

MARX'S ECOLOGY

Materialism and Nature

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CHAPTER 5

THE METABOLISM OF NATURE AND SOCIETY

Before the ink was even dry on *The Communist Manifesto* a wave of revolutions broke out in Paris in 1848, quickly spreading across continental Europe. Although the *Manifesto* itself played no immediate part in this new phase of bourgeois revolution, its timing could scarcely have been better, and events seemed to underscore the importance of its revolutionary analysis. Both Marx and Engels participated in the uprisings then taking place in France and Germany, Marx starting up a revolutionary paper in Cologne, the *Neue Rheinische Zeitung*, but the revolutions were quickly defeated and Marx, no longer welcome in Prussia, France or Belgium, took refuge with his family in England, taking up residence in London. It was here that he was to live for the rest of his life, and where he was to write his great work, *Capital: A Critique of Political Economy*.

It was in *Capital* that Marx's materialist conception of nature became fully integrated with his materialist conception of history.¹ In his developed political economy, as presented in *Capital*, Marx employed the concept of "metabolism" (*Stoffwechsel*) to define the labor process as "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." Yet an "irreparable rift" had emerged in this metabolism as a result of capitalist relations of production and the antagonistic separation of town and country. Hence under the society of associated producers it would be necessary to "govern the human metabolism with nature in a rational way," completely beyond the capabilities of bourgeois society.²

This conceptual framework was important because it allowed Marx to tie together his critique of the three principal emphases of bourgeois political economy: the analysis of the extraction of surplus product from the direct producer; the related theory of capitalist ground rent; and the Malthusian theory of population, which connected the two to each other. Moreover, Marx's concept of metabolic rift in the relation between town

and country, human beings and the earth, allowed him to penetrate to the roots of what historians have sometimes called the "second agricultural revolution," occurring in the capitalism of his day, and the crisis in agriculture with which this was associated, thereby enabling him to develop a critique of environmental degradation that anticipated much of present-day ecological thought. Analytically, Marx's critique of capitalist agriculture passed through two stages: (1) the critique of Malthus and Ricardo (a critique in which James Anderson's analysis played a central role); and (2) a consideration of the second agricultural revolution and the implications of Justus von Liebig's soil chemistry, which compelled Marx to analyze the conditions underlying a sustainable relation to the earth.

Overpopulation and the Conditions of Reproduction of Human Beings

At the heart of Marx's analysis was always his critique of Malthusian population notions, which Malthus had propounded with what Marx called "clerical fanaticism." As Marx was to argue in the *Grundrisse* (1857-1858)—his great preliminary attempt to sketch out his whole critique of political economy—what was at issue here was the extremely complex historical and theoretical problem of "the conditions of reproduction of human beings," in which all human history was distilled, but which occurred under varying conditions in different social formations and different historic epochs.³

Malthus's theory, Marx contended, was significant for two reasons: first, because it gave "brutal expression to the brutal viewpoint of capital"; second, because it "asserted the fact of overpopulation in all forms of society." Although Marx did not deny—indeed he emphasized—the existence of overpopulation in earlier societies, he objected to Malthus's refusal to look at the "specific differences" that this assumed in different social formations at different phases of historical development, and his reduction of all these different cases to one numerical relation based in unchanging natural law. "In this way he transforms the historically distinct relations into an abstract numerical relation, which he has fished purely out of thin air, and which rests neither on natural nor historical laws."

Specifically, by reducing all questions of reproduction to two equations, one for plants and animals used for human subsistence, which Malthus insisted were limited to an arithmetical rate of increase, and the other for human beings, which Malthus claimed tended to grow by geometrical progression (when unchecked), Malthus had, according to Marx, commit-

ted both logical and historical errors. The claim that human population increased geometrically until checked externally (by such natural factors as high infant mortality, disease, and starvation) refused to acknowledge the historical and social character of human reproduction. At the same time Malthus sometimes wrote as if plants and animals had an immanent tendency to be limited to an arithmetical rate of population increase. (Indeed, Malthus initially had no explanation for his arithmetical ratio.) In contrast, Marx suggested, there was no such clear immanent limit to the demographic increase of plants and animals, which were checked only externally. If they encountered no external barrier, "The ferns would cover the entire earth. Their reproduction would stop only where space for them ceased." Hence, Malthus, according to Marx, had erroneously transformed "the immanent, historically changing limits of the human reproduction process into *outer barriers*; and the *outer barriers* [that is, the external checks on the growth of food] into *immanent limits* or *natural laws* of reproduction."

