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MARX, NATURAL SCIENCE AND THE MATERIALIST CONCEPTION OF NATURE

INTRODUCTION

This article is about the relationship between Marxism and Science. This relationship is considered to be highly controversial and a vast literature exists on the subject reflecting debates that emerged in the earliest days of Marxism. One of the reasons is because "science" and "Marxism" are both terms that have been understood in various ways over the course of the last 100 years.

One can distinguish at least two main currents within Marxism: classical 'scientific' Marxism and humanist critical Marxism initiated by G. Lukacs and the Frankfurt School in the '20s.

While 'classical' Marxism stresses the scientific character of Marxism, 'critical' Marxism is highly critical of science and its practice. The two currents of Marxism differ on the degree that consider important the Hegelian influence on Marx. A general inclination of criticizing science has been a characteristic feature of Hegelian perspectives within Marxism. Alternatively, Marxists who embrace science have a tendency to minimize Hegel's influence on the development of Marx's thought.

This paper stands on the grounds of 'scientific' Marxism. It argues that i) Marx was both a materialist and a scientific realist recognising the ontological objectivity of nature as highlighted mainly in the 'Theses on Feuerbach' ii) Marx employed a materialist conception of nature, which was not at all foreign to the major revolutions in the science of his time and which he combined with a dialectic of emergence and contingency. To substantiate these claims, the paper follows closely Marx's intellectual

development examining his relationship with the two figures that assume special importance in the development of his materialism: the ancient Greek philosopher Epicurus and Charles Darwin. From Epicurus, Marx in his doctoral dissertation developed his critique of teleological explanations in natural and human history. From Darwin, Marx developed a distinctive theory of 'coevolution' that accounted for the ways in which society shaped, and in turn was shaped by nature. Linking together Marx's materialism with his critique of capitalism is the concept of 'metabolism' which Marx derived from the work of the German chemist Justus von Liebig in soil chemistry. For Marx, 'The Capital' is a work of science.
In the final section a general discussion of Marx's materialism as a form of scientific materialism is given along with implications for environmental and science education.

THE TOPOGRAPHY OF MARXISM

Marxism and Marxist scholars have been divided into roughly two tendencies: one conceiving Marxism as "critique" and the other conceiving it to be a social "science." Marxism has been divided between Critical Marxists and Scientific Marxists. The Two-Marxisms are both in fact differentiations of a single originally undifferentiated Marxism.
As different, elaborated versions of Marxism, Critical and Scientific Marxism emerge under different socio-historical conditions and among different persons and in differentiated social networks and groups.
Critical Marxism includes Georg Lukacs, Karl Korsch, Antonio Gramsci, J-P. Sartre, Lucien Goldmann and members, or onetime members, of the "Frankfurt School" as Max Horkheimer, T. W. Adorno, Leo Lowenthal, Erich Fromm, Walter Benjamin, Herbert Marcuse, or its second generation, such as Jurgen Habermas.
Opposed to this group, are Marxists who turn their back on critical theory as mere ideology and who conceive Marxism as a true science. They include Galvano della Volpe, Louis Althusser and those influenced by him, Goran Therborn, and Robin Blackburn, an editor of the prestigious British journal New Left Review.
The most important part of this theoretical tension is organized as a

conflict between those supporting (and those rejecting) the importance of Hegel for Marx, and between those using and those rejecting a more Hegelian conception of "ideology critique."

Both Scientific and Critical Marxism tend to view ideology differently and their critique of ideology differs as well. Scientific Marxism views ideology as a distorted reflection of the world, indeed, as turned upside down by the distorting lens of self-interest but, nonetheless, as a reflection mirroring the world. Critical Marxism, however, believes that even as men go about fashioning ideological masks for class domination, they do so under the scrutiny of their own and others' critical reason, and must thus seek masks that will persuade themselves and others. What makes ideologies persuasive is precisely their elements of rationality. From the standpoint of Critical Marxism, then, reason even seeps into ideology itself and it must, therefore, contain something more than the false and mistaken; consequently, ideology cannot simply be shrugged aside as a mere tool of domination, or straightened out simply with a transformative criticism that turns it "right side up."

The difference between Critical and Scientific Marxism reflects a conflict between those viewing Marx as the culmination of German idealism and those emphasizing Marx's superiority to that tradition. It is, therefore, also a difference between those accepting the young (and consequently more Hegelian) Marx as authentically Marxist and others who regard the young Marx as still mired in ideology.

Critical Marxists conceive of Marxism as critique rather than science; they stress the continuity of Marx with Hegel, the importance of the young Marx, the ongoing significance of the young Marx's emphasis on ''alienation," and are more historicist.

