2
Metabolic urbanization

The making of cyborg cities

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METABOLIC URBANIZATION AND CYBORG CITIES

> A cyborg is a cybernetic organism, a hybrid of machine and organism, a creature of social reality as well as a creature of fiction.
>
> (Haraway 1991:149)

In the introductory chapter we argued that cities are constituted through dense networks of interwoven socio-ecological processes that are simultaneously human, physical, discursive, cultural, material, and organic. Circulatory conduits of water, foodstuffs, cars, fumes, money, labour, etc., move in and out of the city, transform the city, and produce the urban as a continuously changing socio-ecological landscape. Imagine, for example, standing on the corner of Piccadilly Circus in London, and consider the socio-environmental metabolic relations that come together in this global-local place: smells, tastes, and bodies from all nooks and crannies of the world are floating by, consumed, displayed, narrated, visualized and transformed. The "Rainforest" shop and restaurant play to the tune of eco-sensitive shopping and the multi-billion pound eco-industry while competing with McDonalds' burgers and Dunkin' Donuts, whose products—like burgers, coffee, orange juice, or cream cheese—are equally the result of processes that fuse together and interconnect social and biochemical relations from many places, near and far away. Consider how human bodies—of migrants, prostitutes, workers, capitalists—spices, clothes, foodstuffs, and materials from all over the world whirl by. The neon lights are fed by energy coming from nuclear power plants and from coal-, oil-, or gas-burning electricity generators. Cars, taxis, and buses move on fuels from oil-deposits (now again from Iraq) and pump CO_2 into the air, affecting peoples, forests and climates in places around the globe. All these flows complete the global geographic mappings and traces that flow through the urban and "produce" London (or any other city) as a palimpsest of densely layered bodily, local, national and global—but depressingly geographically uneven—metabolic socio-ecological processes. This intermingling of material and symbolic things produces the vortexes of modern life, combines to produce a particular socio-environmental milieu that welds nature, society, and the city together in a deeply heterogeneous, conflicting and often disturbing whole (Swyngedouw 1996).

The view that a city is a particular process of environmental production, sustained by particular sets of socio-metabolic processes that shape the urban in distinct, historically

contingent ways, a socio-environmental process that is deeply caught up with socio-metabolic processes operating elsewhere, rarely grabs the headlines. Of course, the "Hygienic City" of the nineteenth century (Gandy 2004; this volume) already celebrated the making of the city as a system of circulatory conduits that would render the metabolism of the city rhyme in concert with the bio-chemical metabolisms associated with a sanitized urban life. Haussmann's opening up of Paris, King Leopold's sanitation of Brussels, the visionary construction of Vienna's Ringstrasse, and London's slum clearance also point to these combined processes of political-ecological transformation and socio-cultural reconstruction. The ecological anarchism of radical thinkers like Kropotkin or Elisee Reclus, and the various attempts at creating socially or ecologically harmonious "utopian" cities pursued with equal fervour by anarchists, socialists, liberals, and fascists, also illustrate nineteenth- and early-twentieth-century concerns with producing socially just and sustainable urban environments.

Urbanization can indeed be viewed as a process of contiguous de-territorialization and re-territorialization through metabolic circulatory flows, organized through social and physical conduits or networks of "metabolic vehicles". In this chapter, we consider how nature becomes urbanized through proliferating socio-metabolic processes. "Metabolism" and "circulation" will be the central metaphors that will guide us in this endeavour. They are not randomly selected. Both concepts have a long conceptual, cultural, social, material, and arte-factual history. They emerged as coherent concepts and materially mobilized principles in the mid-nineteenth century and both were deeply connected with projects, visions, and practices of modernization, and with the associated "modern" transformation of the city. Most importantly, in contrast to other fashionable metaphors that attempt to fuse together heterogeneous entities—like networks, assemblages, rhizomes, imbroglios, collectives—the former convey a sense of flow, process, change, transformation, and dynamism in addition to the "inner-connectedness" suggested by the other tropes. They embody what modernity has been, and will always be about: change, transformation, flux, movement, creative destruction. With its emphasis on movement, change, and process and its insistence on the socially mobilized "materiality" of life, historical materialism has been among the first social theories to embrace and mobilize "metabolism" and "circulation" as entry-points in undertaking "ontologies of the present that demand archaeologies of the future" (Jameson 2002:215). These ontologies and archaeologies are what we shall turn to next.

HISTORICAL-GEOGRAPHICAL MATERIALISM: ENTERING METABOLISM AND CIRCULATION

Historical materialism and the remaking of environments

> Certainly we continue to have crickets and thunderstorms…and we continue to understand our psyches as driven by natural instincts and passions; but we have no nature in the sense that these forces and phenomena are no longer understood as outside, that is,

> they are not seen as original and independent from the civil order.
>
> (Hardt and Negri 2000:187)