What was important in dealing with the question of overpopulation was the specific historical way it emerged in each case. "In different modes of social production," Marx wrote, "there are different laws of the increase of population and of overpopulation.... How small do the numbers which meant overpopulation for the Athenians appear to us!" Malthus's theory, Marx argued,

abstracts from these specific historic laws of the movement of population, which are indeed the history of the nature of humanity, the *natural laws*, but natural laws of humanity only at a specific historic development.... Malthusian man, abstracted from historically determined man, exists only in his brain; hence also the geometric method of reproduction corresponding to this natural Malthusian man.⁴

Marx sided with Ricardo's criticism of Malthus, in which Ricardo had pointed out that it was not the amount of grain that was most significant in determining overpopulation, that is, the existence of paupers, but rather the amount of employment. But for Marx the point needed to "be conceived more generally, and relates to the *social mediation* as such, through which the individual gains access to the means of his reproduction and creates them; hence it relates to the *conditions of production* and his relation to them." Overpopulation under capitalism was therefore determined not simply by the existence of a relative surplus population of workers seeking employment and thereby means of subsistence; but more fundamentally by the relations of production that made the continual existence of such a relative surplus population necessary for the system.

A fuller critique of Malthus's population theory, however, required, as Marx realized, a critique of the classical theory of differential rent to which it was eventually linked. If Malthus did not offer any genuine explanation for his arithmetical ratio in any of the six editions of his *Essay on Population*, and hence, as Marx was wont to point out, the theory of rent was not "proper to Malthus at all," it is nevertheless true that Malthus was to turn to the classical theory of rent in order to defend his arithmetical ratio at the end of his life in his *A Summary View of the Principle of Population*, and that this was the basis on which classical Malthusianism eventually came to rest.

James Anderson and the Origins of Differential Fertility

Although it is often assumed that Marx simply followed Ricardo in the realm of rent theory and the analysis of agricultural development, he was in fact a sharp critic of this theory for its failure to understand the historical development of the cultivation of the earth or soil. The main weaknesses of the Ricardian theory of rent (sometimes known as the Malthusian/Ricardian theory of rent), in Marx's view, derived from its failure to incorporate a theory of historical development (and the fact that the subsequent historical development of agriculture had made this theory antiquated). In this respect, Marx argued that the work of the real originator of the classical theory of differential rent, the Scottish political economist and gentleman farmer James Anderson (1739–1808), was far superior to that of Malthus and Ricardo.⁵

Anderson developed all of the key theoretical propositions of the classical theory of rent as early as 1777 in *An Enquiry into the Nature of the Corn Laws*, and continued to expand upon this in subsequent works. Rent, he claimed, was a charge for the use of the more fertile soils. The least fertile soils in cultivation generate an income that simply covers the costs of production, while the more fertile soils receive a "certain premium for an exclusive right to cultivate them; which will be greater or smaller according to the more or less fertility of the soil. It is this premium which constitutes what we now call rent; a medium by means of which the expense of cultivating soils of very different degrees of fertility may be reduced to perfect equality."⁶

For Malthus and Ricardo, writing decades later, the source of this differential fertility came to be seen almost entirely in terms of conditions of natural productivity independent of human beings. As Ricardo wrote,

rent could be defined as "that portion of the produce of the earth, which is paid to the landlord for the use of the original and indestructible powers of the soil."⁷ Moreover, Malthus and Ricardo argued—with the presumed backing of natural law—that lands that were naturally the most fertile were the first to be brought into production, and that rising rent on these lands and diminishing agricultural productivity overall were the result of bringing lands of more and more marginal fertility into cultivation, in response to increasing population pressures.

In contrast, Anderson's earlier model had attributed the existence of differential rent primarily to historical changes in soil fertility, rather than to conditions of "absolute fertility." Continual improvement of the soil, through manuring, draining, and irrigating, was possible, and productivity of the least fertile land could rise to a point that brought it much closer to that of the most fertile land; yet the converse was also true, and human beings could degrade the soil. It was such changes in relative productivity of the soil, according to Anderson, that accounted for differential rent—and not the conditions of absolute fertility—as in the later arguments of Malthus and Ricardo.

Where general failures in the improvement of soil fertility occurred, these were largely a consequence, Anderson argued, of the failure to adopt rational and sustainable agricultural practices. The fact that the land in England was owned by landed proprietors and farmed by capitalist tenant farmers, he argued, placed major obstacles in the way of rational agriculture, since the farmer tended to avoid all improvements, the full return for which would not be received during the term of the lease.⁸

In *A Calm Investigation of the Circumstances that have Led to the Present Scarcity of Grain in Britain* (1801), Anderson contended that the growing division between town and country had led to the loss of natural sources of fertilizer. "Every person who has but heard of agriculture," he wrote, "knows that animal manure, when applied to the soil, tends to add to its fertility; of course he must be sensible that every circumstance that tends to deprive the soil of that manure ought to be accounted an uneconomical waste highly deserving of blame." Indeed, it was possible, Anderson contended, by the judicious application of animal and human wastes, to sustain the "soil for ever after, without the addition of any extraneous manures." Yet London, with its gargantuan waste of such natural sources of fertility, "which is daily carried to the Thames, in its passage to which it subjects the people in the lower part of the city to the most offensive effluvia," was an indication of how far society had moved from a sustainable agricultural economy.⁹ Armed with this critical analysis, and a

historical perspective, Anderson directly opposed the Malthusian view that the shortage of grain could be traced to rising human population and its pressures on a limited supply of land.¹⁰