The Scientific Marxists, or anti-Hegelians, have stressed that Marx made an epistemological rupture with Hegel after 1845. Marxism for them is science, not critique, entailing a "structuralist" methodology whose paradigm is the "mature" political economy of Capital rather than the "ideologized" anthropology of the 1844 Manuscripts.

In one part, the controversy about the young versus the old Marx is a metaphor for the more analytic distinction between Critical and Scientific Marxism. Critical Marxists, therefore, commonly stress the continuity between the young and old Marx because the young Marx was patently an Hegelian;

they wish to establish Marxism's enduring link with the larger tradition of German philosophy of which Hegel was the culmination.
Correspondingly, Scientific Marxists may stress the quantum leap that the maturing Marx presumably made from ideology to science, as well as ascribing sharp differences between ideology and science in general.

MARX AND SCIENCE

Marx himself wrote no systematic treatise on science, but throughout his writings there are numerous scattered passages in which he comments on the nature of science and on general questions of methodology. There are also several places in which Marx compares his own historical, economic and political studies with the kind of research carried out by natural scientists.
In Capital, for instance, he compares his 'scientific analysis of competition', based on an account of the 'inner nature of capital', to the way in which astronomers explained the 'apparent motions of the heavenly bodies' by developing a theory of 'their real motions...which are not directly perceptible by the senses' [1].
There are few discussions of Marx's views on science, and those which exist (such as David-Hillel Ruben's Marxism and Materialism [2] or Patrick Murray's Marx's Theory of Scientific Knowledge [3] tend to be highly academic, so there is little alternative to plunging into Marx's writings themselves.

1 K. Marx, Capital vol 1, New York 1967, ch XII, p316.
2 2nd edn Brighton, 1979. Ruben discusses how Marx's views about knowledge and reality emerged from, and help solve, problems left by his philosophical predecessors, and he attempts to articulate a Marxist theory of knowledge in greater detail. By calling his account a 'reflection theory', however, Ruben encourages a confusion between a theory of truth and a theory of knowledge which, as we shall see, it is important to avoid. The book's final chapter is a sympathetic discussion of Lenin's Materialism and Empirio-Criticism. Ruben is also the co-editor (with John Mepham) of the multi-volume series Issues in Marxist Philosophy (Atlantic Highlands, New Jersey, 1979) which contains a number of essays on dialectics, materialism and science.
3 Atlantic Highlands, New Jersey, 1988. Murray shows how Marx's own scientific method emerged from an internal critique of Hegel, and examines Marx's critique of political economy in the light of this. I have discussed Murray's interpretation in a review of his book in the Radical Philosophy Review of Books, no 2 (1990).

Most of Marx's explicit comments on methodology and science are scattered in such works as *The Holy Family*, *The Economic and Philosophical Manuscripts*, the *Theses on Feuerbach*, *The German Ideology*, the *Grundrisse*, *Capital*, and in his *Correspondence*.[4]

From Marx's direct remarks, a relatively systematic account of science emerges. While recognising that 'sense-experience must be the basis of all science',[5] Marx rejects the empiricist view that science is largely concerned with systematising what is directly observable rather than with discovering underlying causes. As the philosopher Allen Wood notes, Marx 'criticises empiricists for emphasising observation too much at the expense of theory, and for treating scientific concepts and theories only as convenient mechanisms for relating isolated facts rather than as attempts to capture the structure of reality'.[6]

Marx is a scientific realist who holds that science aims to give us knowledge of the underlying structure of an independently existing material world.[7] He notes that *'all science would be superfluous if the outward appearance and the essence of things directly coincided'*.[8] He takes it to be obvious that there are 'sensuous objects, really distinct from the thought objects' [9] so that 'the priority of external nature remains unassailed',[10] and he scorns the views of the Young Hegelian philosophers in the 1840s by comparing them to what he regards as the absurd view that the world is constructed by consciousness.

Many influential scholars have argued that Marx was not a realist, and

4 The Holy Family and The German Ideology are, of course, joint works written with Engels, but precisely because they are joint works they reflect Marx's views at the time as well.

5 Economic and Philosophical Manuscripts, in D McLellan (ed), Karl Marx: Selected Writings (Oxford, 1977), p94.

6 K. Marx (London, 1981), p162. Wood's book is a very clear discussion of various aspects of Marx's philosophical thought. The sections on 'Philosophical Materialism' and 'The Dialectical Method' are particularly relevant to the topic of this article.