Both "metabolism" and "circulation" have long conceptual and material histories. "Circulation" gained wide currency after William Harvey's postulation of the double circulation of blood in the body. Movement, flux and conduits rapidly thereafter became formative metaphors that would shape radically new visions of and practices for acting in the world. The concept of "metabolism" arose in the early nineteenth century, particularly in relationship to the material exchanges in the body with respect to respiration. It became extended later to include material exchanges between organisms and the environment as well as the bio-physical processes within living (and non-living or decaying) entities. For example, in the writings of Jacob Moleschott (1857) and Justus von Liebig (1840; 1842), metabolism denoted not only the exchange of energy and substances between organisms and the environment, but the totality of biochemical reactions in a living thing. In fact, von Liebig's analysis turned organisms into living processes, gave them a history-as-process. Interestingly enough, von Liebig, like Edwin Chadwick, had taken the temporal/spatial separation of spaces of production and spaces of consumption through the emergence of long-distance trade and the process of urbanization (what von Liebig called the "metabolic rift") as the pivotal causes of the decline in the productivity of agricultural land on the one hand, and the problematic accumulation of excrement, sewage and garbage in the city on the other. For them, the "unsustainability" of nineteenth-century forms of urbanization was, as it is today, directly related to the spatio-temporal organization of metabolic flows and circuits. With this view of metabolism as ecological-historical process, and combined with Darwin's equally historical-metabolic views of the biological world, and Lyell's theories of the world's geological reconstruction, historical-geographical materialism could mobilize the concept of metabolism, neither as just an organic analogy to the social order (see Padovan 2000) nor as a mere metaphor to be transposed onto society, but as the very foundation of and lasting condition for the social.[1]

In social theory, the concept of metabolism was introduced in an ontological and epistemological framework in the early Marxist formulations of historical materialism. In its most general sense, materialism asserts that both origin and development of what exists is dependent on nature and "matter". Or, in other words, a certain physical Reality exists that is prior to thought, and to which thought must be related or interlinked (although it can never be identical to the Real) (Foster 2000). As Roy Bhaskar argued, "neither thought nor language form a realm of their own, they are only manifestations of actual life" (Bhaskar 1979:100).[2] Karl Marx's historical materialism was arguably the first coherent attempt to theorise the internal metabolic relationships that shape the transformations of the earth's surface and make and remake the social and physical world. In *Grundrisse, Capital* and, in particular, *The German Ideology,* Marx insisted on the "natural" foundations of social development (see also Hughes 2000):

> The first premise of all human history is, of course, the existence of living human individuals. Thus the first fact to be established is the physical

> organization of these individuals and their consequent relationship to the rest of nature…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…[M]en must be in a position to live in order to be able to "make history" …The first historical act is thus the production of the means to satisfy these needs, the production of material life itself.
>
> (Marx (1974 [1846]:42 and 48)

This environmental "production" process is conceived in the broadest possible sense. It refers to the metabolic process that is energized through the fusion of the physical properties and creative capacities of humans with those of non-humans. For Marx, this is what defines the act of "labouring", i.e. the purposeful metabolic process intended to produce and reproduce (human) life. Production is an organic process in the first instance, similar (but not reducible or identical) to the act of producing things new by other organic and non-organic "actants". What differentiates human actants from others is their organic capacity to wish differentially, to imagine different possible futures, to act differentially in ways driven and shaped by human drives, desires, and imaginations (as distinct from those of rivers, viruses, cows, or tulips). This form of acting differentiates human acting from other active "moments" or "agents" in the production and transformation of "environments". As Marx puts it:

> A spider conducts operations that resemble those of a weaver, and a bee in the construction of her cells puts to shame many an architect. But what distinguishes the worst architects from the best of bees is this, that the architect arises his structure in imagination before he erects it in reality.
>
> (Marx 1971 [1867]:Ch.5)

Labouring is therefore nothing other than engaging the "natural" physical and mental forces and capabilities of humans in a metabolic physical-material process with other human and non-human actants and conditions. It is through the process of "transposition of labour power into human organism" (Marx 1971:323) that this metabolic process is mobilized:

> Nature builds no machines, no locomotives, railways, electric telegraphs, self-acting mules, etc. These are products of human industry; natural material transformed into organs of the human will over nature, or of human participation in nature. They are organs of the human brain, created by the human hand.
>
> (Marx 1973 [1858]:706)

These products of transformed nature and embodied "dead" labour take on a thing-like character, which, like any other actant, is enrolled again in subsequent assemblages. In fact, "[A]ny product can take on a 'life' of its own, and may come to dominate the living labour that makes it. The 'nature of things' is indeed to become non-human actors" (Kirsch and Mitchell 2004:23). If the act of labouring, broadly conceived, constitutes a socio-ecological process, then the particular relational frame through which this labour is

socially organized has to become an integral part of understanding the continuous (re-)making of what we can now discern as socio-natural entities (Castree 2000; 2002). The circulation of goods, or of entities, is evidently directly associated with the notion of metabolism, which involves precisely such a process of transformation-in-movement. In other words, metabolic circulation fuses together physical dynamics with the social regulatory and framing conditions set by the historically specific arrangement of the social relations of appropriation, production, and exchange—in other words, the mode of production. The things, the products used by labour in production always enter the metabolic processes as already configured assemblages, collectives, networks that, in turn, through socio-metabolic circulatory processes, mobilize new human and non-human "actants" and produce new assemblages or collectives. As Timothy Luke (1999:39) notes:

> Marx can be seen as an extended critique of Latour's sense of collectivization, inasmuch as he uses the notion of the commodity to describe the association of humans and nonhumans. Since Marx's examination of the commodity form under capitalism looks at ways in which human labor is mixed with nonhuman things to create value, much of his analysis is a careful study of who dominates whom in the process of such collectivization, with commodification leading to the endless "co-modification" of human and nonhuman beings in both nature and culture. These ties now define coevolution.

