ephemera | articles
theory & politics in organization

ISSN 1473-2866
www.ephemeraweb.org
volume 9(1): 26-43

The Production of Informational Objects in Innovation Work: Pharmaceutical Reason and the Individuation of Illnesses

Alexander Styhre

abstract Innovation work and other forms of knowledge-intensive work operate on the basis of the production of informational objects – epistemic things – anchored in techno-scientific procedures and embedded in a broader set of social, cultural, political and juridical institutions and practices. Examining new drug development in the biotechnology and pharmaceutical complex, it is suggested that the linear causal relationship between illness and prescribed therapies can no longer be taken for granted. Drawing on the writing of Gilbert Simondon and what he calls *transduction*, the meta-stabilization of individuated entities, illnesses and their therapies are seen as being mutually constituted and co-produced in a bio-capital regime of accumulation dominated by what has been called pharmaceutical reason. It is thus suggested that alternative routes of investigation in the study of new drug development may be fruitful for understanding emerging forms of innovation work and knowledge-intensive work.

Venturing in the Bio-economy

> By storing your baby's umbilical cord blood with California Cryobank Stem Cell Services, you are safeguarding the future health of your child by providing your baby with a lifetime of insurance needed to take advantage of today's medical breakthroughs and tomorrow's discoveries. – Web Advertising – Cryobank Inc. (cited in Brown and Kraft, 2006: 322)

Quite recently, Dougherty (2007) addressed a series of fallacies within innovation research and called for alternative perspectives on how pharmaceutical companies are organizing and managing their new drug development work. In the innovation literature and in the knowledge management literature, there is an unfortunate tendency to conceive of objects of knowledge underlying innovations, that is, what Rheinberger (1997) calls *epistemic things*, as being self-enclosed and ready-made. This paper aims at critically discussing such perspectives on the basis of the theoretical framework formulated by the French philosopher Gilbert Simondon. Following Schultze (2000: 7), knowledge work is conceived of as the "production and reproduction of informational objects"; knowledge workers are operating on the basis of ensembles of entities that are simultaneously material and informational.

However, rather than subscribing to such an 'entitative view' of objects of knowledge, these objects must become subject to analysis in their own right, that is, in terms of being events (Whitehead, 1978), assemblages (Deleuze and Parnet, 1987; DeLanda, 2006), or, as in the case of technologies, as ensembles (Orlikowski and Iacono, 2001). In the research on innovation in the biotechnology and pharmaceutical industries – two interrelated but not overlapping industries (Rajan, 2006) – new registered drugs are often seen as what emerges in a linear process from the synthesis of a new molecule, in vitro and in vivo testing, and eventually large-scale clinical testing. In this perspective, new drug development is a linear and essentially rational process aimed at providing adequate therapeutic effects on basis of a predefined and semi-fixed set of targeted illnesses that have been evaluated to represent a substantial market opportunity.

However, in actual new drug development, the relationship between illness, therapy, and all the multiplicity of social actions that emerges in between the two 'endpoints' is less clear-cut and schematic. Instead, as with research in the field of new drug development, the relationship between illnesses and therapy is a complex socially embedded agreement of what qualifies as an illness and a legitimate drug, including many parties and significant techno-scientific, economic, moral and political capital. Today, in late modernity and in the era of advanced techno-scientific capitalism – a period characterized by a vast inflow of venture capital in the life sciences – new drugs are always the outcome of complicated social negotiations and coalitions across organizational boundaries and between professions and interests.

In addition, Foucault (2008) suggests – a position further developed by Cooper (2008) more recently – that the regime of biopolitics and its various social practices have been co-evolving with liberalism and neo-liberalist thinking, representing a very skeptical attitude towards state-intervention and political governance. This new situation, accounted for in the literature (Rajan, 2006; Lakoff, 2006; Waldby and Mitchell, 2006; Rose, 2007), calls for new analytical frameworks that may help apprehending both the fluidity and porosity of the innovation system and the significant immutable effects produced when a multiplicity of resources are brought together in techno-scientific systems propelled by venture capital, commercial interest, and therapeutic possibilities. In the contemporary period, with late modernity characterized by what has been called the bioeconomy, researchers and media pundits expect the biopharmaceutical industry to play a significant role not only for the economy but also in terms of redefining life *per se*; life is no longer what is given but what is to be managed and monitored, thereby generating a number of pressing ethical concerns and practical choices and tradeoffs (Franklin and Roberts, 2006; Braidotti, 2008).

In this paper, the analytical framework developed by Gilbert Simondon (1980, 1992) will be applied when examining how illnesses and corresponding therapies are enacted and gain social legitimacy in terms of their mutual stabilization, or, in the vocabulary of Simondon, how they are *individuated* in a process of ontogenesis. In the 1950s and early 1960s, Simondon, a graduate student of Maurice Merleau-Ponty (Hansen, 2004, refers to Simondon as a 'bio-phenomenologist'), developed a sophisticated analytical framework for understanding how both biological organisms and technological artifacts

or systems are capable of becoming part of metastable systems in what he calls the process of *transduction.*[1]

While the work of Simondon remains little explored in the Anglo-American intellectual tradition – one of his two main works are not available in English – the interest for Simondon has gained some momentum through the recognition of his work in Deleuze's writings, most notably in *A Thousand Plateaus*, the second part of the collaborative work of Deleuze and Félix Guattari. Simondon's work is of great value for innovation management and knowledge management theory because he is not foreclosing the nature of seemingly stable entities, such as a tool like an axe, or a technological system, such as a computer, but rather conceives of such 'entities' as temporarily stabilized agreements that may dissolve under new regimes of interpretation and practice. Using Simondon's analytical framework to examine the new drug development practices of the biotechnology and pharmaceutical industries helps us understand the dynamic and frail qualities of the nexus between illness and therapy.

As, for instance, the French philosopher of science, Georges Canguilhem (1991) – another prominent contemporary thinker in Simondon's proximity – suggests, the very concept of illness emerges from the very line of demarcation between the normal and the pathological. Illnesses are then techno-scientific agreements that help mobilize social action (Rabinow, 1992; Novas and Rose, 2000; Rose and Novas, 2005; Hacking, 2006), subject to continuous modifications and corrections, that at times become subjected to widespread disagreement and controversy (such recent examples include disputed illnesses such as 'The Chronic Fatigue Syndrome', 'Irritable Bowel Syndrome', and 'Fibromyalgia' [see Collins and Pinch, 2005], seeking what Lakoff [2008: 744] calls *disease specificity* – "illnesses are stable entities that exist outside of their embodiment in particular individuals and that can be explained in terms of specific causal mechanisms that are located within the sufferer's body"). Similarly, therapies aimed at responding to such epistemologically porous illnesses are in themselves subject to extensive disclosure and scientific, ethical, and political negotiations. Given these significant epistemological concerns, Simondon's analytical framework is of great value as a means of advancing a more process-oriented view of innovation management and knowledge management.