Marx studied Anderson's work as early as 1851, incorporating brief excerpts from two of Anderson's works into his notebooks.¹¹ Writing in the 1850s and 1860s in *Theories of Surplus Value*, his long, three-part exegesis on the development of classical political economy, Marx argued that the core of Anderson's contribution lay in the fact that the latter had historicized the issue of soil fertility. "Anderson by no means assumes ... that different *degrees of fertility* are merely the product of nature." Instead, "the differential rent of the landlords is partly the result of the fertility that the farmer has given the land artificially."¹² Marx originally emphasized the significance of Anderson's model in understanding the possibility of agricultural improvement, and how this was consistent with the theory of differential rent. But it also followed from Anderson's *historical* perspective (as he himself demonstrated in his later writings) that a general decline in soil fertility ought to be attributed, not, as in the Ricardian theory, to decreases in the aggregate productivity of the soil due to the cultivation of marginal lands, but to such factors as the failure to invest in the improvement of the soil due to the class conflict between capitalist tenant farmer and landed proprietor, or the actual impoverishment of the soil associated with the failure to recycle manure (because of the growing division between town and country).¹³

Hence, in combining political economy with agronomy, Anderson developed at the end of the eighteenth century a body of thought that was unusually prescient—foreshadowing the concern with the interrelationship between soil fertility and soil chemistry (as well as such questions as the relationship between town and country, and between landed property and capitalist farming) that was to come to the fore around four decades later as a result of the scientific revolution in soil chemistry. Anderson helped Marx to historicize the problem of capitalist ground rent, while more fully comprehending the conditions of the soil. It was the crisis of soil fertility in European and North American agriculture and the great advances in soil science in Marx's own day which were, however, to allow Marx to transform this historical approach to the question of agricultural improvement into an ecological critique of capitalist agriculture.¹⁴

Anderson not only developed a historically based analysis of rent and agricultural improvement (and degradation); he also emerged at the very end of his life as one of the leading critics of Malthus's 1798 *Essay on Population*. Anderson's *Calm Investigation* was written largely in response to

Malthus's *Essay on Population*—and probably in response as well to Malthus's pamphlet *An Investigation of the Cause of the Present High Price of Provisions* (1800). Anderson sent a copy of the *Calm Investigation* to Malthus, which was probably the latter's first introduction to the work of the former, and Malthus struggled repeatedly to answer Anderson in subsequent editions of his essay. (Marx was to contend that Malthus's acquaintance with the relatively little known work of Anderson, in the area of economics, allowed him to adopt without acknowledgement elements of Anderson's rent theory, without fully understanding it, in his own 1815 *Inquiry into the Nature and Progress of Rent*.)

Anderson's critique of Malthus's arithmetical ratio, which he also presented in the third volume of his *Recreations in Agriculture* (1801), was all the more devastating because in presenting this ratio (that is, the assumption that the rate of increase in food could never go beyond a fixed increment, which he claimed was at best equal to the entire agricultural production for the year 1798) Malthus had offered as "proof" the fact that no knowledgeable observer of agriculture would contradict this. Yet, Anderson, who was certainly one of the most knowledgeable analysts of agriculture in his day, set out to refute Malthus's argument. Indeed, Anderson argued that "if the population of any country shall advance, and if the people in it be chiefly employed in the cultivation of the soil, its productiveness will keep pace with that population, whatever it shall be; and they will have abundance at all times: and this the experience of all nations hath confirmed." Nevertheless, it was possible by the division of town and country, improper cultivation, and the failure to recycle organic wastes to create "an opposite state of progression, until, by a gradual process of deterioration, it [the soil] shall revert nearly to the original point from which it set out"—that is, the benefits of all improvement will have been lost. In this latter case the availability of food could prove insufficient due to the distortions produced within society and in the cultivation of the soil—rather than due to the inherent inadequacies of agriculture. Anderson went on to discuss the degradation of the soil in northern Africa, Sicily, and Italy itself in comparison to Roman times.¹⁵

Liebig, Marx, and the Second Agricultural Revolution

If Anderson's historical approach to the question of agriculture, which emphasized the possibility of improvement (and also degradation), was far superior to that of Malthus and Ricardo that followed, it is nonetheless true that all of these early classical economic theories suffered from the

lack of a scientific understanding of the composition of the soil. This was most evident in Malthus and Ricardo, who relied almost exclusively on a natural law conception. Although it is true that Ricardo recognized the possibility of improvement of the land through better manuring, rotation of crops, and so on, he nevertheless placed little emphasis on this, stressing that the room for improvement was quite limited. His theory saw the properties of the soil as generally fixed. Hence, the failures of agriculture could be attributed almost entirely to the cultivation of inferior grades of land in response to increased demand emanating from increased populations.