These "collectives" are those proliferating objects that Donna Haraway calls "cyborgs" (Haraway 1991) or that Bruno Latour refers to as "quasi-objects" (Latour 1993); these hybrid, part social, part natural—yet deeply historical and thus produced—objects/subjects are intermediaries that embody and express nature *and* society and weave networks of infinite liminal spaces. These assemblages, like commodities, are simultaneously real, like nature; narrated, like discourse; and collective, like society (Latour 1993:122). They take on cultural, social, and physical forms and enter social and ecological processes in new and transformed manners. The city, in its parts and as a whole, is a kaleidoscopic socio-physical accumulation of human/non-human imbroglios. In the production of these assemblages and entanglements, the figures of "metabolism" and of "circulation" take centre stage in a historical materialist and dialectical account. In the next section, we shall delve deeper into the origin and mobilization of "metabolism" and "circulation" within historical materialism.

Metabolism as metaphor and practice

Marx and Engels were among the first to engage the term "metabolism" to grapple with the dynamics of socio-environmental change and evolution (Fisher-Kowalski 1998; 2003). In fact, "metabolism" is the central metaphor for Marx's definition of labour and for analyzing the relationship between human and nature:

> Labour is, first of all, a process between man and nature, a process by which man, through his own actions, mediates, regulates, and controls the

> *metabolism* between himself and nature. He confronts the materials of nature as a force of nature. He sets in motion the natural forces which belong to his own body, his arms, legs, head, and hands, in order to appropriate the materials of nature in a form adapted to his own needs. Through this movement he acts upon external nature and changes it, and in this way he simultaneously changes his own nature. …[labouring] is the purposeful activity aimed at the production of use-values. It is an appropriation of what exists in nature for the requirements of man. It is the universal condition for the metabolic interaction between man and nature, the ever-lasting nature-imposed condition of human existence, and it is therefore independent of every form of that existence, or rather it is common to all forms of society in which human beings live.
>
> (Marx 1971 [1867]: 283 and 290)

For Marx, this socio-natural metabolism is the foundation of history, a socio-environmental history through which the natures of humans and non-humans alike are transformed (see also Godelier 1986). To the extent that labour constitutes the universal premise for human metabolic interaction with nature, the particular social relations through whom this metabolism of nature is enacted shape its very form. Clearly, any materialist approach insists that "nature" is an integral part of the "metabolism" of social life. Social relations operate in and through metabolizing the "natural" environment, and transform both society and nature. For historical materialism, then, ecology is not so much a question of values, morals, or ethics, but rather a mode of "understanding the evolving material interrelations (what Marx called 'metabolic relations') between human beings and nature…From a consistent materialist standpoint, the question is…one of coevolution" (Foster 2000:10–11) (see also Norgaard 1994; Levins and Lewontin 1985). Foster (2000:15–16) continues to argue that:

> [A] thoroughgoing ecological analysis requires a standpoint that is both materialist and dialectical…[A] materialist sees evolution as an open-ended process of natural history, governed by contingency, but open to rational explanation. A materialist viewpoint that is also dialectical in nature (that is, a non mechanistic materialism) sees this as a process of transmutation of forms in a context of interrelatedness that excludes all absolute distinctions…A dialectical approach forces us to recognize that organisms in general do not simply adapt to their environment; they also affect that environment in various ways by affecting change in it.

In other words, non-human entities act in their metabolic exchange—in their "enrolment" as Latour (1993) would call it—with other human and non-human actants. This materialist view is decidedly "constructionist" in the sense that it considers socio-natural processes as historically specific, produced, and contingent. However, it does not foreground a notion of "social construction", as the non-human plays a pivotal and foundational role in the process; it merely evocates the view of nature as "produced".

Marx undoubtedly borrowed the notion of "metabolic interaction" from Justus von Liebig,[3] the founding theoretician of modern agricultural chemistry. In contrast to other

sociologists avant-la-lettre, like Comte and Spencer, who used the concept of metabolism as an analogy to grapple with social metabolism and for whom "nature offered the gnoseological structures to survey the workings of society" (Padovan 2000:7), Marx, Engels, or Adam Schäffle, mobilized "metabolism" in an ontological manner in which human beings, like society, were an integral, yet particular and distinct, part of nature.

The original German word for metabolism is *Stoffwechsel,* which translates literally as "change of matter". This simultaneously implies circulation, exchange *and* transformation of material elements. As matter moves, it becomes "enrolled" in associational networks that produce qualitative changes and qualitatively new assemblages. While the newly produced "things" embody and reflect the processes of their making (though a process of internalization of dialectical relations—see Harvey (1996)), they simultaneously differ radically from their constituent relational parts. For von Liebig, chemical metabolism was a process of "creative destruction" in which the new irrevocably transformed the old. Metabolism as a biochemical process is a contradictory one, predicated upon fusion, tension, conflict, and ultimately transconfiguration, which, in turn, produces a series of new "entities", often radically different from the constituting components, yet equally re-active. Metabolism (with a few rare exceptions), consequently, is a historical process, it has a time arrow. Labour (itself an organic metabolic procedure), then, becomes the organic activity through which this metabolic process is mobilized in a purposeful, human manner by enrolling heterogeneous things into specific metabolic interactions:

> Actual labour is the appropriation of nature for the satisfaction of human needs, the activity through which the metabolism between man and nature is mediated.
>
> (Marx 1861–1863)

While every metabolized thing embodies the complex processes and heterogeneous relations of its making at some point in the past, it enters (or becomes enrolled), in its turn and its own specific manner, into new assemblages of metabolic transformation. These dynamic heterogeneous assemblages form a circulatory (although not necessarily closed) process. Under conditions of generalized commodity production, the process takes on the form of circulation of commodities and the circulatory reverse flow of capital (as embodied dead labour, that is past metabolic transformations). This processual metabolism is, according to Foster (2000), central to Marx's political economy and is directly implicated in the circulation of commodities and, consequently, of money: "[t]he economic circular flow then was closely bound up, in Marx's analysis, with the material exchange (ecological circular flow) associated with the metabolic interaction between human beings and nature" (Foster 2000:157–158). Indeed, under capitalist social relations, the metabolic production of use values operates in and through specific control and ownership relations, and in the context of the mobilization of both nature and labour to produce commodities (as forms of metabolized socio-natures) with an eye towards the realization of the embodied exchange value. The circulation of capital as value in motion is, therefore, the combined metabolic transformations of socio-natures in and through the reverse circulation of money as capital under social relations that combine the mobilization of capital, nature or dead labour, and labour power. New socio-natural

forms, including the transformation of labour power as living labour, are continuously produced as moments and things in this metabolic process (see Grundman 1991; Benton 1989; 1996; Burkett 1999; Foster 2000). Whether we consider the production of dams, the re-engineering of rivers, the management of biodiversity hotspots, the transfiguration of DNA codes, the cultivation of tomatoes (genetically modified or not) or the construction of houses, they all testify to the particular associational relations through which socio-natural metabolisms are organized (in terms of property and ownership regimes, production or assembly activities, distributional arrangements, and consumption patterns).

Of course, the ambition of classical Marxism was broader than reconstructing the dialectics of historical socio-natural transformations and their contradictions. Historical materialism also questioned and critiqued the process of discursive (or ideological in Marxist terms) purification, of separation and binarization of the world into things "social" and things "natural" that, in Latour's vocabulary, produced the modern "constitution" and derailed the project of becoming "modern" (while, in the process, filling this symbolic void with all manner of socio-natural imbroglios). Historical-geographical materialism as a dialectical (that is, non-teleological) evolutionary (that is, actively produced history) organicism (that is, the unity of the heterogeneous social and the heterogeneous natural) not only addresses the cultural, discursive, "ideological", moral/ethical constructions of nature that were as prevalent in the nineteenth century as they are today, but offered a view of the world that unified the natural and the social while critiquing radically the "modern" separation of "society" from "nature".[4] In fact Marx had already prefigured Bruno Latour's clarion call to "re-modernise", to re-connect the two poles that have been severed by modernity, in *Grundrisse:*

> It is not the unity of living and active humanity, the natural, inorganic conditions of their metabolic exchange with nature, and hence their appropriation of nature, which requires explanation, or is the result of a historic process, but rather the separation between these inorganic conditions of human existence and his active existence
>
> (Marx 1973 [1858]:489)

However, by concentrating on the labour process as mere social process (as was and is the case for most of modern sociology, Marxist sociology included), some Marxist analysis—particularly during the twentieth century—tended to replicate the very problem it meant to criticize. The "void" referred to above was silenced rather than problematized, ignored rather than taken as the "space" for politics, for struggle, for pre-figuring radical socio-ecological transformation, and realizing alternative socio-natural relations. In other words, while mainstream economics forgot the natural foundations of economic life[5] (only to rediscover them recently, under the guise of environmental economics), much of Marxist theory equally became an exclusively "social" theory, rather than a socio-ecological one. Put simply, the over-emphasis on the social relations under capitalism that characterized much of Marxist (and other) social analysis tended to abstract away from or ignore the material and socio-physical metabolic relationships, their phantasmagorical representations and symbolic ordering. This resulted in a partial

blindness in the social sciences of the twentieth century to questions of political ecology and socio-ecological metabolisms.

Some recent approaches to the society–nature problematic, such as Actor Network Theory or (political-) ecological theories of a variety of kinds, have provided a new grammatical apparatus that has "profoundly revitalized empirical studies of human–nature–technology relations…But…it remains important that we incessantly raise the question…why are 'things as such' produced in the way they are—and to whose potential benefit" (Kirsch and Mitchell 2004). While a historical-materialist mobilization of metabolism might begin to shed light on the production of socio-natural entities, this has to be fused together with another equally central metaphor and material condition, one that is closely related to metabolism, namely, circulation.

The invention of circulation

> Enlightened planners wanted the city in its very design to function like a healthy body, freely flowing as well as possessed of clear skin. Since the beginnings of the Baroque era, urban planners had thought about making cities in terms of efficient circulation of the people on the city's main streets. The medical imagery of life-giving circulation gave a new meaning to the Baroque emphasis of motion. Instead of planning streets for the sake of ceremonies of movement toward an object, as did the Baroque planner, the Enlightenment planner made motion an end in itself.
>
> (Sennett 1994:263–264)

Alongside the emergence of the notion of "metabolism" in the natural and social sciences (an emergence not wholly disassociated with the rising "metabolic rift" caused by industrialization and urbanization), the notion of "circulation" began to gain greater and wider currency. For example, the idea of "water circulation", that water piped into the city must leave the city by its sewers is not older than the nineteenth century (in the west). Circulating water, following a given path and finally returning to its source, remained foreign to western urban imaginations, spatial representations and engineering systems until then. Modern urbanization, highly dependent on the mastery of circulating flows, was linked with the representation of cities as consisting of and functioning through complex networks of circulatory systems (Kaika and Swyngedouw 1999).