---

1 The conceptual framework of Simondon is developed to address the individuation of biological and technical entities, that is, entities that are not by definition 'social', at least not exclusively so. The use of Simondon's bio-phenomenological vocabulary when examining innovation work and new drug development work, two inherently social activities, is therefore not uncomplicated. Simondon's work is aiming at making a contribution to the understanding of how 'metastability' is accomplished in processes of ontogenesis. This thinking of fluidity and change, a form of critique of what is integrated and determinate, has been emphasized in the social sciences as well, and in management studies such as within the framework advocated by Robert Cooper (1986, 2005, 2007a, 2007b). Using Simondon's framework does then not suggest that biological concepts or analytical frameworks are imposed onto social phenomena; it rather suggests a form of synchretism, a tolerance for or even appreciation of complementary and transdisciplinary analytical frameworks when discussing social practices such as innovation management. More specifically, Simondon's work is brought into the discussion as an implicit critique of the instrumental and linear mainstream theories of innovation management.

This paper is structured accordingly: First, the theoretical framework of Gilbert Simondon is discussed. Second, the emerging biotechnology and pharmaceutical industry is examined, and the concept of transduction is employed to explore the contingent and situated nature of illness. Finally, some theoretical and practical implications are drawn.

Simondon and the Concept of Individuation: The Case of Pharmaceutical Reason in a Biocapital Framework

Although Simondon remains relatively obscure to the broader organization theory and management studies readership, as well as the social sciences more generally, there is a small but growing corpus of literature drawing on his thinking. It is common to divide his work into two separate yet mutually related works, that of his analysis of technological systems and biological organisms (Mackenzie, 2002). While some commentators emphasize the 'biophilosophical' strain in his thought (Lecourt, 1998; Beistegui, 2005; Chabot, 2005; Harvey, Popowski and Sullivan, 2008), other use Simondon to inform technology and media studies (Hansen, 2006; Mackenzie, 2005; Dodge and Kitchin, 2005) or information theory and communication studies (Terranova, 2004).

What unifies these two bodies of work is what Simodon calls *individuation*. For Simondon, one must not assume that the individual is the starting point for an analysis of individuation; on the contrary, one must understand how the individual is the outcome of a *process of individuation,* that is, the 'ontogenetic' process wherein the individual is constituted *qua* individual, i.e., as a freestanding individual entity (Simondon, 1992: 300). For Simondon, the individual is a *temporal stabilization*, a *metastablility,* accomplished on basis of the information available in the system within which individuation is taking place. Such a system is never in "stable equilibrium and rest" (Simondon, 1992: 302) but is continually reshaped and restructured on the basis of information and signals from the environment wherein the individual is located. Simondon also argues that the 'living system' (when speaking of biological organisms) is capable of 'individuating itself', that is, it operates on the basis of what Maturana and Varela (1980) much later would call *autopoesis*:

> The living entity is both the agent and the theater of individuation: its becoming represents a permanent individuation or rather *a series of approaches to individuation* progressing from one state of metastability to another. The individual is thus no longer either a substance or a simple part of the collectivity. The collective unit provides the resolution of the individual problematic, which means that the basis of the collective reality already forms a part of the individual in the form of the preindividual reality, which remains associated with the individual reality. (Simondon, 1992: 307)

For Simondon, there is always a dynamic relationship between what he calls the 'pre-individual' and what is individuated. A being does not posses a stable 'unity or identity' prior to the individuation but instead becomes individuated as a *transductive unity.* The concept of transduction, a central term in Simondon's thinking, and perhaps the most complicated term, is used in the life sciences to denote how DNA can be transferred

from bacteria to a cell. In addition, the concept of *signal transduction* denotes the process where energy is transformed from one form into another, e.g., from electric energy to chemical energy in a biological system. In Simondon's framework, the term is used to "denote a process – be it physical, biological, mental or social – in which an activity gradually sets itself in motion, propagating within a given area, through the structuration of the different zones of the area of the area over which it operates" (Simondon, 1992: 313).

This is a complex formulation not easily understood, but Simondon suggests that transduction is the process in which the pre-individual state of the being is gradually transformed into a metastable position qua individual. For instance, a biological organism is responding to changes in the physical environment and seeks to optimize its chances for long time survival in a given situation. When changes occur in the environment, e.g., a change in climate or the presence of competing species, the organism seeks to respond to such changes in its own interests in as favourable a manner as possible. The accumulated responses to the available information in the biotope constitute the transductive process and the organism becomes individuated en route. "The transductive process", Simondon (1992: 313), argues,

> is thus an individuation in progress. Physically, it might be said to occur at its simplest in the forms of progressive iteration . . . Transduction occurs when there is activity, both structural and functional, which begins at a center of the being and extends itself in various directions from this center, as if multiple dimensions of being were expanding around the central point.

The concept of transduction thus lends itself to the analysis of "[a]ll of the different areas of individuation; it applies to all these cases where an individuation occurs and reveals the genesis of a network of relations based on the being", Simondon (1992: 313) suggests. For Simondon, this conceptual framework represents a radical break with Aristotelian hyle-morphism, which assumes that there is an innate potentiality in entities to be realized (Simondon, 1992: 316). In the transduction perspective, there is no assumption regarding essences or 'potentiality' but instead, to repeat, the individuation of organism or technological system are outcomes from responses and reiterations with the information and signals in the system – 'physical, biological, mental or social' – where a metastable, transductive unity, an individuation, is accomplished.

