The concepts of State science and nomad science can shed light on the biopolitical dimensions of contemporary biosciences, as well as on the tension between the genocentric, molecular paradigm and alternative perspectives. In this thesis it is argued that aspects of nomad science are manifested most strongly in the work of biologists such as Lynn Margulis, Susan Oyama, Brian Goodwin, Stuart Kauffman, and Donna Haraway, who are critical of the molecular paradigm and variously emphasize ecological *relations*. Their perspectives resonate strongly with the bio-sf novels under scrutiny in this study.

Chapter 1 presents the research goal sketched above and provides an outline of the chapters. Chapter 2 places this thesis in a recent scholarly trend that combines theories and methodologies from science studies and sf studies, regarding sf texts as useful thought-experiments about the future of humanity and its environments. This chapter reads Fredric Jameson’s highly influential theory of sf together with Deleuze and Guattari’s approach to literary texts, and their concept of “minor literature” in particular. A major advantage of Deleuze and Guattari’s approach is that it corrects Jameson’s assertion that sf is strictly about sociality. Firstly, this chapter argues that apart from renegotiating social practices and norms, “minor” bio-sf conjures up the possibility of *another life* by constructing the narrative around radical biophysical events. Secondly, it is argued that the central role of such biophysical events in minor bio-sf necessitates an engagement with *scientific elements* in sf that is almost absent in Jameson’s work. To provide an example, the chapter discusses Greg Bear’s novel *Blood Music* (1985), in which a nano-engineered virus escapes from the lab, infecting the whole population of North America and transforming human beings in a featureless, reddish flesh covering the landscape. This state of affairs, however, does not necessarily mark an end-point or death; the mass of flesh does seem to be alive and, moreover, to exhibit some form of collective consciousness. The import of Bear’s narrative cannot be sufficiently understood without pondering the (imagined) possibilities of nanoscience emerging at this particular historical moment, possibilities that blur the boundaries between the living and the dead, the organic and the inorganic, the human and the nonhuman.

Chapter 3 discusses the concepts of “State science” and “nomad science,” placing them in the context of contemporary bioscience through the case of (post-)genomics and the research

projects of Craig Venter in particular. Modulating the term “State science” into “control science,” the chapter analyzes how science functions within contemporary regimes of biopower in which corporations become important strongholds alongside states. The chapter observes that (post-)genomics, while providing new technologies of control, also contains the promise of nomadic approaches to life. In particular, Venter’s 2004–2008 endeavor to map “the genome of the ocean itself” on the basis of water samples has apparent nomadic features, modeling a fluid, topological space whose complexity seemingly resists rigid models and quick solutions. It is argued, however, that if Venter unearths nomadic potentials in (post-)genomics, he ultimately fails to pursue them, reverting to a reductionist image of life as “DNA-software.” Glossing over Deleuze’s biophilosophy, this chapter contrasts Venter’s image with Deleuze’s concept of “a life” that is irreducible to any substrate or transcendental cause. I propose that Deleuze’s abstract yet material conception of life can serve as a catalyst for nomadic ideas in the biosciences.

Chapter 4, the first of three case studies, reads Bear’s sf novel *Darwin’s Radio* (1999) together with evolutionary biologist Lynn Margulis’s theory of symbiogenesis which holds that a species’ DNA is an assemblage of many genomes “acquired” in symbiotic relations. According to this theory, evolution is a creative, collective process rather than a blind process of accumulative random mutation and natural selection. In Bear’s novel, which was partly inspired on Margulis’s theory, the course of human evolution is altered through the activation of an “endogenous retrovirus,” ironically located in a “non-coding region” of the human genome. This activation, termed SHEVA (Scattered Human Endogenous Retro Virus Activation), causes humans to metamorphose into another species. At first perceived as a global plague, SHEVA provokes mass panic. In the US a task force is assembled to control the crisis and to find out how SHEVA operates at the genomic level. However, as research progresses, it becomes manifest that SHEVA is too complex to locate, decode, or “treat”—moreover, that it may not represent a disease at all, but rather an emergent, posthuman stage in evolution. Bear’s novel can be understood as a literary experiment with scientific ideas, notably the theory of symbiogenesis. Bear’s novel calls the neo-Darwinian conception of slow evolution into question, turning evolution into an immediate biopolitical issue. The import of *Darwin’s Radio* is not crass “prediction,” but a nomadic vision of life as always already *different* (impure, infected) and in becoming—a counterpoint to the image of the double helix as the bedrock of human identity and the promise of a man-made future.