Before the "discovery" of circulatory systems, the movement of water was seen merely as evaporation: the separation of the "spirit" from the "water" (Goubert 1989). This view that things happen, appear, or disappear through "extraction" was widely held before circulatory views began to replace them. In chemistry, for example, phlogiston theory of the seventeenth century, formulated by Johann Becher and still defended by Priestley, rested on the basis of extractionist views. Such theories prevailed until Antoine Lavoisier's eighteenth-century discovery, which postulated chemical reactions as (metabolic) transfigurations or re-arrangements of components that in the process

produced qualitatively new assemblages, but in which nothing was lost or disappeared. Together with phlogiston theory, the representation of the respiratory system, plant growth, the Physiocrats' view of the production of material wealth from the given natural conditions of the soil, even the Malthusian unidirectional flow of food, all indicate the incapacity of early post-renaissance people to conceive of "circulation" as an infinite cyclical process.

When William Harvey (1628) promulgated his ideas of the double circulation of blood in the vascular system of the human body in 1628, a revolutionary insight came into being which would begin to permeate and dominate everyday life, engineering, and intellectual thought for centuries to come, both metaphorically and materially.[6] By the end of the century, medical practice had accepted the idea of the circulatory (metabolic) system, leading to a profound re-definition of the body. In the nineteenth century, the metabolic circulation of chemical substances and organic matter (see von Liebig's contribution above) became increasingly accepted, and would form the basis of modern ecology. The "circulation" and the "metabolism" of matter became fused together as the two central metaphors through which to capture processes of socio-natural change, and of modernity itself.

Indeed, the use of the word "circulation" to refer to the movement of money within a national economy established itself within a generation of William Harvey's claim (Harvey 1999 [1628]). Thomas Hobbes, in *Leviathan* (1651), for example, had already compared the problems of a government that was unable to raise sufficient tax revenue to "an ague; wherein, the fleshy parts being congealed, or by venomous matter obstructed, the veins which by their natural course empty themselves into the heart, are not, as they ought to be, supplied from the arterie, whereby there succeedeth at first a cold contraction, and trembling of the limbs; and afterwards a hot, and strong endeavour of the heart, to force the passage of the blood" (cited in Harvey 1999 [1628]). Francis Bacon, in his essay *Of Empire,* wrote that merchants "are vena porta; and if they flourish not, a kingdom may have good limbs, but will have empty veins, and nourish little" (cited in Harvey 1999 [1628]).

At the beginning of the eighteenth century, the term "circulation" had become established in many sciences, referring to the flow of sap in plants and the circulation of matter in chemical reactions (Teich 1982). "Circulation" becomes a dominant metaphor after the French Revolution: ideas, newspapers, gossip and—after 1880 —traffic, air, and power "circulate". From about 1750, wealth and money begin to "circulate" and are spoken of as though they were liquids, flowing incessantly to become a process of accumulation and growth. Society begins to be imagined as a system of conduits (Sennett 1994). Montesquieu in *Lettres Persanes* (p. 117) speaks of "[T]he more 'circulation' the more wealth" and in *l'Esprit des Lois* of "[Multiplying wealth by increasing circulation". Rousseau (1766) refers to "[T]his useful and fecund circulation that enlivens all society's labour" and to "a circulation of labour as one speaks of the circulation of the money" (cited in Illich 1986). Of course, by the mid-nineteenth century, the *flâneur*—dandy, artist, detective, and stroller, the favourite literary characters of Baudelaire and, later, with Walter Benjamin, of the *passages*—has been well represented and theorized as an object of circulation within this urban space. Of course, in the process, "circulation" became less and less identified with closed circular movement, and more with change, growth, and accumulation. Similar to the way von Liebig discovered the mechanisms of

metabolism through considering the "metabolic rift", "circulation" gained greater socio-ecological currency exactly when it became seen as an integral part of a process of change and transformation.

Adam Smith and Karl Marx conceived of a capitalist economy as a metabolic system of circulating money and commodities, carried by and structured through social interactions and relations. Accumulation is dependent on the swiftness by which money circulates through society. Each hiccup, stagnation or interruption of circulation may unleash the infernal forces of devaluation, crisis and chaos. Society's wealth and the relationships of power on which wealth is constructed are seen as intrinsically bound up with and expressed by the "circulation speed" of money in all its forms (capital, labour, commodities). Later, David Harvey (1985) would analyze the circulation of capital and its urbanization as a perpetual mobile channelled through a myriad of ever-changing production, communication and consumption networks. The development and consolidation of circulating money as the basis of material life, and the relations of domination and exclusion through which the circulation of money is organized and maintained shapes this "urbanization of capital".