Simondon's arguments have been replicated and related to more recent contributions within technoscientific, philosophical and social science literatures. For instance, Terranova (2004), in discussing Simondon's work from an information theory perspective, argues that in his framework information has always, of necessity, material implications and ramifications, and therefore information is not strictly a matter of communication but of accommodation and response. Terranova (2004) here makes references to the much-debated Human Genome Project wherein the human genome was mapped in its entirety. The passage is worth citing at length:

> As we know now, the DNA strings mapped out by the field of bioinformatics are not a form in the Platonic sense of an immaterial and transcendental Idea looking for some kind of female Substance on which to imprint its mark. The emergence of a living organism involves an active process of transduction, where information expresses simply the direction along which a living organism individuates itself through the expression of a tension or potential within the overall field. For Simondon, an understanding of informational dynamics actually offers the key to a

> reconceptualization of the relation of form and matter in terms of mutual affection that always involves the power if an overall milieu . . . Information is always entangled with and dependent on a material milieu defined by its tensions and incompatibilities in a process that can only be described in terms of the different tendencies that it gives expression to. (Terranova, 2004: 68)

For Terranova (2004), Simondon is a resource in escaping from what Haraway (1997) has called 'gene fetishism', Rajan (2006) names 'genomic fetishism', and LeBreton (2004) dismisses as 'gene fundamentalism' (see also Griffith, 2001), the belief that the human genome is the 'book of life' from which one can decode the great and ultimate secrets of human being. Instead, with Simondon, the individuation of the biological organisms can never be, to use Whitehead's (1925) term, simply located in the DNA code. Instead, as Hansen (2006: 85) says, Simondon develops "[a]n account of the human as a living being constitutively in excess of itself and necessarily endowed with a collective dimension". Rather than conceiving the DNA code (or any other biological codes such as the production of proteins on basis of animo-acids) as what ultimately determines the organism, a form of Aristotelian hylemorphism *mutatis mutandis*, Simondon thinks of matter, with Chabot's (2005: 106) metaphor, as a *theatre of individuation.* By this he means that matter is the scene of the creative process of individuation. Simondon's most widely cited example is the transduction of crystals as a process of individuation, examined by Chabot (2005: 106):

> This process happens in a *metastable* structure, which is a structure which is able to develop given certain temperature conditions. In this structure, a *germ*, or a shock, may start up a process of organization in that matter. Molecules gather themselves in geometrical order around this germ. Layer after layer, they form a crystal.

The contribution of Simondon lies in his insistence on formulating a general framework for how technologies or biological organisms are individuated in their active responses to and reiterations with environments. Working in a process thinking tradition represented by Henri Bergson and William James, but also incorporating the work of, for instance, Georges Canguilhem, Simondon provides a framework that emphasizes a process-based view of social, technological and biological entities. With a Simondonian lens, such 'entities' are never more than metastable accomplishments under the continual influence of new information and signals, a flow of events that may undermine the metastability of the transductive entity. In the next section, this theoretical framework will be used to examine how illnesses and drugs can be seen as transductive entities devoid of inherent stability but very much developed and enacted in tandem. What Simondon helps us to accomplish is to always conceive of the temporality and transient nature of social, technological and biological entities; time is always already inscribed and incorporated in the process of continual transduction.

Pharmaceutical Reason and the Production of Illnesses

The roots of biotechnology stretch back to the Prussian court physicist Georg Ernst Stahl (1659-1734) – commonly held as one of the 'founding fathers of chemistry' besides Antoine Laurent de Lavoisier – whose publication *Zymotechnia Fundamentalis* (1697) introduced the concept of *Zymotechnology*, a scientific field examining all sorts of 'industrial fermentation', for instance the process of brewing beers (Bud, 1993). In

1828, the German chemist Friedrich Wöhler managed to synthesize urea, thereby further eroding the difference between natural and chemical, i.e., 'artifical', products (Bud, 1993: 10). In addition, the modern biotechnology discipline is often associated with Austrian physicist Erwin Schrödinger's publication *What is life?* (1944) wherein he proposed that 'code-scripts' underlying all forms of life could be identified (Kay, 2000: 59). Eventually, from the 1970s and 1980s, biology, a rather recent scientific discipline (Keller, 2002), would take the place of physics as the dominant scientific discipline, very much in the same manner as physics displaced chemistry at the turn of the nineteenth century.

It would not be an exaggeration to claim that the emergence of the biotechnology industry in the 1970s and 1980s represents a major shift in focus in the world economy (Rajan 2006; Jong, 2006). This was spurred on by a series of techno-scientific 'discoveries' or innovations, starting arguably with Cohen and Boyer's discovery and patenting of the recombinant DNA, also called 'gene splicing'. Cohen and Boyer's discovery, and Stanford's subsequent patenting of the research results had a long series of social, cultural and economic consequences. For instance, it become possible to patent federally financed research findings in the U.S. after the U.S. Supreme Court made a historical 5-4 voting in favour of the patent proposal. Stanford's attempt to patent Cohen and Boyer's research finding was highly controversial. Cohen claimed himself that he had not "dreamed of the notion of patenting this" (cited in Smith Hughes, 2001: 548) and Cohen and Boyer were occasionally approached with hostility when they presented their research in seminars and at conferences during the seventies (Smith Hughes, 2001: 558). Boyer moved on to found Genentech, the first biotechnical company to be listed on the New York stock exchange and one of the most widely known biotechnical companies, holding patents in, for instance, artificial human insulin.

Another major thrust for the biotechnology industry was when the Polymerase Chain Reaction (PCR) was invented by the California based bio-technology firm Cetus, a discovery that was awarded a Nobel Prize (Rabinow, 1996). In addition, by the end of the 1980s, the Human Genome Project was initiated. By the end of the 1990s, a full cartography of the human genome was available for further exploration. Since the early 1970s, the biotechnology and the pharmaceutical industry have went through a series of radical economic, social, cultural and institutional changes all contributing to the emergence of a biotechnology industry. For instance, the major controversy regarding the ability of organizations and companies to patent biological species has been resolved – juridically not ethically – and today there is 2,000-3,000 types of genetically modified mice in the world (Braidotti, 2006: 101). The aggregate of biotechnology and pharmaceutical companies is today an important component of the contemporary capitalist system and what Appadurai (1996: 34) calls the global *technoscape*, a term denoting "the global configuration, also very fluid, of technology and the fact that technology, both high and low, both mechanical and informational, now moved at high speeds across various kinds of previously impervious boundaries" (see also Petryna, 2006).

Perhaps the single most important aspect today of this emerging biotechnological and pharmaceutical global techno-scape is the advancement of genomics, along with its consequences for turning the life sciences into *information sciences,* rather than

diagnostic/therapeutic sciences (Rajan, 2006: 3). Rajan argues that the idea that 'life is information' has been very much part of the central dogma of molecular biology where; "DNA gets *transcribed* into RNA, which gets *translated* into proteins – an algorithmic conception of life that has been prominent within molecular biology since at least the 1950s" (Rajan, 2006: 16). The difference today, Rajan (2006: 16; see also Kay, 2000: 61) emphasizes, is that genomics allows the *metaphor* of 'life-as-information' to become a "*material* reality that can be commodified". Not only is it analytically helpful to conceive of life as strings of information but it is also practically and, above all, economically and politically feasible to adhere to such (with Foucault's term) *practico-theoretical frameworks*.