7 It is no coincidence that many recent defenders of scientific realism have been influenced by Marx. In the US these have included Hilary Putnam (in the late 1960s and early 1970s), Richard Boyd, Richard W Miller, Peter Railton and Michael Devitt. In Britain the best known figure is Roy Bhaskar. Essays by Putnam, Boyd, Miller and Railton can be found in R Boyd et al (eds), The Philosophy of Science, op cit.

8 K. Masrx, Capital vol 3, New York, 1967, ch XLVIII, p817.

9 K. Marx, Theses on Feuerbach, in D McLellan (ed), op cit, p156.

10 The German Ideology, in D McLellan (ed), op cit, p175.

that he did not believe that the natural world exists independently of our knowledge of it. Perhaps the first to come to this conclusion was the Hungarian Marxist Georg Lukács, who claimed in the 1920s that to distinguish between 'thought and existence' is to accept 'a rigid duality'.[11]
Lukács abandoned this view in the 1930s after reading Marx's *Economic and Philosophical Manuscripts*, which convinced him of the importance of recognising the 'ontological objectivity of nature',[12] but many others have advocated similar views since then.
Often, Marx's 'Second Thesis on Feuerbach' is taken to support this interpretation:

> *The question whether objective truth belongs to human thinking is not a question of theory but a practical question. It is in practice than man must prove the truth, ie, the actuality and might, the this-sidedness of his thinking. The dispute over the actuality or non-actuality of thinking isolated from practice is a purely scholastic question*.[13]

Scholars who deny that Marx was a realist claim that this passage shows that he defined truth in terms of practical success, not in terms of some kind of correspondence with independent reality, and that he rejected arguments about whether thought actually does correspond with reality as 'scholastic'.
But this is to misread Marx's formulation. His claim is that practical success is a guide to truth, not that truth is literally no more than practical success, and what he rejects as scholastic is not the question about whether thought corresponds to reality, but the attempt to answer that question purely theoretically, without reference to practice.
In fact there are passages where Marx explicitly accepts a correspondence view of truth. In the *Afterword* to the second German edition of Capital, for instance, Marx says that an adequate description is one in which 'the life of the subject-matter is ideally reflected as in a mirror', and he adds that 'the ideal is nothing else than the material world reflected by the

11 History and Class Consciousness (London, 1971), p204. Lukács is led to this claim because he rejects the view that human consciousness passively reflects existing reality. He is right to reject the latter view, but wrong to think that it is implied by realism or a correspondence theory of truth.
12 Ibid, pxvii.
13 D McLellan (ed), op cit, p156.

human mind, and translated into forms of thought'.[14]

Marx is quite clear that it does not follow from this that truth can be obtained simply by, so to speak, holding a mirror up to nature. That, he thinks, was the mistake of the empiricists who thought that the world would simply imprint knowledge on our passive minds. But knowledge can only be obtained by a combination of actively constructing theories which attempt to understand what is going on beneath surface appearances, and by actively intervening in the world to see if these ideas can survive the test of practice. A theory of what it is for a claim to be true is one thing. A theory of knowledge (which will tell us how to obtain truth) is quite another.

Marx is aware that there is no timeless, ahistorical set of concepts out of which scientific theories are to be constructed, and no timeless, ahistorical scientific method by which such theories can be tested. As our knowledge of the material world develops, our understanding of the appropriate methods to use to find out more about the world, and our understanding of the concepts appropriate to describe it, develop as well. Moreover, methods and concepts may well be subject matter specific - what is appropriate in one area will probably not be appropriate in another. Marx insists that there is 'a dialectic of concept and fact', because the categories which we use to describe experience must be carefully scrutinised and grounded in the particular subject matter under examination.[15]

For example, the concepts in physics did not arise automatically from experience, but were developed by a long and complex process of abstraction. The same holds true for the very different concepts employed in biology or in any of the other areas of science.

Marx thus sees science as a dialectical process in the sense that its methods and concepts, as well as its theories, develop over time in dynamic interaction with one another and with the material world, allowing progressively more accurate descriptions of reality to emerge.

In addition to advocating a realist and dialectical conception of science, Marx emphasises that science can only be fully understood in its broader

14 K. Marx, Capital vol 1, p19.

15 P. Murray, op cit, pxiv.

social context. Where, he asks in The German Ideology, 'would natural science be without industry and commerce? Even this "pure" natural science is provided with an aim, as with its material, only through trade and industry'.[16] Or as he puts it in Capital, 'modern industry ... makes science a productive force distinct from labour and presses it into the service of capital'.[17]

Thus, for example, the scientific revolution and the rise of modern physics in the 17th century can only be properly understood in the context of the development of capitalism.