Chapter 5 reads Octavia Butler’s trilogy *Lilith’s Brood* (1987; 1988; 1989) alongside the recent work of biologist-turned-cultural theorist Donna Haraway in which the relations between species are center stage. Taking the cue from Haraway’s concept of “worlding,” this chapter analyzes Butler’s trilogy as a literary experiment in which species co-evolve, building a new world out of an uncomfortable contact zone. In *Lilith’s Brood* an extraterrestrial species called Oankali has rescued humanity from Earth, which had become inhospitable to humans due to pollution and atomic warfare. They start an experiment of “genetic trade” in which humans and Oankali will eventually transmute into another kind of being. The trade, however, is hampered by a significant number of humans who are in fear of losing their human identities and autonomy. Literary critic Molly Wallace has argued that the Oankali’s “natural” capacity for genetic engineering represents strategies of contemporary technoscientific biopower, where genetic engineering

is falsely presented as something inevitable and inherently beneficial. I agree partially with this reading, although I emphasize that the Oankali embody the ambiguity of technoscience. The Oankali's experiment challenges humans (including the reader) to think life in nomadic terms as a continual struggle to connect, forget, and become.

Chapter 6 reads Kim Stanley Robinson's *Mars* trilogy (1992; 1993; 1996) together with evolutionary psychologist Susan Oyama's concept of "constructive interactionism." Oyama's theory puts the *interplay* between (living) systems center stage, thus offering an alternative to genocentrism. In the trilogy, American physicist-turned-biologist Sax Russell appears a typical "state scientist" eager to control life on Mars, to turn Mars into a second earth. Sax's "terraformation" team is able to manipulate the atmosphere, making it breathable, by releasing genetically engineered, oxygen-excreting microorganisms. In a few decades, the face of the planet turns from red to green (due to the introduction of plants and trees) and eventually from green to blue (after the its icecap has melted, creating oceans and seas). While state and corporate forces try to harness the process of terraformation, it soon becomes clear that the experiment cannot be controlled. Instead, as an unidentified narrator proclaims, it is Mars *itself* (read: network of planetary systems) that is the most advanced "genetic engineer." Life on Mars arises not from a human *bauplan*, but from the constructive interaction between systems. As this chapter demonstrates, those nomad scientists in the trilogy who understand the Martian experiment along the lines of Oyama's "constructive interactionism" are most successful at coping with the tough conditions on Mars and giving birth to sustainable ways of living.

Chapter 7 synthesizes and expands on the observations about nomad science in the previous chapters. It presents a number of clusters of nomadic traits that may serve as a rough map for understanding and reinforcing nomadism in contemporary bioscience. The first part of the chapter, which deals with the bio-sf novels, identifies the following clusters of nomadic desires, attitudes, and practices: following—opening up—interacting; risk—secrecy—resistance; fascination—imagination—intuition; problematization—cooperation—introduction; and immersion—self-experimentation—becoming. The second part of the chapter identifies a number of clusters of fundamental nomadic *ideas* on the basis of the biological theories discussed: multiplicity—immanence—nested scales; relation—interaction—coevolution; embodiment—fluidity—folding; and instability—nonlinearity—transformation. The common thrust of nomad biology, it is argued, is to incorporate and connect to *everything*, so that bioscience ends up dealing with life, and the future of humanity, as cosmic.