For numerous writers, the concept of information is of central importance here. As Katherine Hayles (1999: 104) points out, already in the 1950s in his path-breaking *The Human use of Human Beings* (1954), Norbert Wiener, the founder of cybernetic theory, spoke of humans as being "[n]ot so much bone and blood, nerve and synapse, as they are patterns of organization". Instead, over the course of the biological organism's lifetime, it is the information contained in the cell that allows for a reproduction and replication of new cells and tissues. Thus, for Wiener, "[t]o understand humans, one needs to understand how the patterns of information they embody is created, organized, stored, and retrieved" (Hayles, 1999: 104). Hayles (1999: 13-14) herself speaks of *virtuality* whenever informational and material systems converge and intersect; the human body is, for instance, such a virtuality in Hayles's understanding – always already both material and informational. However, not everyone agrees with Hayles that the concept of information is unproblematically related to the concept of materiality. For instance, Latour (1983: note 2, 243) says that "when you hold a piece of information you have the *form* of something without the thing itself" and Terranova (2004: 56), strictly adhering to Claude Shannon's mathematical definition, suggests that "[i]nformation does not involve meaning but only statistical patterns of redundancy and frequency – a modulation of signal to noise". Information is for Terranova what denotes a relationship between signal and non-signal – one may here recall Gregory Bateson's (1972) frequently cited definition (used by for instance by Niklas Luhmann) as 'a difference that makes a difference' – and is in itself not meaningful.

However, notwithstanding the more conceptual intricacies being addressed in the literature, the 'informatization' of biotechnology and new drug development under new techniques such as pharmacogenomics and related screening techniques such as virtual screening and high-throughout screening (Eckert and Bajorath, 2007; Oprea, 2002; Walters, Stahl and Murcko, 1998) represents a turn in the industry. Rajan (2006) here speaks of the emergence of what he calls *biocapital* on basis of the new life sciences paradigm:

> Biocapital is creating a series of cultural transformations in the materiality and exchangeability of what we call 'life'. These transformations are created through shifting and variable use of market commodification versus public commons or public good formation, both of which are disciplined by new forms of capitalist logic, conforming neither to those of industrial capitalism nor to those of so-called postmodern information capitalism. This is the rationale for the term 'biocapital', which ask the question of how life gets redefined through the contradictory processes of commodification. (Rajan, 2006: 47)

For Rajan (2006), the bottom line of the emergence of the new body of biocapital is not the various uses of new technology or the new technoscientific theories or practices but that the very concept of life is put, with Derrida's (1976) formulation, 'under erasure' [*sous rature*]. Rather than conceiving of life and 'forms of life' (in the broadest sense of the term), bio-capital is reformulating life and deviances from what are regarded as 'proper' forms of life (e.g., illnesses, deformities or deviances that needs to be corrected, see Franklin and Roberts, 2006) in terms of what can be commodified. Rose (2007) sketches some of the changes over the last century brought by new, advanced medicine:

> At the risk of simplification, one may say that the vital politics of the eighteenth and nineteenth centuries was a politics of health – of rates of birth and death, of diseases and epidemics, of the policing of water, sewage, foodstuffs, graveyards, and of the vitality of those agglomerated in towns and cities . . . [t]he vital politics of our own century looks quite different. It is neither delimited by the poles of illness and death, 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. It is, I suggest, a politics of life itself. (Rose, 2007: 3)

For Rajan (2006), Rose (2007) and other students of the global biotechnology and pharmaceutical industry such as Lakoff (2006), this is an overturning of the conventional causality enacted in scientific medicine where illnesses precede their therapies. In a Foucaultian perspective, discursive formations produce material consequences; discourses on madness produce psychiatric wardens, discourses on penal practices lead to the establishment of new penitentiary practices and institutions. In the discourse on the opportunities and possibilities emerging from new biotechnology and new pharmaceutical practices, new materializations are provided. In his detailed account of how the Argentinean psychoanalytic community, the '*mundo psi*' in Buenos Aires, resists new forms of psychopharmacological drugs developed by a French company aimed at treating so-called bipolar disorder, Lakoff (2006) suggests that the causality diagnosis-treatment at the core of the medical profession and practice is overturned and displaced by a new causality advanced by what he calls 'pharmaceutical reason':

> Illness comes gradually to be defined in terms to what it 'responds'. The goal of linking drug directly to diagnosis draws together a variety of projects among professionals, researchers and administrators to craft new techniques of representation and intervention. These projects range from diagnostic standardization and the generalization of clinical protocols to drug development and molecular genetics. This constellation of heterogeneous elements is joined together by as strategic logic I call 'pharmaceutical reason'. The term 'pharmaceutical reason' refers to the underlying rationale of drug intervention in the new biomedical psychiatry: that targeted drug treatment will restore the subject to a normal condition of cognition, affect, or volition. (Lakoff, 2006: 7)

Under the regime of pharmaceutical reason, the bipolar disorder patient (or any other patient suffering from psychological illness) is subjected to what Clarke *et al* (2003) call *biomedicalization*, and others have called *medicalization* (e.g., Conrad, 2007), located in a network of practices, ideologies, and beliefs that (1) strongly emphasize the need to correct the patient's behaviour or condition, and (2) offers primarily (but not exclusively) pharmacological therapies (i.e., marketable commodities) to accomplish this objective. In Argentina, Lakoff (2006) found the community of psychoanalysts, in

many cases trained in Lacanian psychoanalytical practice and following an anti-capitalist credo, resisted this bio-medicalization tendency. There was thus a clash of cultures between, on the one hand, the traditional psychoanalytical procedures and practices and the new, emerging techno-scientific medicine provided by multinational pharmaceutical companies. Lakoff (2006: 174) concludes: "In a world of gene-chip-based diagnostic test in the clinic, the broad categories that govern psychiatric practice might be broken down in terms of medical response, so that diagnostic questions would appear no longer as – 'is it bipolar disorder or schizophrenia?' – but 'is it lithium or an olanzapine response profile?'".

What Lakoff (2006) suggests here is that there is no longer – if that was ever the case – a prerogative of (academic) scientific medicine being given the prerogative to define and establish taxonomies of illnesses and etiologies, from which the pharmaceutical companies could later select targets for their new drug development practices. Instead, the line of demarcation between pure and applied medicine and theoretical and commercial interests no longer fully applies (Fujimura, 1996). Today, Lakoff (2006) suggests, the 'scientization' and 'biomedicalizaiton' of psychiatry is totally complicit with drug-disease co-production; the scientific objectives are increasingly subsumed under economic and practical (i.e., therapeutic) interests.