It does not follow from this, however, that science is no more than bourgeois ideology. It is true that capitalism may set the agenda for scientific research, and that capitalist ideology may have a significant influence on the development of scientific theories. Thus for example, Marx notes that 'Descartes, in defining animals as mere machines, saw with the eyes of the manufacturing period'.[18] But at the same time, economic competition, the expansion of production and the need to find more efficient ways of generating profits gives the bourgeoisie an interest in acquiring objective knowledge of the natural world, since without such knowledge they will fail to accomplish their goals. So, while capitalist ideology may often limit scientific development, the need to construct practically successful theories allows natural science under capitalism to achieve a considerable degree of objectivity. To put the point slightly differently, Marx recognises that the objectivity of scientific results does not require impartial or value-free motivations for engaging in scientific research, but only requires that the values which drive science are ones which are likely more often than not to lead to more accurate theories of the world.[19]

All these themes in Marx's writings are developed at much greater length in the works of Engels, particularly in his Anti-Dühring (1878), Ludwig Feuerbach and the Outcome of Classical German Philosophy (1888) and Dialectics of Nature (not published during Engels' lifetime). These

16 D McLellan (ed), op cit, p175.

17 Vol 1, ch XIV, section 5, p361.

18 Ibid, ch XV, section 2, p390n.

19 This argument is laid out in greater detail in P Railton, 'Marx and the Objectivity of Science', op cit.

books present Engels' attempts to formulate a sophisticated, non-reductionist and dialectical version of materialism, to develop a comprehensive, scientific worldview which sees a fundamental unity between the natural and social worlds, and to articulate a dialectical account of scientific method.

Unfortunately, for much of the 20th century Engels' discussions of these questions suffered a dual fate. In the Soviet bloc, at least from the 1930s, a caricatured version of Engels' views was treated as the Holy Bible, and serious critical discussion was virtually non-existent. By contrast, in the West Engels' work was either completely ignored or rejected as worthless, even by authors who are otherwise relatively sympathetic commentators on the Marxist tradition.[20]

Recent scholarship has confirmed that there is no evidence of any fundamental disagreement between Marx's and Engels' ideas about science.[21] What is true is that Engels had a much more detailed grasp of contemporary scientific developments than Marx. In fact, the biologist J B S Haldane regarded Engels as 'probably the most widely educated man of his day',[22] and Hilary Putnam describes him as 'one of the most scientifically learned men of his century'.[23]

THE INFLUENCE OF EPICURUS ON MARX

Two figures assume special importance in Marx's materialism: the ancient Greek philosopher Epicurus and Charles Darwin. From Epicurus, Marx developed his critique of teleological explanations in natural and human history. From Darwin, Marx developed a distinctive theory of

20 F. Engels, New York 1977, p91.

21 See, for instance, J D Hunley, The Life and Thought of Friedrich Engels (London, 1991).

22 Preface to Dialectics of Nature (New York, 1940), pxiv.

23 'The Philosophy of Science', in B Magee (ed), Men of Ideas (Oxford, 1982), p206. In the late 1960s and early 1970s Putnam developed a version of scientific realism strongly influenced by Marxist ideas, but by the time of this interview he had abandoned both realism and Marxism. Putnam goes on to claim that, while Engels' views on science are largely sensible, they are not original, but then immediately undermines this judgment by noting that Marxism 'might have made a contribution [to mainstream philosophy of science] if people had been less ideologically divided, because I think non-Marxists could have learned something from it.'

coevolution that accounted for the ways in which society shaped, and in turn was shaped by nature.

Along with German idealism Marx was struggling early on with ancient materialist natural philosophy and its relation to the 17th century scientific revolution, and the 18th century Enlightenment.

For Kant, 'Epicurus can be called the foremost philosopher of sensibility,' just as Plato was the foremost philosopher 'of the intellectual'. Epicurus, Hegel claimed, was 'the inventor of empiric natural science'. For Marx himself Epicurus was the 'the greatest figure of the Greek Enlightenment'.[24]

For Marx, Epicurus represented, most importantly, a non-reductionist, non-deterministic materialism, and articulated a philosophy of human freedom. In Epicurus could be found a materialist conception of nature that rejected all teleology and all religious conceptions of natural and social existence. In studying Epicurus's natural philosophy, Marx was addressing a view that had a powerful influence on the development of European science and modern naturalist-materialist philosophies, and one that had at the same time profoundly influenced the development of European social thought.