Looking back in the mid-1860s at these early theories of agriculture and rent, when he was writing *Capital*, Marx was to place strong emphasis on the historical division separating such analyses from his own time, by observing that "the actual natural causes for the exhaustion of land ... were unknown to any of the economists who wrote about differential rent, on account of the state of agricultural chemistry in their time."¹⁶ Marx made this observation after reading Liebig's assessment, in the seventh edition of his *Organic Chemistry in its Application to Agriculture and Physiology*, of the state of agricultural knowledge prior to 1840, the date at which the first edition of his landmark work had been published. According to Liebig, agricultural knowledge prior to the 1840s had emphasized the role of manure and the "latent power" in the land or soil. Since the chemical properties of the soil were unknown at that time, the nature of plant nutrition was also unknown. Hence, the latent power attributed to the soil was frequently seen as inherently limited and at the same time indestructible. In no way could the real problems of agriculture be ascertained.¹⁷

These observations by Liebig and Marx serve to underscore what some agricultural historians have called "the second agricultural revolution."¹⁸ Although historians often still refer to a single agricultural revolution that occurred in Britain in the seventeenth and eighteenth centuries and that laid the foundations for industrial capitalism, agricultural historians sometimes refer to a second and even a third agricultural revolution. According to this conception, the first revolution was a gradual process taking place over several centuries, connected with the enclosures and the growing centrality of the market; technical changes included improvements in manuring, crop rotation, drainage, and livestock management. In contrast, the second agricultural revolution took place over a shorter period—1830–1880—and was characterized by the growth of a fertilizer industry and the development of soil chemistry, associated in particular with the

work of Justus von Liebig.¹⁹ The third agricultural revolution took place still later, in the twentieth century, and involved the replacement of animal traction with machine traction on the farm, followed by the concentration of animals in massive feedlots, coupled with the genetic alteration of plants (producing narrower monocultures) and the more intensive use of chemical inputs—such as fertilizers and pesticides.²⁰

Marx's critique of capitalist agriculture and his contributions to ecological thought in this area have to be understood therefore in the context of the second agricultural revolution occurring in his time. The beginnings of this revolution correspond closely to the origins of Marx's thought. Already in 1844 in "Outlines for a Critique of Political Economy" Engels had referred to the scientific revolution associated with Liebig as a reason why Malthusian fears about the dearth of food for a growing population were misplaced. At the outset, Marx and Engels, like many other observers in their time, including Liebig himself, responded to this agricultural revolution by concluding that agricultural progress in the immediate future might outpace industry itself. Significantly, one of Marx's notebooks from 1851 opened with excerpts from Liebig, followed by excerpts from Malthus and various anti-Malthusian thinkers, and ended up (except for some very minor extracts that followed) with excerpts from James F.W. Johnston, a British soil chemist, whose work was closely related to that of Liebig. The overwhelming emphasis of Johnston's, as well as Liebig's, work at this time was the possibility of agricultural improvement—which Marx clearly regarded as a refutation of Malthusian assumptions about soil productivity. Yet, this optimistic assessment was to give way in the 1860s, in Marx's analysis—closely reflecting the changing views of Liebig—to a much more sophisticated understanding of ecological degradation within capitalist agriculture.²¹

Liebig and the degradation of the soil

During the nineteenth century the depletion of soil fertility was the chief environmental concern of capitalist society throughout Europe and North America, comparable only to concerns about the growing pollution of the cities, the deforestation of whole continents, and Malthusian fears of overpopulation. The critical nature of this problem of the relation to the soil can be seen quite clearly in the 1820s and 1830s, during the period of outright crisis that engendered the second agricultural revolution. But the problem did not simply end with the science of soil chemistry. Rather there was a growing recognition of the extent to which the new methods had only served to rationalize a process of ecological destruction.

In the 1820s and 1830s in Britain, and soon afterward in the other developing capitalist economies of Europe and North America, pervasive concerns about "soil exhaustion" led to a virtual panic, and a phenomenal increase in the demand for fertilizer. European farmers in this period raided the Napoleonic battlefields of Waterloo and Austerlitz and reportedly dug up catacombs, so desperate were they for bones to spread over their fields. The value of bone imports to Britain skyrocketed from £14,400 in 1823 to £254,600 in 1837. The first boat carrying Peruvian guano (accumulated dung of sea birds) arrived in Liverpool in 1835; by 1841 1,700 tons were imported, and by 1847 220,000.²²

This second agricultural revolution associated with the origins of modern soil science was closely connected to the demand for increased soil fertility to support capitalist agriculture. The British Association for the Advancement of Science commissioned Liebig in 1837 to write a work on the relationship between agriculture and chemistry. The founding of the Royal Agricultural Society of England, a leading organization in the British high farming movement—a movement of wealthy landowners to improve farm management—took place in the following year. Two years later, in 1840, Liebig published his *Organic Chemistry in its Applications to Agriculture and Physiology* (known as his *Agricultural Chemistry*), which provided the first convincing explanation of the role of soil nutrients such as nitrogen, phosphorous, and potassium, in the growth of plants.²³ One of the figures most influenced by Liebig's ideas (as well as a rival whose discoveries challenged Liebig's own) was the wealthy English landowner and agronomist J.B. Lawes. In 1842 Lawes invented a means of making phosphate soluble, enabling him to develop the first agricultural fertilizer, and in 1843 he built a factory for the production of his new "superphosphates." Following the repeal of the Corn Laws in 1846, Liebig's organic chemistry, together with Lawes's new synthetic fertilizer, were seen by the large agricultural interests in Britain as offering the solution to the problem of obtaining larger crop yields.²⁴

Nevertheless, the new technology represented by Lawes's fertilizer factory was slow to diffuse outside of Britain. The first factories for the production of superphosphates were introduced in Germany only in 1855; in the United States only after the Civil War; and in France only after the Franco-Prussian War. Moreover, the results obtained from the application of a single nutrient (such as phosphate) to the soil, though initially producing dramatic results, tended to diminish rapidly after that, since overall soil fertility is always limited by the nutrient in least abundance (Liebig's Law of the Minimum).