One relevant indication of this bundling of science and commercial interest is the growth of ghost-written scientific papers where credible scientists endorse a certain therapy and sign journal papers that have been prepared by professional public relations agencies (Healy, 2006). "[G]hostwriting", Healy (2006: 72) contends, "is no longer occurring only in peripheral journals and affecting only review articles. It happens in the most prestigious journals in therapeutics, and it probably happens preferentially for papers reporting randomized trails and other data-driven papers". Under the new regime of bio-capital (Rajan, 2006) and the influence of pharmacological reason (Lakoff, 2006), illnesses and therapies are therefore inextricably linked and related, enmeshed in textures of relation that defies any linear causality; illnesses and therapies are instead *co-produced* (Jasanoff, 2004):

> Science, in the co-productionist framework, is understood as neither the simple reflections of the truth about nature nor an epiphenomenon of social and political interests. Rather, co-production is symmetrical in that it calls attention to the social dimensions of cognitive commitments and understandings, while at the same time underscoring the epistemic and material correlates of social formation. Co-production can therefore be seen as a critique of the realist ideology that persistently separates the domain of nature, facts, objectivity, reason and policy from those of culture, values, subjectivity, emotions and politics. (Jasanoff, 2004: 3)

Another way to express the idea of co-production and the general emphasis on intricate relations between illness and therapy is to adhere to the theoretical framework advocated by Simondon (1992). In this view, an illness is not what is constituted in terms of its unique and clearly bounded and diagnosable features and sealed off from alternative explanations, it is instead what achieves its status as an individual illness in terms of its very relationship between a series of forces or flows of information in the milieu in which it is diagnosed and defined. While illness has historically been constituted *qua* metastable transductive unities not solely on basis of academic scientific medicine but also in connection with commercial and political interests, in the

new regime of bio-capital, and under the influence of pharmaceutical reason, there are new forms of informational entities produced under the influence of Big Pharma and the competitive strategies of the various actors. Terms such as the tissue economy (Waldby and Mitchell, 2006), the geneticization of illnesses (Shostak and Conrad, 2008), and bio-value (Waldby, 2002) are indicative of a new regime of bio-capital is on its way, effectively rendering domains of reproduction as scientifically and financially lucrative domains (Almeling, 2007; Franklin and Roberts, 2006; Waldby and Cooper, 2007). The emerging stem cell research program is another domain that is regarded as being of major importance for the bio-economy in the coming decades (Rubin, 2008; Brown and Kraft, 2006; Franklin, 2005) and in general, the bio-pharmaceutical advancement is rendering a variety of tissues commodities to be explored, bought and sold (Almeling, 2007; Calvert, 2007; Sharp, 2000).

The entire field of pharmaco-genomics emerging over the last few years is producing vast amounts of information – Thacker (2006: 128) is talking about a 'tsunami of data' being generated – that in various ways helps shape the conception of what an illness is. For instance, Rajan (2006: 43) points at the 'pervasive rhetoric' surrounding the emergence of pharmaco-genomics and emphasizes that the rapid generation of information is "[a]lmost one of breathlessness, conveying a sense of being overwhelmed with a huge amount of (presumably) valuable data that is virtually impossible to keep up with". A lingering concern that one is not capable of scanning and examining all the information provided, thereby running the risk of missing some extremely valuable pieces of information in the vast haystack of data, is endemic in the pharmaceutical industry (Styhre, 2008). In the new regime of bio-capital, substantial resources are being spent on technology, equipment, and training in order to master the new tools of pharmaco-genomics. While critics point at relatively modest output in terms of innovative new registered drugs (Angell, 2004), the whole assemblage of technologies, practices, and theories constituting the pharmaco-genomic 'research program' (to use Lakatos's, 1970, apt phrase), is, in a Simondonian perspective, what is plays a key role in individuating the specific new metastable transductive unities that we refer to as illnesses.

The pharmaco-genomic assemblage is then not only capable of identifying genetic sequences (so called SNPs, *single neucleotide polymorphisms*) postulated to be underlying various illnesses but is also, in the transduction perspective, capable of *producing* illnesses. Just like solutions may search for problems in a so-called garbage decision-making process (March and Olsen, 1976), a SNPs may seek an illness, to gain scientific legitimacy and, ultimately, commercial interest. In the transduction framework, the individuation of an illness is no longer strictly a matter of a fixed etiology and a stable set of symptoms, but is also influenced by the kinds of solutions that are offered. Thus, in the case of Lakoff's (2006) study, bipolar disorder is no longer a self-enclosed set of experiences and symptoms but gradually converges towards the kinds of therapies that are offered. In a transduction perspective, the individuation of an illness, that is, its inscription into a bio-medicalized framework regulating what is perceived as normal or pathological, is the accomplishment of a meta-stable transductive unity capable of responding to all the information provided in the framework. Expressed differently, there is no longer strictly an inside and an outside, an

illness and its prescribed therapy, rather the illness and the therapy Are co-produced in a process that follows the principles for transduction outlaid by Gilbert Simondon (1992).

Discussion

Under the emerging regime of bio-capital, governed by pharmaceutical reason, the concept of life and what qualities of life to expect and demand are no longer anchored in theological credo but become a matter of techno-scientific practices and accomplishments. Biotechnology and pharmaceutical companies are increasingly capable of producing drugs that in various ways enhance the longevity and vitality of the human organism but the production of such new offerings are accompanied by a series of technical, political, ethical, political, and practical concerns and considerations. In the regime of bio-capital and pharmaceutical reason, there is not – if ever there was – a distinction between the 'inside of the laboratory' and the outside world of politics and markets; the techno-scientific new drug development work is structured in a Moebius-strip-like organization where inside and outside are no longer conceivable.

Drawing on the work of Gilbert Simondon (1992), conceiving of equally technological artifacts and biological organisms as being metastable transductive unities, rendered 'ontologically stable' on basis of their capacity to respond to the flow of information in their environment, illnesses and their therapies are no longer strictly separated but the boundaries between them become increasingly blurred. This conception of techno-scientific work and, in its implication; innovation and knowledge management work engaging in the production of informational objects (Schultze, 2000), suggests that there is a need for rethinking some of the basic assumptions regarding the nature of innovation work. For instance, in a recent paper, Deborah Dougherty (2007) argues that most pharmaceutical companies have invested billions into what she calls 'megatechnologies' such as rational drug design, high-throughput screening, combinatory chemistry, imaging technologies and genomics. In other words, new drug development has been considered primarily a 'technological problem': "bring in more machinery, devices, automation, assays and other scale-ups to do more things faster" (Dougherty, 2007: 266). However, Dougherty (2007) believes that this 'techno-hype' limits knowledge and innovation management by "glossing over the differences between technology versus science, blinding us to the fact of technology's blind search, and blackboxing the nature of knowledge involved" (Dougherty, 2007: 266).