In the Epicurean materialist worldview, knowledge of the world started with the senses. The two primary theses of Epicurus's natural philosophy make up what we today call the principle of conservation: nothing comes from nothing, and nothing being destroyed is reduced to nothing. For Epicureans there was no scale of nature, no sharp, unbridgeable gaps between human beings and other animals. Knowledge of Epicurus provides a way of understanding Marx's materialism in the area of natural philosophy. His study of ancient and early modern materialism brought Marx inside the scientific understanding of the natural world in ways that influenced all of his thought, since it focused on evolution and emergence, and made nature not god the starting point. Moreover, Marx's dialectical encounter with Hegel has to be understood in terms of the struggle that Marx was carrying on simultaneously regarding the nature of materialist philosophy and science.

Epicurus, not Hegel, emerges as the pivotal figure in Marx's early de-

24 See J B Foster, *Marx's Ecology*, op cit, pp49-51.

velopment. Marx's doctoral dissertation assumes decisive weight in this account, marking a significant (albeit incomplete) rupture with Hegel. Rather than contained within the idealist philosophy of the Hegelian system, Marx's thesis aimed at recuperating an antiteleological materialism that (dialectically) "incorporated the activist element" of Hegelianism (p. 15). Formally, "the doctoral thesis pivoted on the differences between [Epicurus and Democritus on] the physics of the atom" (p. 52). These differences, however, "pointed beyond physics to epistemology" (p. 52) and thus to broader conflicts within European philosophy in the 18th and 19th centuries - between teleological and antiteleological perspectives, and especially between materialism and speculative philosophy.

Building on Epicurus, Marx's emergent materialism denied neither the objectivity of nature, as Hegel did, nor humans' active relation to nature and to each other, as did the mechanical materialism of Francis Bacon, Isaac Newton, and others.

Three aspects of Epicurus's materialism were especially importance for Marx:

First, all divine intervention, direct or indirect, and thus all absolute determinisms, all teleological principles, were expelled from nature (p. 35). The very creation of the world, argues Epicurus, can be accounted for only by reference to the realm of chance, created by the "swerve" of the atom. The collision of atoms resulting from these swerving atoms—which themselves have "no *cause*" (p. 54) - allows for "a kind of freedom for rational organization of historical life, building on constraints first established by the material world" (p. 53).

Second, his argument for the swerve is evidently premised on the objectivity of nature independent of human thought, in contrast to the Hegelian formulation. Yet Epicurus, contends Marx, went beyond a view that "reduce[d] thought to 'passive sensation'" (p. 55). Quite the contrary, Epicurus argued that "perception through the senses is only possible because it expresses *an active relation to nature* - and indeed, of nature to itself" (p. 55, emphasis added).

Third, this conception of the nature - society dialectic as driven by an active relation of humans to nature was embedded in a sophisticated treatment of time.

Prefiguring the historical geologists of the 18th and 19th centuries, Epicurus argued for a conception of "deep time" (p. 46). "Central to Epicurus' view was that life was born from the earth, rather than descending from the sky" (p. 39). Epicurus's notion of deep time applied not only to natural but also to social history, identifying distinct periods of socio-historical development. Even more significant for Marx's thinking was Epicurus's notion that "material existence was only evident through change, that is, evolution" (p. 40). The idea that evolutionary processes existed only through time - that is, in terms of emergence - would remain a cornerstone of Marx's dialectical method.

For Marx "Dialectical reasoning can thus be viewed as a necessary element of our cognition, arising from the *emergent, transitory* character of reality as we perceive it" (p. 232).

Marx developed a "dialectical naturalism" (p. 229) that admits a dialectical approach to the study of nature as well as society, contra Georg Lukacs's (1972) contention that imposing the dialectical method on nature amounts to positivism (pp. 136-140). Hence, Marx's examination of Epicurus's dialectical treatment of time and evolution provided a much more thoroughgoing materialist foundation for subsequent investigations of human society.

Marx's doctoral thesis shows that he was "ambivalent from the start" about the Hegelian system (p. 33). "Not only did Marx demonstrate an independence from Hegel in his very first literary work; he did so on the basis of an encounter with materialism, which was to have a lasting influence on his thinking" (p. 65). Still, the thesis was a "transitional work" that achieved only a partial rupture with Hegelianism.

MARX AND DARWIN

Darwin's theory of natural selection amplified Epicurus's critique of teleology, this time on the basis of natural history, thereby "annihilating the 'doctrine of final causes'" that had gained widespread currency as a conservative response to materialism's implications in 19th century Europe (p. 192).