Hence, Liebig's discoveries at first only intensified the sense of crisis with capitalist agriculture, making farmers more aware of the depletion of soil minerals and the paucity of fertilizers. Moreover, capital's ability to take advantage of these breakthroughs in soil chemistry was limited by the development of the division of labor inherent in the system, specifically the growing antagonism between town and country. Hence by the 1860s, when he wrote *Capital*, Marx had become convinced of the unsustainable nature of capitalist agriculture, due to two historical developments in his time: (1) the widening sense of crisis in both European and North American agriculture associated with the depletion of the natural fertility of the soil—a sense of crisis which was in no way alleviated, but rather given added impetus, by the breakthroughs in soil science; and (2) a shift in Liebig's own work in the late 1850s and 1860s toward a strong ecological critique of capitalist development.

The contradictions within agriculture in this period were experienced with particular intensity in the United States—especially among farmers in upstate New York and in the Southeastern plantation economy. Blocked from easy, economical access to guano (which was high in both nitrogen and phosphates) by the British monopoly on Peruvian guano supplies, the United States undertook—first unofficially and then as part of a deliberate state policy—the imperial annexation of any islands thought to be rich in this natural fertilizer. Under the authority of what became the Guano Islands Act, passed by Congress in 1856, U.S. capitalists seized ninety-four islands, rocks, and keys around the globe between 1856 and 1903, sixty-six of which were officially recognized by the Department of State as U.S. appurtenances. "In the last ten years," Liebig was to observe in 1862, "British and American ships have searched through all Seas, and there is no small island, no coast, which has escaped their enquiries after guano." Nine of these guano islands remain U.S. possessions today. Yet guano imperialism was unsuccessful in providing the United States with the quantity and quality of natural fertilizer it needed.²⁵

Meanwhile, Peruvian guano supplies had begun to run out in the 1860s and had to be replaced increasingly by Chilean nitrates. Although potassium salts discovered in Europe gave ready access to that mineral, and both natural and artificial supplies of phosphates made that nutrient more available, the limiting factor continued to be fertilizer nitrogen. (Synthetic nitrogen fertilizer was not developed until 1913, when the German chemist Fritz Haber, who was to go on to pioneer in the development of explosives and nerve gases for war production, originated such a process.)

The decline in natural fertility due to the disruption of the soil nutrient cycle accompanying capitalist agriculture, the growing knowledge of the need for specific soil nutrients, and limitations in the supply of both natural and synthetic fertilizers that would compensate for the loss of natural fertility all contributed, therefore, to a widespread sense of a crisis in soil fertility.

In the United States this was further complicated by geographical factors. In upstate New York, which by 1800 had displaced New England as a center for wheat cultivation, the relative exhaustion of the soil was brought into sharp relief by the steadily increasing competition from new farmlands to the West in the decades following the opening of the Erie Canal in 1825. Meanwhile the slave plantations of the Southeast experienced dramatic declines in fertility, particularly on lands devoted to the production of tobacco.

In New York farmers responded to the crisis by promoting a more rational agriculture through the creation of agricultural societies. In 1832 the New York Agricultural Society was formed. Two years later Jesse Buel, an Albany newspaper editor, started the *Cultivator*, which sought to promote the kind of improved farming already being introduced in Britain, concentrating on such issues as manures, draining wet soils, and crop rotation. With the publication of Liebig's *Agricultural Chemistry* in 1840, New York agriculturists turned to the new soil science as a savior. In 1850 the Scottish agricultural chemist James F.W. Johnston, whom Marx was to call "the English Liebig," traveled to North America, and in his influential work *Notes on North America* documented the loss of natural soil fertility, demonstrating in particular the depleted condition of the soil in New York as compared to the more fertile farmlands to the West.²⁶

These issues were embraced in the 1850s by the U.S. political economist Henry Carey (1793-1879). In 1853 Carey observed in *The Slave Trade Domestic and Foreign*—a work that he sent to Marx—that "it is singular that all of the political economists of England have overlooked the fact that man is a mere borrower from the earth, and that when he does not pay his debts, she does as do all other creditors, that is, she expels him from his holding." On January 11, 1855, a young agronomist, George Waring (1833-1898), who began his career in the 1850s as an agriculturist and who later ended up as the leading sanitary engineer in the United States and the principal advocate and practitioner of the cleaning up of cities within the urban conservation movement, delivered a speech, entitled "The Agricultural Features of the Census for 1850," to the New York State Geographical Society in which he tried to demonstrate em-

pirically that the soil was systematically being robbed of its nutrients. That speech was later published in the *Bulletin of the American Geographical and Statistical Association* in 1857. In an important essay in his *Letters to the President, on the Foreign and Domestic Policy of the Union* (1858) Carey quoted extensively from a speech by an "eminent agriculturist" (Waring, in the speech referred to above), who had provided some rough national estimates on the loss of soil nutrients through the shipment of food and fiber over long distances in a one-way movement from country to town. Waring had concluded his argument by declaring:

[W]hat with our earth-butchery and prodigality, we are each year losing the intrinsic essence of our vitality... The question of the economy should be, not how much do we annually produce, but how much of our annual production is saved to the soil. Labor employed in robbing the earth of its capital stock of fertilizing matter, is worse than labor thrown away. In the latter case, it is a loss to the present generation; in the former it becomes an inheritance of poverty for our successors. Man is but a tenant of the soil, and he is guilty of a crime when he reduces its value for other tenants who are to come after him.²⁷

Throughout the late 1840s and 1850s Carey laid stress on the fact that long-distance trade arising from the separation of town and country (and agricultural producer and consumer) was a major factor in the net loss of soil nutrients and the growing crisis in agriculture—a point later developed further by Liebig and Marx.²⁸ "As the whole energies of the country," Carey wrote of the U.S. in his *Principles of Social Science* (1858)—quoting again from Waring—"are given to the enlargement of the trader's power, it is no matter of surprise that its people are everywhere seen employed in 'robbing the earth of its capital stock.'"²⁹

Waring's and Carey's views were to have an important impact on Liebig. In his *Letters on Modern Agriculture* (1859) Liebig repeated the entire statement from the "eminent agriculturist" (Waring) that Carey had included in his *Letters to the President* and went on to argue that the "empirical agriculture" of the trader gave rise to a "spoliation system" in which the "conditions of reproduction" of the soil were undermined. "A field from which something is permanently taken away," he wrote (quoting the practical agriculturalist Albrecht Block), "cannot possibly increase or even continue in its productive power." In fact, "every system of farming based on the spoliation of the land leads to poverty." For Liebig, "rational agriculture, in contradistinction to the spoliation system of farming, is based upon the principle of *restitution*; by giving back to the fields the conditions of their fertility, the farmer insures the permanence of the

latter." English "high farming," he argued, was "not the open system of robbery of the American farmer ... but it is a more refined species of spoliation which at first glance does not look like robbery." Following Carey, Liebig observed that there were hundreds, sometimes thousands, of miles in the United States between the centers of grain cultivation and their markets. The constituent elements of the soil were therefore shipped to locations distant from their points of origin, making the reproduction of soil fertility that much more difficult.³⁰ A few years later Liebig warned somewhat apocalyptically in the famous introduction to the 1862 edition of his *Agricultural Chemistry*, which influenced Marx, that, "if we do not succeed in making the farmer better aware of the conditions under which he produces and in giving him the means necessary for the increase of his output, wars, emigration, famines and epidemics will of necessity create the conditions of a new equilibrium which will undermine the welfare of everyone and finally lead to the ruin of agriculture."³¹ What was needed, Liebig contended at another point in that same work, was the discovery of "deposits of manure or guano ... in volumes approximating to those of the English coalfields."³² Ultimately, it was a question, as Liebig wrote in his *Familiar Letters on Chemistry*, of "the restoration of the elementary constituents of the soil," which had been withdrawn from it by the marketing over long distances of food and fiber and by the removal of cattle.³³

The problem of the depletion of the soil was also tied, according to Liebig, to the pollution of the cities with human and animal wastes. The relation between Liebig's treatment of the soil nutrient cycle and the waste problem in the large cities had already been taken up by Edwin Chadwick as early as 1842 in his *Report on the Sanitary Condition of the Labouring Population of Great Britain*, which started the public health movement and greatly influenced Engels.³⁴ In his influential *Letters on the Subject of the Utilization of the Municipal Sewage* (1865) Liebig himself insisted—relying on an analysis of the condition of the Thames—that organic recycling that would return to the soil the nutrients contained in sewage was an indispensable part of a rational urban-agricultural system. "If it were practicable to collect, without the least loss, all the solid and fluid excrements of the inhabitants of towns," he was to write, "and to return to each farmer the portion arising from produce originally supplied by him to the town, the productiveness of his land might be maintained almost unimpaired for ages to come, and the existing store of mineral elements in every fertile field would be amply sufficient for the wants of the increasing populations."³⁵

Marx's theory of metabolic rift

Marx was deeply affected by Liebig's analysis when writing *Capital* in the early 1860s. In 1866, the year before the first volume of *Capital* was published, he wrote to Engels that in developing his critique of ground rent in volume 3, "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 the economists put together." Indeed, "to have developed from the point of view of natural science the negative, i.e. destructive side of modern agriculture," Marx noted in volume 1 of *Capital*, "is one of Liebig's immortal merits."³⁶