By the mid-nineteenth century some British architects also begin to speak of the inner city mobilizing the metaphor of circulation. Sir Edwin Chadwick formulated the ideology of circulating waters effectively for the first time in his 1842 *Report into the Sanitary Conditions of the Labouring Population of Great Britain*. In his report, Chadwick imagined the new city as "a social body through which water must incessantly circulate, leaving it again as dirty sewage". Water ought to "circulate" through the city without interruption to wash it of sweats and excrements and wastes. The brisker this flow, the fewer stagnant pockets that breed congenital pestilence there are and the healthier the city will be. Unless water constantly circulates through the city, pumped in and channelled out, the interior space imagined by Chadwick can only stagnate and rot. This representation of urban space as constructed in and through perpetually circulating flows of water is conspicuously similar to imagining the city as a vast reservoir of perpetually circulating money. Viollet-le-Duc introduced circulation as a bodily metaphor for the organization of the urban villa. In fact, Chadwick's papers were published under the title *The Health of Nations* during the centenary commemoration for Adam Smith (Chadwick 1887). Like the individual body and bourgeois society, the city was now also described as a network of pipes and conduits. The brisker the flow, the greater the wealth, the health and hygiene of the city would be. Just as William Harvey redefined the body by postulating the circulation of the blood, so Chadwick redefined the city by "discovering" its needs to be constantly washed (Illich 1986:45). New principles of city planning and policing were emerging based upon the medical metaphors of "circulation" and "flow". The health of the body became the comparison against which the greatness of cities and states was to be measured. The "veins" and "arteries" of the new urban design were to be freed from all possible sources of blockage (Sennett 1994:262–265; Corbin 1994).

With circulation as a metabolic process firmly established as practice and as solid representation of the process of socio-ecological change, attention quickly moved from metabolism and circulation to "speed" or, in other words, to the "movement of movement". Metabolic circulation of the kind analyzed by Marx, and now firmly rooted in generalized commodity production, exchange, and consumption, is increasingly subject to the socially constituted dynamics of a capitalist market economy in which the

alpha and omega of the metabolic circulation of socio-ecological assemblages is the desire to circulate money as capital. As Douglas (2004) notes:

> Not only now would political rationality understand the motion of matter, and of bodies, it would seek above all to perfect the mechanisms of producing it. The "movement-of-movement", or "speed", as a technical achievement, emerges at this time (the early nineteenth century) as a societal principle, reordering the whole of the modern world. In the most radical way possible Virilio begins to answer the question of how efficiency was established in the modern urban landscape…The power of movement was subject to a spatial codification (in the city, in the workhouse, in the hospital, in the manufactory). By the beginnings of the nineteenth century this "codification" had been achieved, and a second "reordering" could now be effected. This reordering, rather than charting the middle ground between rapidity and stasis, aimed to "release" the full productive, dynamic efficiency of the (national) population in and through time. Motion had emerged as the destiny and law of a new politics of order. The full equivalence of Virilio's "metabolic vehicles" to Foucault's "bearers of order" becomes clear. Dromological power—or in the words of Foucault, "capillary power"—had emerged as the practical basis and first principle of the "free society" and "coded individual" established simultaneously with the apparatus of modern "governmentality". Mobility, in other words, had become simultaneously the means to liberation and the means to domination; the "accumulation of men" running simultaneously with "the accumulation of movement", and—one might add—the "accumulation of capital".

For Paul Virilio (1986), the freedom for people to come and go was replaced by an obligation to move. The creation of urban space as space of movement of people, commodities, and information radically altered the choreography of the city. Places and spaces became less and less shared, motion devalues or threatens to devalue place; connections are lost, identities reconfigured, and attachments broken down. While the urbanization of nature led to a spiralling accumulation of unstable socio-natural assemblages, the components of these assemblages became radically disassociated from their geographical origin as speed, movement and mobility ironically rendered the fields of vision and connections more opaque, transient, and partial. Although the city turned into a metabolic vehicle, the rift between the social and the natural became engrained deeper than ever in the modern urban imagination.

(HYBRID) NATURES AND (CYBORG) CITIES

> The metabolic requirements of a city can be defined as the materials and commodities needed to sustain the city's inhabitants at home, at work and at play …The metabolic cycle is not completed until wastes and residues of daily

> life have been removed and disposed of with a minimum of nuisance and hazard.
>
> (Wolman 1965:179)
>
> A barrel of crude oil sold for about $13 in 1998. The same quantity of whole blood, in its "crude" state, would sell for more than $20,000 [in Manhattan, NY].
>
> (Starr 1998)

When mobilizing the twin vehicles of "metabolism" and "circulation" from a historical-materialist epistemological perspective, the modernist tropes of "nature" and "society" transform radically. Modernity's bifurcation, separation, and binarization is recognized by historical materialism as exactly what it is: an image, a metaphor, a trope; one that can be and is mobilized for all manner of cultural, social, or political projects (Kaika 2005). A dialectical approach recognises both the radical non-identity of actants (human and non-human) enrolled in socio-metabolic processes within an assemblage, while recognising the social, cultural, and political power relations embodied relationally in these socio-natural imbroglios. The production of (entangled) things through metabolic circulation is necessarily a process of fusion, of the making of "heterogeneous assemblages", of constructing longer or shorter networks. In fact, both "hybridity" and "cyborg" are misleading as tropes, and may even be implicated in radically reproducing the underlying binary representation of the world. Hence, the bracketing of "hybrid" and "cyborg" in the title of this section refers exactly to the "excess of meaning" inscribed in coding the city as either "hybrid" or "cyborg".