Darwin had similar roots in natural philosophy, linked to the anti-teleological tradition extending back to Epicurus, which had found its

modern exponent in Bacon. We now know, as a result of the publication of Darwin's notebooks, that the reason that he waited so long--20 years--before making public his theory on species transmutation was due to the fact that his theory had strong materialist roots, and thus raised the issue of heresy in Victorian England. Darwin's view went against all teleological explanations, such as those of the natural theology tradition. He presented an account of the evolution of species that was dependent on no supernatural forces, no miraculous agencies of any kind, but simply on nature's own workings.

Marx and Engels greeted Darwin's theory immediately as 'the death of teleology', and Marx described it as 'the basis in natural science for our views'.[25] Not only did they study Darwin intensely, they were also drawn into the debates concerning human evolution that followed immediately on Darwin's work, as a result of the discovery of the first prehistoric human remains[26].

Many major works, mostly by Darwinians, emerged in just a few years to address this new reality, and Marx and Engels studied them with great intensity. Among the works that they scrutinised were Charles Lyell's *Geological Evidences of the Antiquity of Man* (1863), Thomas Huxley's *Evidence as to Man's Place in Nature* (1863), John Lubbock's *Prehistoric Times* (1865), Darwin's *Descent of Man* (1871), along with a host of other works including Lewis Henry Morgan's *Ancient Society* (1881).

Out of their studies came a thesis on the role of labour in human evolution that was to prove fundamental. Inspired by the ancient Greek meaning for organ (*organon*)--or tool, which expressed the idea that organs were essentially the 'grown-on' tools of animals, Marx referred to such organs as 'natural technology', which could be compared in certain respects to human technology. A similar approach was evident in Darwin, and Marx was thus able to use Darwin's comparison of the development of specialised organs in plants and animals to that of specialised tools (in chapter 5 of *The Origin of Species* on 'Laws of Variation') to help explain his own conception of the development of natural and human

25 See the discussion ibid, pp196-207, 212-221.

26 Neanderthal remains had been found in France in 1856, but it was the discovery of prehistoric remains that were quickly accepted as such in England in Brixham Cave in 1859, the same year that Darwin published his *The Origin of Species*.

technology. The evolution of natural technology, Marx argued, rooting his analysis in *The Origin of Species*, was a reflection of the fact that animals and plants were able to pass on through inheritance organs that had been developed through natural selection in a process that might be called '"accumulation" through inheritance'. Indeed, the driving force of evolution for Darwin, in Marx's interpretation, was 'the gradually accumulated [naturally selected] inventions of living things'.[27]

In this conception, human beings were to be distinguished from animals in that they more effectively utilised tools, which became extensions of their bodies. Tools, and through them the wider realm of nature, as Marx said early on in his *Economic and Philosophic Manuscripts*, became the 'inorganic body of man'. Or as he was to observe in Capital, 'thus nature becomes one of the organs of his [man's] activity, which he annexes to his own bodily organs, adding stature to himself in spite of the Bible'.[28]

Engels was to develop this argument further in his work, 'The Part Played by Labour in the Transition from Ape to Man' (written in 1876, published posthumously in 1896). According to Engels' analysis--which derived from his materialist philosophy, but which was also influenced by views voiced by Ernst Haeckel a few years before--when the primates, who constituted the ancestors of human beings, descended from the trees, erect posture developed first (prior to the evolution of the human brain), freeing the hands for tool-making. In this way:

> ...the hand became free and could henceforth attain ever greater dexterity and skill, and the greater flexibility thus acquired was inherited and increased from generation to generation. Thus the hand is not only the organ of labour, it is also the product of labour.[29]

As a result, early humans (hominids) were able to alter their relation to their local environment, radically improving their adaptability. Those

27 K Marx, *Theories of Surplus Value*, vol 3, Moscow, 1971, pp294-295.

28 K Marx, *Early Writings*, New York, 1974, p328; K Marx, *Capital*, vol 1, op cit, pp285-286. See also J B Foster and P Burkett, 'The Dialectic of Organic/Inorganic Relations: Marx and the Hegelian Philosophy of Nature', *Organization and Environment*, vol 13, no 4 (December 2000), pp403-425.

29 F Engels, *The Dialectics of Nature*, New York 1940, p281.

who were most ingenious in making and using tools were most likely to survive, which means that the evolutionary process exerted selective pressures toward the enlargement of the brain and the development of language (necessary for the social processes of labour and tool-making), leading eventually to the rise of modern humans. Thus the human brain, like the hand, in Engels' view, evolved through a complex, interactive set of relations, now referred to by evolutionary biologists as 'gene-culture co-evolution'. All scientific explanations of the evolution of the human brain, Stephen Jay Gould has argued, have thus far been theories of gene-culture co-evolution, and 'the best 19th century case for gene-culture co-evolution was made by Frederick Engels'.[30]

All of this points to the fact that Marx and Engels had a profound grasp of ecological and evolutionary problems, as manifested in the natural science of their day, and were able to make important contributions to our understanding of how society and nature interact. If orthodoxy in Marxism, as Lukács taught, relates primarily to method, then we can attribute these insights to a very powerful method, but one which, insofar as it encompasses *both* a materialist conception of natural history and of human (ie social) history, has not been fully investigated by subsequent commentators. Behind Marx and Engels' insights in this area lay an uncompromising materialism, which embraced such concepts as emergence and contingency, and which was dialectical to the core.