Rather than continuing along this technological pathway to accomplish what biotechnological and pharmaceutical companies regularly claim they are capable of accomplishing, Dougherty (2007) suggests that there is a need for thinking of new drug development as the production of 'non-decomposable' epistemic objects, that is, each active compound has a complex and intricate relationship with the biological system in which it operates and therefore there are little opportunities for reducing these relations to the level of singular cause-effect relations (Dougherty, 2007: 270). Dougherty (2007) thus advocates a process-oriented view of new drug development. Although Dougherty (2007) is pointing at a series of practical problems facing the biotechnical and pharmaceutical industries and a set of epistemological and methodological issues

pertaining to innovation and knowledge management studies, the process-orientation that is advocated needs to be anchored in a proper theoretical framework acknowledging the complexities and contingencies of new drug development process and its relationship to selected targets (i.e., illnesses and their 'indications').

Following Simondon's (1992) meta-theoretical framework, applicable within the practical research work reported by both science and technology studies scholars engaging in laboratory studies (e.g., Knorr Cetina, 1981, 1999; Fujimura, 1996; Rheinberger, 1997) and anthropological studies of the increasingly important field of biocapitalist enterprises (Rabinow, 1996; Rajan, 2006; Lakoff, 2006), may enable a broader understanding of how both illnesses and therapies are metastable transductive entities that are always open-ended and contingent upon the flows of information in their environment. In other words, the contribution of Simondon (1992) to the growing research interest in the production of informational objects in the biotechnology and pharmaceutical industries lies in the ability to overcome established epistemological dualities without entirely abolishing them; such dualities are not ontologically stable but are produced en route in the transductive process. Moreover, Simondon is offering an analytical framework that reaffirms the concept of what Duns Scotus calls a *haecceity*, the unique 'thisness' (Lynch, 1993: 283) of an object such as an illness (see also Deleuze and Guattari, 1988). In Simondon's (1992) view, a *haecceity* is what is individuated in a transductive process. Both illness and their corresponding drugs are *haecceities* that have their individual features but their 'thisness' is always already transient and dependent on contingencies and situations. Ultimately, Simondon helps us restore ontology and epistemology in technoscience studies and innovation and knowledge management work though the overcoming of a conceiving of ontology as "static, fixed, composed of universal principles or ideals, indifferent to history, particularity, or change" (Grosz, 2005: 5). Instead, when examining the industries and social practices engaging with life per se, there is a need for thinking of life not in such static terms but as being "[a] mode of self-organization that overcomes itself, diverges from itself, evolves into something different over time" (Grosz, 2005: 8). Perhaps these alternative theoretical perspectives are capable of accomplishing a shift in focus that will offer new perspectives on the concerns addressed by Dougherty (2007).

This paper has contributed to the literature on innovation management, organization learning, and knowledge management, and the emerging literature on the biotechnology and pharmaceutical industries, though its emphasis on enacting alternative and ultimately more productive ways of conceiving how new product offerings are produced under the regime of bio-capital and the influence of pharmaceutical reason. Rather that seeing illness and therapies as separated by an iron curtain of techno-scientific procedures of proof and fact-making, the relationship between illness and prescribed therapies are more closely connected and entangled. In order to theorize this intricate relationship, Simondon's (1992) thinking of transduction has been examined and related to relevant literature.

Conclusion

The biotechnology and pharmaceutical industries are often referred to as what will possibly play the same role for twentieth-first century capitalism as the manufacturing and especially automotive industry played for the twentieth century. So far, the Henry Fords and Alfred Sloans of the bio-capitalist regime of accumulation have not been crystallized even though major scientists and entrepreneurs such as Herbert W. Boyer of UCSF and co-founder of Genentech may be qualified candidates (Jong, 2006; Shapin, 2008). Being able to understand the dynamics and work procedures of these emerging industries demands, as for instance Barley and Kunda (2001: 86) point out, a new set of concepts capable of apprehending the new mode of working, thinking, and speaking. What is at the centre of the new biocapitalist regime is not only technoscientific ideologies and institutions, organizational standard operation procedures, commodities and services, but in fact the question of *life itself*; biotechnology and pharmaceutical firms operate on basis of what may prove to be the ultimate matter of biological organisms (cell lines, DNA studies, SNPS, proteins, amino-acids, and so forth) and their product offerings are intimately related to advanced techno-scientific expertise in this quickly expanding domain. Therefore, there is a need for establishing theoretical frameworks and research methodologies capable of capturing the changes and movements in this alleged defining industry of the century. To bring the thinking of Gilbert Simondon may be one such approach that may prove viable for empirical studies.

This paper aims at making a contribution to innovation management literature, and more specifically, the innovation management literature that addresses science-based innovation. Instead of assuming that innovation is a linear and instrumental process wherein some product of service is produced, some domains of innovation are better understood through analytical frameworks that can tolerate or even be affirmative of fluidity and changes. From Simondon we learn that entities, be they biological, technological, or social in nature, are always no more than metastable instances, transductive entities, in a process of ontogenesis. Recognizing the value of such analytical perspective is potentially helping to understand the nature of innovation work in the emerging bio-economy wherein scientific theories, technological apparatuses and equipment, and biological tissues are the operative resources that will possible produce great wealth and new opportunities for mankind.

references

Almeling, R. (2007) 'Selling genes, selling gender; egg agencies, sperm banks, and the medical market in genetic material, *American Sociological Review*, 73(3): 319-340.

Angell, M. (2004) *The Truth About the Drug Companies: How They Deceive Us and What To Do About It*. New York: Random House.

Appadurai, A. (1996) *Modernity at Large: Cultural Dimensions of Globalization*. Minneapolis and London: Minnesota University Press.

Barley, S. and G. Kunda (2001) 'Bringing work back in', *Organization Science*, 12(1): 76-95.

Bateson, G. (1972) *Steps to an Ecology of Mind*. Chicago: Chicago University Press.

Beistegui, M. de, (2005) 'From Merleau-Ponty's 'reduction' to Simondon's 'transduction'', *Angelaki: Journal of Theoretical Humanities*, 10(3): 109-122.