Chapter 8, finally, presents some key findings and consequences of this thesis and points to possibilities for further research. It argues that "minor" bio-sf narratives that innovatively couple biological and social, human and nonhuman existence, may be of value for science studies in three ways. Firstly, minor bio-sf offers inspiring examples of *thinking together with bioscience* about common challenges, rather than taking a distanced or critical position. Secondly, such narratives confront science with the fluid, chaotic side of life, and with the bigger questions—issues from which many scientists tend to shy away, sometimes simply for lack of time. Such a confrontation may help spark the development of complex, long-term scientific views on the future of humans and their environments. Thirdly, minor bio-sf allows science studies to demonstrate how science is a *dramatic* endeavor, involving actors, passions, encounters, and

so on, but also that life *as such* is dramatic. Here, Shakespeare's famous line "All the world's a stage" attains a new meaning, pointing towards an eco-aesthetics of existence, where humans perform or play together with others—notably with other species—as inhabitants of a plethora of merging habitats. In short, these are narratives with the power of transmutation, bringing science to life.

SAMENVATTING

(DUTCH SUMMARY)

In dit proefschrift worden de hedendaagse biowetenschappen beschouwd door de lens van bio-sf romans (biologisch georiënteerde science fiction). Het vertrekpunt is de gedachte dat romans niet alleen inzicht kunnen bieden in de psychologische en sociale dimensies van de wetenschap, maar ook in de spanningen die bestaan tussen verschillende wetenschappelijke ideeën, praktijken, en attitudes. Bio-sf romans gaan meestal over een ingrijpende gebeurtenis, zoals een ontmoeting met buitenaards leven. In dit proefschrift wordt geanalyseerd hoe zo'n fictieve gebeurtenis spanningen in de biowetenschappen zichtbaar maakt. In de bio-sf romans die worden bestudeerd, ondergaat de mensheid een radicale 'transmutatie' die soms zelfs resulteert in een nieuwe, post-humane soort. Wat deze verhalen bijzonder maakt, is dat de verandering niet door mensen is bewerkstelligd. Het gaat om een spontane gebeurtenis die voortkomt uit het samenspel tussen mensen en hun nieuwe en/of veranderende omgeving. In de romans proberen bepaalde wetenschappers tevergeefs het transformatieproces te stoppen of onder controle te krijgen. De hoofdpersonen daarentegen zijn zich bewust van de onbeheersbare complexiteit van de transformatie. Zij proberen het proces te begrijpen en passen gaandeweg hun eigen manieren van denken en leven aan. De mens — en de wetenschapper in het bijzonder — wordt kortom ten tonele gevoerd als een *medespeler* in plaats van een regisseur van zijn omgeving.

De wetenschappelijke aspecten van bio-sf romans worden in dit proefschrift geanalyseerd aan de hand van twee concepten van de filosofen Deleuze en Guattari, namelijk 'staatswetenschap' en 'nomadenwetenschap'. Staatswetenschap is gericht op orde, duidelijkheid, hiërarchie en oplossingen, terwijl nomadenwetenschap een voorkeur heeft voor fluiditeit, wordingsprocessen, open ruimten en problematisering. Waar staatswetenschap zich in beginsel richt op het in kaart brengen en in toom houden van de natuur, laat nomadenwetenschap zich leiden door onvoorspelbare bewegingen en transformaties. Deze begrippen moeten beslist niet worden gezien als etiketten die gemakshalve op individuele wetenschappers kunnen worden geplakt. Het gaat om basale tendensen, die zich ook in een en dezelfde persoon

kunnen voordoen. In dit proefschrift wordt beargumenteerd dat 'nomadische' manieren van denken van belang zijn in een tijdperk van grootschalige veranderingen —denk aan globalisering en klimaatverandering. Nomadenwetenschap is beter in staat om zulke complexe processen te begrijpen. Daarnaast kan zij bijdragen aan de ontwikkeling van nieuwe, meer duurzame manieren van leven die aansluiten bij onze veranderende omgeving. Het potentieel van nomadenwetenschap wordt in dit proefschrift niet alleen onderzocht in een aantal Amerikaanse bio-sf romans, maar ook in (populair-)wetenschappelijke teksten. Met deze *cross-reading* wordt beoogd een bijdrage te leveren aan de onderzoeksgebieden wetenschapsstudies, literatuur en wetenschap, en sf studies.