Darwin's *The Origins of Species*, Marx wrote in 1860, "contains the basis in natural history for our view"; it "provides a basis in natural science for the historical class struggle" (p. 197). What could this mean? Marx shared with Darwin a view of history characterized by struggle, adaptation, transformation, and the dialectical interplay of organism and nature. Marx's great innovation was to take Darwin's conception of natural history, in which organism and environment alike are transformed, to comprehend human history as a coevolutionary process. From this standpoint, human evolution, comprising natural as well as social history, had to be traced through the development of tools. This was because tools represented the development of human productive organs—the evolution of the human relation to nature—just as animal organs rep-

30 S J Gould, *An Urchin in the Storm* (New York, 1987), pp111-112.

resented the instruments by which animals had adapted to their local environments (p. 201). In this way, Darwin helped Marx establish a basis in natural history for an original and "general theory of the role of labour in the development of human society" (p. 202).

METABOLISM, THE METABOLIC RIFT

Binding together Marx's coevolutionary materialism with his critique of capitalism is the concept of metabolism (*Stoffwechsel*). In Marx's hands, this concept has a broad social meaning referring to "the complex, dynamic, interdependent set of needs and relations brought into being and constantly reproduced in alienated form under capitalism" (p. 158) and a more specific socioecological meaning that refers to material exchanges between nature and society.

Marx derived the socio-ecological rendering of metabolism from Justus von Liebig's pioneering work in soil chemistry, published in the early 1840s.

In 1862, the great German chemist Justus von Liebig published the seventh edition of his pioneering scientific work, *Organic Chemistry in its Application to Agriculture and Physiology* (first published in 1840). The 1862 edition contained a new introduction. Building upon arguments that he had been developing in the late 1850s, Liebig declared the intensive, or 'high farming', methods of British agriculture to be a 'robbery system', opposed to rational agriculture.[31] They necessitated the transportation over long distances of food and fibre from the country to the city--with no provision for the recirculation of social nutrients, such as nitrogen, phosphorus and potassium, which ended up contributing to urban waste and pollution in the form of human and animal wastes. Whole countries were robbed in this way of the nutrients of their soil. For Liebig this was part of a larger British imperial policy of robbing the soil resources (including bones) of other countries.

31 J Liebig, *Die Chemie in ihrer Anwendung auf Agricultur und Physiologie*, vol 1 (Brunswick, 1862). Except where otherwise indicated all of the brief quotes from Liebig in the text below are taken from an unpublished English translation of the 1862 German edition by Lady Gilbert contained in the archives of the Rothamsted Experimental Station (now IACR-Rothamsted) outside London.

The importance of Liebig's critique did not escape the attention of Karl Marx, who was then completing the first volume of *Capital* and was deeply affected by Liebig's critique. In 1866 he wrote to Engels, 'I had to plough through the new agricultural chemistry in Germany, in particular Liebig and Schönbein, which is more important for this matter than all of the economists put together.' Indeed, 'To have developed from the point of view of natural science the negative, ie destructive side of modern agriculture,' Marx noted in volume one of *Capital*, 'is one of Liebig's immortal merits'.[32]

Marx's two main discussions of modern agriculture both end with an analysis of 'the destructive side of modern agriculture'. In these passages Marx makes a number of crucial points:

(1) capitalism has created an 'irreparable rift' in the 'metabolic interaction' between human beings and the earth, the everlasting nature-imposed conditions of production;
(2) this demanded the 'systematic restoration' of that necessary metabolic relation as 'a regulative law of social production';
(3) nevertheless, the growth under capitalism of large-scale agriculture and long distance trade only intensifies and extends the metabolic rift
(4) the wastage of soil nutrients is mirrored in the pollution and waste in the towns--'In London,' he wrote, 'they can find no better use for the excretion of four and a half million human beings than to contaminate the Thames with it at heavy expense';
(5) large-scale industry and large-scale mechanised agriculture work together in this destructive process, with 'industry and commerce supplying agriculture with the means of exhausting the soil';
(6) all of this is an expression of the antagonistic relation between town and country under capitalism;
(7) a rational agriculture, which needs either small independent farmers producing on their own, or the action of the associated producers, is impossible under modern capitalist conditions; and