Braidotti, R. (2006) *Transpositions: On Nomadic Ethics*, Cambridge and Malden: Polity Press.

Braidotti, R. (2008) 'In spite of the times: the postsecular turn in feminism, *Theory, Culture & Society*, 25(6): 1-24.

Brown, N. and A. Kraft (2006) 'Blood ties: banking the stem cell promise', *Technology Analysis & Strategic Management*, 18(3): 313-327.

Bud, R. (1993) *The Uses of Life: A History of Biotechnology*. Cambridge: Cambridge University Press.

Calvert, J. (2007) 'Patenting genomic objects: genes, genomes, function and information', *Science as Culture*, 16(2): 207-223.

Canguilhem, G. (1991) *The Normal and the Pathological*. New York: Zone Books.

Chabot, P. (2005) 'The philosophical August 4th: Simondon as a reader of Bergson', *Angelaki: Journal of Theoretical Humanities*, 10(3): 103-108.

Clarke, A.E., L. Mamo, J.R. Fishman, J.K Shim and J.R. Fosket (2003) 'Biomedichalization. Technoscientific transformations of health, illness, and U.S. biomedicine', *American Sociological Review*, 68: 161-194.

Cooper, M. (2008) *Life As Surplus: Biotechnology and Capitalism in the Neoliberal Era*. Seattle and London: The University of Washington Press.

Cooper, R. (1986) 'Organization/disorganization', *Social Science Information*, 25(2): 299-335.

Cooper, R. (2005) 'Relationality', *Organization Studies*, 26(11): 1689-1710.

Cooper, R. (2007a) 'Organs of process: rethinking human organization', *Organization Studies*, 28(10): 1547-1573.

Cooper, R. (2007b) 'The social body of organization: di-stance and technology', Paper presented at the 23rd EGOS Colloquium, 5-6 July, Vienna, Austria.

Collins, H. and T. Pinch (2005) *Dr. Golem: How to Think About Medicine*. Chicago and London: The University of Chicago Press.

Conrad, P. (2007) *The Medicalization of Society*. Baltimore: Johns Hopkins University Press.

DeLanda, M. (2006) *A New Philosophy of Society: Assemblage Theory and Social Complexity*. London and New York: Continuum.

Deleuze, G. and F. Guattari (1988) *A Thousand Plateaus Capitalism and Schizophrenia*. Minneapolis: University of Minnesota Press.

Deleuze, G. and C. Parnet (1987) *Dialogues*. London: Athlone Press.

Derrida, J. (1976) *Of Grammatology*. Baltimore: John Hopkins University Press.

Dodge, M. and R. Kitchin (2005) 'Code and the transduction of space', *Annals of the American Geographers*, 95(1): 162-180.

Dougherty, D. (2007) 'Trapped in the 20th century? Why models of organizational learning, knowledge and capabilities do not fit bio-pharmaceuticals, and what to do about that', *Management Learning*, 38(3): 265-270.

Eckert, H. and J. Bajorath (2007) 'Molecular similarity analysis in virtual screening: foundations, limitations and novel approaches', *Drug Discovery Today*, 12(5-6): 225-233.

Franklin, S. (2005) 'Stem Cell R Us: emergent life forms and the global biological', in A. Ong and S.J. Collier (eds.) *Global Assemblages: Technology, Politics, and Ethics as Anthropological Problems*. Malden and Oxford: Blackwell.

Franklin, S. and C. Roberts (2006) *Born and Made: An Ethnography of Preimplantation Genetic Diagnosis*. Princeton and London: Princeton University Press.

Foucault, M. (2008) *The birth of biopolitics*: *Lectures at the Collège de France, 1978-1979*, in M. Senellart (ed.), trans. G. Burchell. Basingstoke: Palgrave.

Fujimura, J.H. (1996) *Crafting Science: A Sociohistory of the Quest for the Genetics of Cancer*. Cambridge, Mass.: Harvard University Press.

Griffith, P.E. (2001) 'Genetic information: a metaphor in search of a theory', *Philosophy of Science*, 68(3): 394-412.

Grosz, E. (2005) *Time Travels: Feminism, Nature, Power*. Durham: Duke University Press.

Hacking, I. (2006) 'Genetics, biosocial groups, and the future of identity', *Daedalus*, Fall 2006: 81-96.

Hansen, M.B.N. (2004) *New philosophy for new media*. Cambridge and London: The MIT Press.

Hansen, M.B.N. (2006) *Bodies in Code: Interfaces with Digital Media*. Cambridge and London: The MIT Press.

Haraway, D. (1997) *Modest=Witness@Second=Millenium. FemaleMan©=Meets=OncoMouse™*. London: Routledge.

Harvey, O., T. Popowski, and C. Sullivan (2008) 'Individuation and feminism: a commentary on Gilbert Simondon's 'the genesis of the individual'', *Australian Feminist Studies,* 23(55): 101-112.

Hayles, N. K. (1999) *How We Became Posthuman: Virtual Bodies in Cybernetics, Literature, and Informatics*. Chicago and London: The University of Chicago Press.

Healy, D. (2006) 'The new medical oikumene', in A. Petryna, A. Lakoff and A. Kleinman (eds.) *Global Pharmaceuticals: Ethics, Markets, Practices.* Durham and London: Duke University Press.

Jasanoff, S. (2004) 'The idiom of co-production', in S. Jasanoff (ed.) *States of Knowledge: the Co-Production of Science and Social Order*. London and New York: Routledge.

Jong, S. (2006) 'How organizational structures in science shape spin-off firms: the biochemistry departments of Berkeley, Stanford, and UCSF and the birth of biotech industry', *Industrial and Corporate Change*, 15(2): 251-283.

Kay, L.E. (2000) *Who Wrote the Book of Life? A History of the Genetic Code*. Stanford and London: Stanford University Press.

Keller, E.F. (2002) *Making Sense of Life: Explaining Biological Development with Models, Metaphors, and Machines*. Cambridge and London: Harvard University Press.

Knorr Cetina, K.D. (1981) *The Manufacture of Knowledge: An Essay on the Constructivist and Contextual Nature of Science*. Oxford: Pergamon Press.

Knorr Cetina, K. (1999) *Epistemic Cultures: How Sciences Make Knowledge*. Cambridge: Harvard University Press.

Lakatos, I. (1970) 'Falsification and the methodology of scientific research programs', in I. Lakatos and A. Musgrave (eds.) *Criticism and the Growth of Knowledge*. Cambridge University Press: Cambridge.

Lakoff, A. (2006) *Pharmaceutical Reason: Knowledge and Value in Global Psychiatry*. Cambridge: Cambridge University Press.