Under the influence of Liebig, whom he studied attentively—making extensive extracts from Liebig's work in his scientific notebooks—Marx was to develop a systematic critique of capitalist "exploitation" (in the sense of robbery, that is, failing to maintain the means of reproduction) of the soil.³⁷ Hence, both of Marx's two main discussions of capitalist agriculture ended with explanations of how large-scale industry and large-scale agriculture combined to impoverish the soil and the worker. Much of this critique was distilled in a remarkable passage at the end of Marx's treatment of "The Genesis of Capitalist Ground Rent" in volume 3 of *Capital*, where he wrote:

Large landed property reduces the agricultural population to an ever decreasing minimum and confronts it with an ever growing industrial population crammed together in large towns; in this way it produces conditions that provoke an irreparable rift in the interdependent process of social metabolism, a metabolism prescribed by the natural laws of life itself. The result of this is a squandering of the vitality of the soil, which is carried by trade far beyond the bounds of a single country. (Liebig.).... Large-scale industry and industrially pursued large-scale agriculture have the same effect. If they are originally distinguished by the fact that the former lays waste and ruins labour-power and thus the natural power of man, whereas the latter does the same to the natural power of the soil, they link up in the later course of development, since the industrial system applied to agriculture also enervates the workers there, while industry and trade for their part provide agriculture with the means of exhausting the soil.³⁸

Marx provided a closely related and equally important distillation of his critique of capitalist agriculture in his discussion of "Large-scale Industry and Agriculture" in volume 1 of *Capital*:

Capitalist production collects the population together in great centres, and causes the urban population to achieve an ever-growing preponderance. This has two results. On the one hand it concentrates the historical motive force of society; on the other hand, it disturbs the metabolic interaction between man and the earth, i.e. it prevents the return to the soil of its constituent elements consumed

by man in the form of food and clothing; hence it hinders the operation of the eternal natural condition for the lasting fertility of the soil.... But by destroying the circumstances surrounding that metabolism ... it compels its systematic restoration as a regulative law of social production, and in a form adequate to the full development of the human race.... [A]ll progress in capitalist agriculture is a progress in the art, not only of robbing the worker, but of robbing the soil; all progress in increasing the fertility of the soil for a given time is a progress toward ruining the more long-lasting sources of that fertility.... Capitalist production, therefore, only develops the technique and the degree of combination of the social process of production by simultaneously undermining the original sources of all wealth—the soil and the worker.³⁹

What is common to both of these passages from Marx's *Capital*—the first ending his discussion of capitalist ground rent in volume 3 and the second concluding his treatment of large-scale agriculture and industry in volume 1—is the central theoretical concept of a “rift” in the “metabolic interaction between man and the earth,” that is, the “social metabolism prescribed by the natural laws of life,” through the “robbing” of the soil of its constituent elements, requiring its “systematic restoration.” This contradiction develops through the growth simultaneously of large-scale industry and large-scale agriculture under capitalism, with the former providing the latter with the means of the intensive exploitation of the soil. Like Liebig, Marx argued that long-distance trade in food and fiber for clothing made the problem of the alienation of the constituent elements of the soil that much more of an “irreparable rift.” For Marx, this was part of the natural course of capitalist development. As he wrote in 1852, “the soil is to be a marketable commodity, and the exploitation of the soil is to be carried on according to the common commercial laws. There are to be manufactures of food as well as manufacturers of twist and cottons, but no longer any lords of the land.”⁴⁰

Moreover, the contradictions associated with this development were global in character. As Marx observed in *Capital*, volume 1, the fact that the “blind desire for profit” had “exhausted the soil” of England could be seen daily in the conditions that “forced the manuring of English fields with guano” imported from Peru.⁴¹ The mere fact that seeds, guano, and so on, were imported “from distant countries,” Marx noted in the *Grundrisse* (1857–1858), indicated that agriculture under capitalism had ceased to be “self-sustaining,” that it “no longer finds the natural conditions of its own production within itself, naturally arisen, spontaneous, and ready to hand, but these exist as an independent industry separate from it.”⁴² A central part of Marx's argument was the thesis that the inherent character of large-scale agriculture under capitalism prevents any truly rational

application of the new science of soil management. Despite all of the scientific and technological development in agriculture, capital was unable to maintain those conditions necessary for the recycling of the constituent elements of the soil.