32 K Marx, *Capital*, vol 1, New York, 1976, p638.

(8) existing conditions demand a rational regulation of the metabolic relation between human beings and the earth, pointing beyond capitalist society to socialism and communism.[33]

Marx's concept of the metabolic rift is the core element of this ecological critique. The human labour process itself is defined in *Capital* as 'the universal condition for the metabolic interaction between man and nature, the everlasting nature-imposed condition of human existence'.[34] It follows that the rift in this metabolism means nothing less than the undermining of the 'everlasting nature-imposed condition of human existence'. Further there is the question of the sustainability of the earth—i.e., the extent to which it is to be passed on to future generations in a condition equal or better than in the present. As Marx wrote:

> From the standpoint of a higher socio-economic formation, the private property of particular individuals in the earth will appear just as absurd as private property of one man in other men. Even an entire society, a nation, or all simultaneously existing societies taken together, are not owners of the earth. They are simply its possessors, its beneficiaries, and have to bequeath it in an improved state to succeeding generations as boni patres familias [good heads of the household].[35]

The issue of sustainability, for Marx, went beyond what capitalist society, with its constant intensification and enlargement of the metabolic rift between human beings and the earth, could address. Capitalism, he observed, 'creates the material conditions for a new and higher synthesis, a union of agriculture and industry on the basis of the forms that have developed during the period of their antagonistic isolation'. Yet in order to achieve this 'higher synthesis', he argued, it would be necessary for the associated producers in the new society to 'govern the human metabolism with nature in a rational way'--a requirement that raised fundamental and continuing challenges for post-revolutionary society.[36] In analysing the metabolic rift Marx and Engels did not stop with the soil

33 Ibid, pp636-639; K Marx, *Capital*, vol 3 (New York, 1981), pp948-950, 959
34 Ibid, vol 1, pp283, 290
35 Ibid, vol 3, p911.
36 Ibid, vol 1, p637; Ibid, vol 3, p959.

nutrient cycle, or the town-country relation. They addressed at various points in their work such issues as deforestation, desertification, climate change, the elimination of deer from the forests, the commodification of species, pollution, industrial wastes, toxic contamination, recycling, the exhaustion of coal mines, disease, overpopulation and the evolution (and co-evolution) of species.

The concept of metabolism illuminates relations at two geographical scales, corresponding roughly to Marx's distinction between the technical and social divisions of labour (Marx, 1867/1977, pp. 470-480). In the first instance, the labour process regulates the relation between the labourer and nature, which becomes a deeply alienated and unsustainable relation with the emergence of capitalism and the development of capitalist class relations. In this way, metabolism "provided Marx with a concrete way of expressing the notion of the alienation of nature (and its relation to the alienation of labour)" (p. 158). Outlined in *Capital*, Marx's conception of metabolism rests on the labour process, through which humans mediate and transform, yet never really control, nature. Consequently, under capitalism the degradation of labour and nature are inextricably (dialectically) linked. Far from a one-sided account, for Marx the historically specific interplay of capitalist class and metabolic relations promised not just degradation but liberation. Thus, "the concept of metabolism allowed [Marx] to express the human relation to nature as one that encompassed both 'nature-imposed conditions' and the capacity of human beings to affect this process" (p. 158). Marx envisioned a future society of associated producers in which freedom in "the realm of natural necessity" (p. 159) is realized through the rational governance of the "human metabolism" (Marx, 1894/1981, p.959, quoted on p. 159).

The metabolism of the labour process at once shapes, and is shaped by, the metabolism of the social division of labour. Transforming the division of labour between town and country, capitalism creates a rift in the metabolic relation between the two: Nutrients flow out of the countryside and into the city and thence into rivers and waste dumps, never returning to the point of origin. In this way, the antagonistic relation of town and country disrupts nutrient cycling and undermines nature's capacity to regenerate.

In Marx's day, this metabolic rift manifested in growing concern throughout Europe and North America over declining soil fertility.
Marx, "made the concept of metabolism *central to his entire system of analysis* by rooting his understanding of the labour process upon it" (p. 157).
Marx's insight that capitalism's metabolic contradictions determine and are determined by capitalism's social contradictions means two things: (a) The degradation of the soil and the degradation of the worker are mutually relational—one cannot exist without the other; (b) the liberation of the soil and the liberation of the worker are mutually relational—alienation can be resolved only through practice that simultaneously restores the general social metabolism *and* the socioecological metabolism to equilibrium.

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