Metabolic circulation, then, is the socially mediated process of environmental, including technological, transformation and trans-configuration, through which all manner of "agents" are mobilized, attached, collectivized, and networked. The heterogeneous assemblages that emerge, as moments in the accelerating and intensifying circuitry of metabolic vehicles, are central to a historical-geographical materialist ontology:

> As plants, animals, minerals, air, light, etc., in theory form a part of human consciousness, partly as objects of natural science, partly as objects of art... so they also form in practice a part of human life and human activity. Man lives physically only by those products of nature; they may appear in the form of food, heat, clothing, housing, etc. The universality of man appears in practice as the universality which makes the whole of nature his inorganic body: (1) as a direct means of life, and (2) as the matter, object, and instrument of his life activity. Nature is the inorganic body of man, that is nature insofar it is not the human body. Man lives by nature. This means that nature is his body with which he must remain in perpetual process in order not to die.
>
> (Marx 1982:63)

As Luke (1999:43) argues, "the conditions of associating humans and nonhumans in ancient, Asiatic, feudal, or capitalist relations of collectivization can thus be used to

understand how power, knowledge, and conflict co-modified people and their things in any given society". These assemblages of humans and non-humans, of dead labour and inert materials, are reminiscent of the "hybrids" and the "cyborgs" of Latour and Haraway, respectively (see Luke 1999). However, while Haraway asks penetrating questions as to why "cyborgs" are produced the way they are and the relations of power inscribed in these imbroglios, this question remains silent in Latour's work. For him, the key issue centres on transforming the "constitutional" arrangements through which human and non-human actants become mobilized or enrolled (Latour 2004). In sum, while Latour defends a democratic republic of heterogeneous associations, Haraway maintains a perspective that emerges from a radically different ontological position. A deep ontological divide opens here. As Benedikte Zitouni (2004) convincingly argues:

> Haraway views any entity as an *embodiment* of relations, an *implosion,* the threads of which should be teased apart in order to understand it. Whereas Latour views any entity as *a piece of matter* that is continuously affected and that contracts links with a larger networks *that allows it to live, to be*. On the one hand, the entity *crystallizes* the network; on the other hand the entity is *supported* by the network. Haraway studies the network in order to define the entity; Latour studies that same network in order to define the entity's consistency and persistence…Dialectics, congealment, crystals, prisms, representations are not possible tools any longer for urban studies but instead we view pieces of matter, of any kind, that act, react and interact with one another, that gain their consistency, persistence and existence or lose them through the affects and links to other agents. Power differences and inequality can no longer be stated as such, as a departure point into the city but have to be explained through the many actions and relations between objects, humans and non humans. There is nothing *behind* any space or agent, only attachments *aside* of it that make it stronger or weaker, allow it to exist or lead it to perish.
>
> (Zitouni 2004)

It is in this latter sense that we wish to see the city as a metabolic circulatory process that materializes as an implosion of socio-natural relations, a process which is organized through socially articulated networks and conduits whose origin, movement, and position is articulated through complex political, social, economic, and cultural relations. These relations are invariably infused with myriad configurations of power that saturate material, symbolic, and imaginary (or imagined) practices.

Studies on urban metabolism have often uncritically pursued the standard industrial ecology perspective based on some input-output model of the flow of "things" (see Table 2.1 on London's metabolism). Such analysis merely poses the issue, and fails to theorize the making of the urban as a socio-environmental metabolism (see, for example, Weisz *et al.* 2001). While insightful in terms of quantifying the urbanization of nature, it fails to theorize the process of urbanization as a social process of transforming and reconfiguring nature. It would not be too much of an exaggeration to state that most processes of transformation of nature are intimately linked to the process of urbanization and to the urbanization of nature. From this perspective, it is surely strange to note that relatively

little empirical or theoretical work has been undertaken that explicitly attempts to theorise environmental change and urban change as fundamentally interconnected processes.

Modern urbanization or the city can be articulated as a process of geographically arranged socio-environmental metabolisms. These are mobilized through relations

Table 2.1 The metabolism of Greater London (7,000,000 inhabitants)

Inputs	*Tonnes per year*
Fuel (oil equivalents	20,000,000
Oxygen	40,000,000
Water	1,002,000,000
Food	2,400,000
Timber	1,200,000
Paper	2,200,000
Glass	360,000
Plastics	2,100,000
Cement	1,940,000
Bricks, blocks, sand, tarmac	6,000,000
Metals	1,200,000
Wastes	*Tonnes per year*
Industry and demolition	11,400,000
Household, civic and commercial	3,900,000
Wet digested sewage sludge	7,500,000
Carbon dioxide gas	60,000,000
Sulfur dioxide gas	400,000
Nitrogen oxide gas	280,000

Source: www.global-vision.org/city/metabolism.html (H.Girardet).

that combine the accumulation of socio-natural use and exchange-values, which shape, produce, maintain, and transform the metabolic vehicles that permit the expanded reproduction of the urban as a historically determined but contingent form of life. Such socially driven material processes produce extended and continuously reconfigured intended and non-intended spatial (networked and scalar) arrangements and are saturated with heterogeneous symbolic (representational) and imaginary (wish images) orders, albeit "overdetermined" (Althusser 1969) by the generalized commodity form that underpins the capitalist "nature" of urbanization. The phantasmagorical (spectacular) commodity-form that most socio-natural assemblages take not only permits and

facilitates a certain discourse and practice of metabolism, but also, perhaps more importantly, "naturalize" the production of particular socio-environmental conditions and relations. For example, it seems much easier to imagine an apocalyptic environmental future of humankind (of the kind perpetuated by global climate change pundits, bio-diversity preservation activists, or GM-warriors) than to imagine a political change in the actually existing social ordering of the metabolic process, one that would imply a re-construction of the produced environments.