In dit proefschrift wordt bekeken hoe bio-sf romans aanhaken bij fundamentele debatten over de aard van het leven, met speciale aandacht voor de rol van genen en genomen. Grofweg sinds de jaren vijftig wordt de biowetenschap gedomineerd door een 'moleculair paradigma': een gerichtheid op de structuur en functie van moleculen zoals DNA en eiwitten. Uit onderzoeksvelden zoals genomics (de studie van de complete DNA-set van een bepaald organisme) komt een reeks inzichten en technologieën voort die het organische leven op moleculair niveau verhelderen. Hierdoor wordt het steeds beter mogelijk om het leven te begrijpen, te voorspellen en te plooiën. Genomics heeft de fundamentele gelegd voor nieuwe vormen van medische behandeling en mogelijk zelfs genezing van talloze ziekten. Biowetenschappers beloven revolutionaire toepassingen zoals *in-vitro* consumptievlees (gekweekt uit stamcellen) of het verminderen van milieuverontreiniging met behulp van genetisch gemodificeerde micro-organismen. De implicaties van dergelijke ontwikkelingen blijven echter onderbelicht zolang ze worden voorgesteld als rationele, eenduidige 'oplossingen' voor maatschappelijke problemen. Ten eerste dienen ze te worden begrepen als *biopolitiek*: onderdeel van een historische transitie in de manier waarop mensen zichzelf en hun omgeving vormgeven. Bovendien, zo beweren diverse biologen, belemmert de dominante positie die genen en genomen binnen de contemporaine biowetenschap innemen de ontwikkeling van een breder, meer genuanceerd begrip van het leven. De concepten staatswetenschap en nomadenwetenschap kunnen licht werpen op de biopolitieke dimensies van de biowetenschap alsmede op de spanning tussen het moleculaire, 'genocentrische' paradigma en alternatieve perspectieven. In dit proefschrift wordt beargumenteerd dat aspecten van nomadenwetenschap zich het meest nadrukkelijk manifesteren in het werk van biologen die zich kritisch verhouden ten opzichte van het moleculaire paradigma. Biologen zoals Lynn Margulis, Susan Oyama, Brian Goodwin, Stuart Kauffman en Donna Haraway leggen in hun werk de nadruk op complexe ecologische *relaties*. Dit perspectief komt sterk naar voren in de bio-sf romans die in dit proefschrift worden belicht.

Hoofdstuk 1 schetst de problematiek van deze studie en geeft vervolgens een overzicht van de verschillende hoofdstukken. In hoofdstuk 2 wordt dit proefschrift binnen een recente trend geplaatst waarin twee onderzoeksvelden elkaar ontmoeten: wetenschapsstudies en sf studies. Binnen deze trend worden sf romans beschouwd als 'literaire experimenten' waarin wordt meegedacht met de wetenschap over de toekomst van de mens en zijn omgeving. Dit hoofdstuk combineert Fredric Jamesons invloedrijke theorie van sf met Deleuze en Guattaris benadering van literaire teksten, in het bijzonder hun concept van 'mineure literatuur'. Een belangrijk voordeel van de benadering van Deleuze en Guattari is dat hiermee een basisassump-

tie in Jamesons werk kan worden weerlegd: namelijk dat sf strikt genomen over *sociale processen* zou gaan. Ten eerste wordt betoogd dat 'mineure' bio-sf de mogelijkheid verbeeldt van een andere vorm van *leven* in de breedste zin des woords. Dit wordt bereikt door het verhaal rond een ingrijpende biofysische gebeurtenis te construeren. Ten tweede wordt beargumenteerd dat de centrale rol van biofysische gebeurtenissen in dit type romans onherroepelijk vraagt om engagement met *wetenschappelijke aspecten*, een engagement dat in Jamesons analyse nagevoelbaar afwezig is. Als voorbeeld wordt Greg Bears roman *Blood music* (1985) besproken, waarin een gefabriceerd nano-virus uit een laboratorium ontsnapt en de gehele menselijke populatie van Noord-Amerika besmet, waardoor die populatie wordt getransformeerd tot een vormloze, roodachtige vleesmassa. Deze toestand markeert niet per se een eindpunt; de vleesmassa is allicht geen organisme, maar vertoont toch een zekere vorm van collectief bewustzijn. De consequenties van Bears roman kunnen niet worden begrepen zonder dat men zich verdiept in de (ingebeelde) mogelijkheden van de nanowetenschap die op dat moment sterk in opkomst was, een veld van onderzoek waarin de scheidslijnen tussen levend en dood, organisch en anorganisch, natuur en cultuur, beginnen te vervagen.