Lakoff, A. (2008) 'The right patients for the drug: pharmaceutical circuits and the codification of illness', in E.J. Hackett, O. Amsterdamska, M. Lynch and J. Wajcman (eds.) *Handbook of science and technology studies*, 3rd. ed. Cambridge and London: The MIT Press.

Latour, B. (1983) 'Give me a laboratory and I will raise the world', in K. Knorr-Certina and M. Mulkay (eds.) *Science Observed: Perspectives on the social study of science*. London: Sage.

LeBreton, D. (2004) 'Genetic fundamentalism and the cult of the gene', *Body & Society*, 10(4): 1-20.

Lecourt, D. (1998) 'Georges Canguilhem on the question of the individual', *Economy & Society*, 27(2/3): 217-224.

Lynch, M. (1993) *Scientific Practice and Ordinary Action*. Cambridge: Cambridge University Press.

Mackenzie, A. (2002) *Transductions: Bodies and Machines at Speed*. London and New York: Continuum.

Mackenzie, A. (2005) 'Problematizing the technological: the object as event?', *Social Epistemology*, 19(4): 381-399.

March, J.G. and J. Olsen (1976) *Ambiguity and Choice in Organizations*. Oslo: Universitetsforlaget.

Maturana, H.R. and F.J. Varela (1980) *Autopoesis and Cognition: The Realization of the Living*. Dordrecht, Boston and London: D. Riedle Publishing.

Novas, C. and N. Rose (2000) 'Genetic risk and the birth of the somatic individual', *Economy and Society*, 29: 485-513.

Oprea, T.I. (2002) 'Virtual screening in lead discovery: a viewpoint', *Molecules* 7: 51-62.

Orlikowski, W.J. and C.S. Iacono (2001) 'Research commentary: desperately seeking the "IT" in IT research - a call to theorizing the IT artifact', *Information Systems Research*, 12(2): 121-134.

Petryna, A. (2006) 'Globalizing human subjects research', in A. Petryna, A. Lakoff, A. Kleinman (eds.) *Global Pharmaceuticals: Ethics, Markets, Practices.* Durham and London: Duke University Press.

Rabinow, P. (1992) 'Artificiality and enlightenment: from sociobiology to biosociality', J. Crarya and S. Kwinter (eds.) *Incorporations*. New York: Zone Books.

Rabinow, P. (1996) *Making PCR: A Story of Biotechnology*. Chicago and London: The University of Chicago Press.

Rajan, K.S. (2006) *Biocapital: The Constitution of Postgenomic Life*. Durham: Duke University Press.

Rheinberger, H.-J. (1997) *Toward a History of Epistemic Things: Synthesizing Proteins in the Test Tube*. Stanford: Stanford University Press.

Rose, N.S. (2007) *The Politics of Life Itself: Biomedicine, Power and Subjectivity in the Twenty-First Century*. Princeton and Oxford: Princeton University Press.

Rose, N. and C. Novas (2005) 'Biological citizenship', in A. Ong and S.J. Collier (eds.) *Global Assemblages: Technology, Politics, and Ethics as Anthropological Problems*. Malden and Oxford: Blackwell.

Rubin, B.P. (2008) 'Therapeutic promise in the discourse of human embryonic stem cell research', *Science as Culture*, 17(1): 13-27.

Schrödinger, E. (1944) *What is Life?: Physical Aspects of the Living Cell*. Cambridge: Cambridge at the University Press.

Schultze, U. (2000) 'A confessional account of an ethnography about knowledge work', *MIS Quarterly*, 24(1): 3-41.

Shapin, S. (2008) *The Scientific Life: A Moral History of a Late Modern Vocation*. Chicago and London: The University of Chicago Press.

Sharp, L. (2000) 'The commodification of the body and its parts', *Annual Review of Anthropology*, 29: 287-328.

Shostak, S. and P. Conrad (2008) 'Sequencing and its consequences: path dependence and the relationships between genetics and medicalization', *American Journal of Sociology*, 114: S287-S316.

Simondon, G. (1958/1980) *On the mode of existence of technical objects,* trans. N. Mallahphy. London: University of Western Ontario.

Simondon, G. (1964/1992) 'The genesis of the individual', in J. Crary and S. Kwinter (eds.) *Incorporations*. New York: Zone Books.

Smith Hughes, S. (2001) 'Making dollars out of DNA: the first major patent in biotechnology and the commercialization of molecular biology, 1974-1980', *Isis*, 92(3): 541-575.

Styhre, A. (2008) *Science-based innovation: From modest witnessing to pipeline thinking.* Basingstoke and New York: Palgrave.

Thacker, E. (2006) *The Global Genome: Biotechnology, Politics and Culture*. Cambridge and London: MIT Press.

Terranova, T. (2004) 'Communication beyond Meaning: On the Cultural Politics of Information', *Social Text*, 22(3): 51-73.

Waldby, C. (2002) 'Stem cells, tissue cultures, and the production of biovalue', *Health*, 6(3): 305-322.

Waldby, C. and M. Cooper (2007) 'The biopolitics of reproduction: post-fordist biotechnology and women's clinical labour', *Australian Feminist Studies*, 23(55): 57-73.

Waldby, C. and R. Mitchell (2006), *Tissue Economies: Blood, Organs, and Cell Lines in Late Capitalism*. Durham and London: Duke University Press.

Walters, W.P., M.T. Stahl, and M.A. Murcko (1998) 'Virtual screening - an overview', *Drug Discovery Today,* 3: 160-178.

Whitehead, A.N. (1925) *Science and the Modern World*. Cambridge: Cambridge at the University Press.

Whitehead, A.N. (1978) *Process and Reality*. New York: Free Press.

the author

Alexander Styhre is professor and chair of operations management at Chalmers University of Technology, Sweden. Alexander has published in the field of organization theory and is the author of a number of books including the most recent *Perception and Organization* (Palgrave, 2008) and *Managing Knowledge in the Construction Industry* (Spon Press, 2009). At present, Alexander is working in a research project on innovation work in biotechnology and pharmaceutical industry financed by The Bank of Sweden's Tercentenary Fund. Otherwise, Alexander listens to La Düsseldorf and other fine Krautrock bands and reads novels by the Swedish author and recently elected Swedish Academy member Lotta Lotass. Contact information: Alexander Styhre, Dept. of Technology Management and Economics, Division of Operations Management, Chalmers University of Technology, Vera Sandbergs Allé 8, SE-412 96, Gothenburg, Sweden.
E-mail: alexander.styhre@chalmers.se