The urbanization of nature is largely predicated upon a commodification of parts of nature while, in the process, producing new metabolic interactions and shaping both symbolic and material socio-natural interactions. The urbanization of nature necessitates both ecological transformation *and* social transformation. Urbanized nature propels the diverse physical, chemical, and biological "natural" flows and characteristics of nature into the realm of commodity and money circulation with its abstract qualities and concrete social power relations. Produced nature becomes legally defined and standardized, according to "scientific" politically and socio-culturally defined norms that are enshrined in binding legislation. Homogenization, standardization, and legal codification are essential to the commodification process. The urbanization process makes nature enter squarely into the sphere of money and cultural capital and its associated power relations, and redraws socio-natural power relations in important new ways. Indeed, the political-ecological history of many cities can be written from the perspective of the need to urbanize and domesticate nature and the parallel necessity to push the ecological frontier outward as the city expanded (Swyngedouw 2004). As such the political-ecological process produces both a new urban and rural socio-nature. The city's growth, and the process of nature's urbanization are closely associated with successive waves of ecological conquest and the extension of urban socio-ecological frontiers. Local, regional, and national socio-natures are combined with engineering narratives, economic discourses and practices, land speculation, geo-political tensions, and global money flows. This metabolic circulation process is deeply entrenched in the political-ecology of the local and national state, the international divisions of labour and power, and in local, regional, and global socio-natural networks and processes.

CONCLUSIONS

"Metabolism" and "circulation" permit excavating the socio-environmental basis of the city's existence and its change over time. The socio-naturally "networked" city can be understood as a giant socio-environmental process, perpetually transforming the socio-physical metabolism of nature. Nature and society are in this way combined to form an urban political ecology, a hybrid, an urban cyborg that combines the powers of nature with those of class, gender, and ethnic relations. In the process, a socio-spatial fabric is produced that privileges some and excludes many, that produces significant socio-environmental injustices. Nature, therefore, is an integral element of the political ecology of the city and needs to be addressed in those terms. Urbanizing nature, though generally portrayed as a technological-engineering problem is, in fact, as much part of the politics of life as any other social process. The recognition of this political meaning of nature is essential if sustainability is to be combined with a just and empowering urban

development; an urban development that returns the city and the city's environment to its citizens. Being modern, as the poet Arthur Rimbaud (1873) captured it in the nineteenth century, is exactly about the active creation of situations and events, and participating in the production of our natures in so doing. Urban modernity as a particular set of processes of socio-metabolic transformations promises exactly the possibility of the active, democratic, and empowering creation of those socio-physical environments we wish to inhabit. In this sense, modernity is not over; it has not yet begun.

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NOTES

1 Ernst Haeckel, who coined the term ecology (1866), mobilized organic metaphors to describe social conditions, and started a long lineage of human ecological analysis, one that would ultimately drive a wedge between the natural sciences and the social sciences as the legitimacy of such unmediated trans-formulations was increasingly questioned. Human ecology would subsequently bifurcate into a dematerialized social ecology, primarily through the Chicago School, on the one hand, and industrial ecology on the other. The latter, moving increasingly in the direction of a variety of types of commodity chain or goods-flow analysis, would increasingly distance itself from relational social theory (Fisher-Kowalski 1998; 2003; Fisher-Kowalski and Hüttler 1999; Newcombe 1977).

2 This statement, of course, does not mean that thought or languages are simply the epiphenomenon of "material" relations. On the contrary, very complex dialectical arrangements infuse the articulation of the real, the symbolic, and the imaginary (for different ways of exploring these articulations, see, for example, Žižek (Žižek and Daly 2003) or Lefebvre (1991) in the construction of the real.

3 Although Schmidt (1971) and Fisher-Kowalski (1998) maintain that Moleschott (1857) provided the influential insights, this is convincingly rebuked by Foster (2000), who maintained that von Liebig (1840) was of central importance. In any case, the use of "metabolism" was widespread in the emerging social sciences at the time and both Marx and Engels were familiar with the ongoing scientific debates in biology.

4 This has become engrained in social theory since its founding fathers Durkheim, Weber, and a "socialized" Marx.

5 While the Physiocrats were radically and correctly critiqued, the rational kernel of their mythical theorization was equally dismissed radically.

6 The first person apparently to suggest the circulation of blood in the arterial system was Ibn-al-Nnafiz (physician, born in Baghdad and died in Cairo in 1288) (Illich 1986:40). The idea of circulation remained alien to the imagination of sixteenth-century Europeans. Two sixteenth-century scientists suspected what Harvey would later discover: Servetus (a Spanish genius and heretic burnt by Calvin—he also edited Ptolemy's geography in Lyon—and student of Vesalius in Paris) and Realdus Colombus of Padua (also student of Vesalius). Harvey was a student of Vesalius in 1603.

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