In hoofdstuk 3 worden de concepten 'staatswetenschap' en 'nomadenwetenschap' besproken en binnen de context geplaatst van de contemporaine biowetenschappen. Dit gebeurt aan de hand van de casus van (post-)genomics en in het bijzonder de onderzoeksprojecten van de pionierende genoomwetenschapper Craig Venter. Het begrip 'staatswetenschap' wordt gemoduleerd tot 'controle wetenschap', mede omdat in de hedendaagse maatschappij naast staten ook bedrijven een belangrijke positie innemen. In dit hoofdstuk wordt vastgesteld dat (post-)genomics nieuwe controle-technologieën voortbrengt, maar tegelijk de belofte van nomadische benaderingen van het leven in zich draagt. Vooral Venters recente project (2004-2008) met als doel 'het genoom van de oceaan zelf' in kaart brengen aan de hand van watermonsters, vertoont evident nomadische kenmerken, want het modelleert een fluïde, topologische materie wier complexiteit weerstand lijkt te bieden aan rigide modellen en technocratische oplossingen. In dit hoofdstuk wordt echter beargumenteerd dat hoewel Venters werk het nomadisch potentieel van (post-)genomics onthult, Venter uiteindelijk geen nomadische route volgt en juist teruggrijpt naar een reductionistisch beeld van het leven als 'DNA-software'. Na een korte omweg langs Deleuzes biofilosofie wordt Venters beeld gecontrasteerd met Deleuzes concept van 'een leven' dat niet tot enig substraat kan worden teruggebracht of kan worden verklaard door een transcendentale oorzaak. Deleuzes even abstracte als materiële conceptie van 'een leven' kan dienen als katalysator voor nomadische ideeën in de biowetenschappen.

Hoofdstuk 4, de eerste van drie case study's, bespreekt Greg Bears roman *Darwin's radio* (1999) samen met de 'symbiogenese'-theorie van de Amerikaanse evolutionair bioloog Lynn Margulis. Volgens deze theorie bevat het genoom van een willekeurige soort in feite vele genomen die zijn verworven in symbiotische relaties met andere soorten. Margulis beschrijft evolutie als een creatief, collectief proces in plaats van een 'blind' proces van accumulerende willekeurige mutaties en natuurlijke selectie. In Bears roman, die ten dele is geïnspireerd op de theorie van Margulis, wijzigt de koers van de menselijke evolutie radicaal wanneer een 'endogeen retrovirus' wordt geactiveerd, dat zich ironisch genoeg bevindt in een 'niet-coderende regio' van het menselijk genoom. Dit proces, dat wordt aangeduid met de naam SHEVA

(Scattered Human Endogenous Retro Virus Activation), gaat gepaard met onthutsende symptomen, waaronder miskramen en een leerachtige gezichtshuid. SHEVA wordt in eerste instantie gezien als een wereldwijde pandemie en veroorzaakt massale paniek. In de Verenigde Staten wordt een speciaal team samengesteld om te achterhalen hoe SHEVA op moleculair niveau werkt. Een nomadische georiënteerde onderzoeker toont echter aan dat SHEVA te complex is om te lokaliseren, te decoderen, of te 'behandelen', en begint te vermoeden dat het weleens helemaal geen ziekte zou kunnen zijn, maar de aanzet tot een posthumane fase in de evolutie. Bears roman kan worden beschouwd als literair experiment met wetenschappelijke ideeën, in de eerste plaats Margulis' theorie van symbiogenese. Bears roman levert een bijdrage aan een nomadische visie op het leven als *altijd al anders* (onzuiver, geïnfecteerd) en *in wording*: een alternatief voor het beeld van de dubbele helix als fundament van een unieke menselijke identiteit en belofte van een door de mens bepaalde toekomst.

Hoofdstuk 5 analyseert Octavia Butler's trilogie *Lilith's brood* (1987; 1988; 1989) aan de hand van het recente werk van de bioloog annex cultuurwetenschapper Donna Haraway, waarin relaties tussen de mens en andere soorten centraal staan. Op basis van Haraways concept 'wording' analyseert dit hoofdstuk Butlers trilogie als literair experiment waarin biologische soorten co-evolueren en samen een nieuwe wereld creëren. In *Lilith's brood* heeft een buitenaardse beschaving genaamd Oankali de mensheid gered van de aarde die voor mensen onbewoonbaar was geworden ten gevolge van milieuverontreiniging en atoomborlogen. De Oankali starten een experiment, een 'genetische handel', waarbinnen zowel mensen als zichzelf uiteindelijk zullen transformeren. Deze handel wordt echter ondermijnd doordat een aanzienlijk deel van de mensheid bang is haar identiteit en autonomie te verliezen. De literatuurcritica Molly Wallace heeft betoogd dat de Oankali met hun 'natuurlijke' capaciteit tot genetische manipulatie symbool staan voor de techno-wetenschappelijke beheersing van (menselijk) leven in onze maatschappij. Volgens Wallace wordt *genetic engineering* in de trilogie ten onrechte gepresenteerd als onvermijdelijk en inherent heilzaam. In dit hoofdstuk wordt deze lezing ten dele bevestigd, maar wordt tegelijk benadrukt dat de Oankali de ambiguïteit van technowetenschap belichamen. Het experiment van de Oankali daagt de mens (de lezer inclusief) uit om het leven in nomadische termen opnieuw te doordenken: als een voortdurende strijd om te verbinden, te vergeten en te veranderen.

In hoofdstuk 6 wordt Kim Stanley Robinsons *Mars* trilogie (1992; 1993; 1996) gelezen vanuit het perspectief van het concept 'constructieve interactie' van de evolutionair psycholoog Susan Oyama. Constructieve interactie is een theorie die het *samenspel* tussen (levende) systemen centraal stelt en als zodanig een alternatief is voor het genocentrisme. Een van de hoofdpersonen, de Amerikaanse natuurkundige en bioloog Sax Russell, lijkt op een typische 'staatswetenschapper' die alles doet om het leven op Mars te controleren, om Mars in een tweede Aarde te veranderen. Door het introduceren van genetisch gemodificeerde, zuurstof-uitscheidende micro-organismen, is het 'terraformatie' team onder leiding van Sax in staat om de atmosfeer van Mars adembaar te maken. Binnen enkele decennia verandert het aanzicht van de planeet van rood naar groen (door de introductie van bomen en planten) en uiteindelijk van groen naar blauw (nadat de ijskap is gesmolten en er oceanen en zeeën zijn ontstaan). Terwijl staten en bedrijven het proces van terraformatie proberen te bestieren, wordt duidelijk dat het

experiment niet in de hand kan worden gehouden. Zoals een anonieme verteller verkondigt: Mars *zelf* (lees: netwerk van planetaire processen) is de meest geavanceerde *genetic engineer*. Het leven op Mars ontvouwt zich niet vanuit een door mensen vervaardigd bouwplan, maar in de 'constructieve interactie' tussen systemen die wordt beschreven in het werk van Oyama. In Robinsons trilogie zijn het juist de nomadenwetenschappers die—vanuit de gedachte van 'constructieve interactie'— het best in staat zijn om de barre omstandigheden op Mars het hoofd te bieden en duurzame manieren van leven te ontwikkelen.

Hoofdstuk 7 is een synthese en uitwerking van de analyses van nomadenwetenschap in de casestudy's. Dit hoofdstuk presenteert een aantal clusters van nomadische eigenschappen die samen een basale landkaart vormen, bedoeld om nomadisme in de biowetenschap te traceren, te begrijpen en te bevorderen. Het eerste deel van het hoofdstuk, identificeert een aantal clusters van nomadische *praktijken, attitudes en verlangens*: volgen—openen—interacteren; risico—heimelijkheid—verzet; fascinatie—verbeelding—intuïtie; problematisering—samenwerking—introductie; en immersie—zelfexperiment—wording. In het tweede gedeelte wordt een aantal clusters van fundamentele nomadische *ideeën* geanalyseerd op basis van de besproken biologische theorieën: multipliciteit—immanentie—genestelde schalen; relatie—interactie—co-evolutie; belichaming—fluiditeit—vouwen; en instabiliteit—non-lineariteit—transformatie. Een algemene conclusie is dat nomadische biologie letterlijk alles wil incorporeren en zich overal toe wil verhouden; de toekomst van de mens en het leven als zodanig wordt dan ook in een kosmisch kader gezet.

Ten slotte behandelt hoofdstuk 8 enkele sleutelbevindingen en consequenties van dit proefschrift en wijst het mogelijkheden aan voor verder onderzoek. Er wordt beargumenteerd dat 'mineure' bio-sf verhalen waarin op innovatieve wijze biologische en sociale, menselijke en niet-menselijke processen aan elkaar worden gekoppeld, op drie manieren relevant zijn voor de wetenschap en wetenschapsstudies in het bijzonder. Ten eerste biedt mineure bio-sf inspirerende voorbeelden van *meedenken met de biowetenschap* over gezamenlijke uitdagingen, in plaats van een afstandelijke of kritische positie in te nemen. Ten tweede wordt de wetenschap in zulke verhalen geconfronteerd met de fluïde, chaotische kanten van het leven, alsmede met de grotere vragen —zaken waar veel wetenschappers zich in praktijk te weinig mee (kunnen) bezighouden. Dergelijke verhalen kunnen dienen als bron van inspiratie voor het genereren van interdisciplinaire, lange-termijn visies op de toekomst van de mens en zijn omgeving. Ten derde kunnen beoefenaren van wetenschapsstudies aan de hand van mineure bio-sf aantonen dat de wetenschap een door-en-door *dramatische* aangelegenheid is —met acteurs, passies, ontmoetingen, enzovoorts— maar ook dat het leven *als zodanig* een drama is. In deze context krijgt Shakespeare's beroemde zin 'All the world's a stage' een nieuwe betekenis, wijzend in de richting van een eco-esthetiek van het Zijn, waarin mensen in een mondiaal of zelfs interplanetair spel verwickeld zijn, samen met anderen —in het bijzonder met andere soorten. Kortom, mineure bio-sf verhalen bezitten de gave van transmutatie: ze brengen de wetenschap tot leven.

CURRICULUM VITAE

Tom Joeri Idema (February 24, 1980) grew up in Amersfoort right in the heart of The Netherlands. After initial plans on becoming an astronaut, he received secondary education at 't Hooghe Landt College in Amersfoort. In 1999 he began his studies at the University of Groningen, where he took a propedeutic exam in History (2000) and earned an MA degree in American Studies (2006). For his MA thesis on Mexican-American women's writing he received the top grade (10). In 2007 Tom earned a Research MA degree in Gender and Ethnicity from Utrecht University with honors. During his studies he taught courses on American history and culture at the University of Groningen and philosophy of science at Utrecht University. He was a member of the curriculum committees of both MA programs.

Between 2008 and 2013 Tom was a PhD candidate at the Department of Philosophy and Science Studies at Radboud University Nijmegen, The Netherlands, where he conducted research and taught on the topic of literature and the biosciences. He participated in the national PhD programs of Onderzoekschool Literatuurstudies (OSL) and Wetenschap, Technologie en Moderne Cultuur (WTMC), and was a member of the OSL program committee from 2009 to 2011. In the Fall of 2011 Tom was a visiting scholar at the English Department at Duke University in Durham, North Carolina, United States, funded by a Fulbright grant. He has been an active member of the Society for Literature, Science and the Arts as well as the Benelux Association for the Study of Culture and the Environment. He has published on literature and science, Deleuze, bioart, and Mexican-American creative writing.

In September 2013 Tom started working as a lecturer at the Literary Studies and American Studies programs at Utrecht University, The Netherlands. In his free time he enjoys cycling and wave surfing. He likes playing drums, keys, and a bit of guitar, and writing songs —preferably with friends.