The key conceptual category in Marx's theoretical analysis in this area is the concept of metabolism (*Stoffwechsel*). The German word "*Stoffwechsel*" directly sets out in its elements the notion of "material exchange" that underlies the notion of structured processes of biological growth and decay captured in the term "metabolism." In his definition of the labor process Marx made the concept of metabolism central to his entire system of analysis by rooting his understanding of the labor process upon it. Thus in his definition of the labor process in general (as opposed to its historically specific manifestations), Marx utilized the concept of metabolism to describe the human relation to nature through labor:

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.... It [the labor process] is the universal condition for the metabolic interaction [*Stoffwechsel*] between man and nature, the everlasting nature-imposed condition of human existence.⁴³

A few years previous to this Marx had written in his *Economic Manuscript of 1861-63* that "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." It followed that the actual activity of labor was never independent of nature's own wealth-creating potential, "since material wealth, the world of use values, exclusively consists of natural materials modified by labour."⁴⁴

Marx utilized the concept of metabolism throughout his mature works, though the context varied. As late as 1880 in his *Notes on Adolph Wagner*, his last economic work, Marx highlighted the centrality of the concept of *Stoffwechsel* to his overall critique of political economy, indicating that "I have employed the word ... for the 'natural' process of production as the material exchange [*Stoffwechsel*] between man and nature." "Interruptions of the formal exchange" in the circulation of commodities, he emphasized, "are later designated as interruptions of the material exchange." The 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. "The chemical process regulated by labour," he wrote, "has everywhere consisted of an exchange of (natural) equivalents." Building on the universal character of material exchange, upon which the formal exchange of economic equivalents in the capitalist economy was a mere alienated expression, Marx referred in the *Grundrisse* to the concept of metabolism (*Stoffwechsel*) in the wider sense of "a system of general social metabolism, of universal relations, of all-round needs and universal capacities ... formed for the first time" under generalized commodity production.⁴⁵

Marx therefore employed the concept both to refer to the actual metabolic interaction between nature and society through human labor (the usual context in which the term was used in his works), and in a wider sense (particularly in the *Grundrisse*) to describe the complex, dynamic, interdependent set of needs and relations brought into being and constantly reproduced in alienated form under capitalism, and the question of human freedom it raised—all of which could be seen as being connected to the way in which the human metabolism with nature was expressed through the concrete organization of human labor. The concept of metabolism thus took on both a specific ecological meaning and a wider social meaning.⁴⁶

Much of Marx's discussion of the metabolic relation between human beings and nature can be seen as building on the early Marx's more directly philosophical attempts to account for the complex interdependence between human beings and nature. In 1844 in his *Economic and Philosophical Manuscripts* Marx had explained that "Man lives from nature, i.e. nature is his body, and he must maintain a continuing dialogue with it if he is not to die. To say that man's physical and mental life is linked to nature simply means that nature is linked to itself, for man is a part of nature."⁴⁷ Marx's later concept of metabolism, however, allowed him to give a more solid and scientific expression of this fundamental relationship, depicting the complex, dynamic interchange between human beings and nature resulting from human labor. The concept of metabolism, with its attendant notions of material exchanges and regulatory action, allowed him 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.

Most importantly, the concept of metabolism provided Marx with a concrete way of expressing the notion of the alienation of nature (and its relation to the alienation of labor) that was central to his critique from his earliest writings on. As he explained in the *Grundrisse*,

It is not the *unity* of living and active humanity with 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 this active existence, a separation which is completely posited only in the relation of wage labour and capital.⁴⁸

Herein was contained the essence of Marx's entire critique of the alienated character of bourgeois society.

According to Tim Hayward, Marx's notion of socio-ecological metabolism

captures fundamental aspects of humans' existence as both natural and physical beings: these include the energetic and material exchanges which occur between human beings and their natural environment ... This metabolism is regulated from the side of nature by natural laws governing the various physical processes involved, and from the side of society by institutionalized norms governing the division of labour and distribution of wealth etc.⁴⁹

Given the centrality that he assigned to the concept of metabolism—constituting the complex, interdependent process linking human beings to nature through labor—it should not surprise us that this concept also plays a central role in Marx's vision of a future society of associated producers: "Freedom in this sphere [the realm of natural necessity]," he wrote in volume 3 of *Capital*, "can consist only in this, that socialized man, the associated producers, govern the human metabolism with nature in a rational way, bringing it under their own collective control instead of being dominated by it as a blind power; accomplishing it with the least expenditure of energy and in conditions most worthy and appropriate for their human nature."⁵⁰

To understand more fully the significance of Marx's use of the concept of metabolism to account for the human-nature relation through social production, it is necessary to look briefly at how this concept emerged. The term "metabolism" (*Stoffwechsel*) was introduced as early as 1815 and was adopted by German physiologists during the 1830s and 1840s to refer primarily to material exchanges within the body, related to respiration. But the term was given a somewhat wider application (and therefore greater currency) by Liebig's use of it in 1842 in his *Animal Chemistry*, the great work that followed his 1840 *Agricultural Chemistry*. In *Animal Chemistry* Liebig introduced the notion of metabolic process in the context of tissue degradation. It was later generalized still further and emerged as one of the key concepts, applicable both at the cellular level and in the analysis of entire organisms, in the development of biochemistry.⁵¹

In Liebig's *Animal Chemistry* the material concept of metabolism was mixed rather inconsistently with the notion of "vital force," in which Liebig hearkened back to an earlier vitalism, identifying physiological motion with unknown, even mystical, sources (imponderables) that could not be reduced to material exchange. (Liebig's contribution here fed into a whole tradition of analysis that has been called "vital materialism," which tried to avoid mechanistic approaches to biochemistry.) His analysis in this respect came under attack in 1845 from the German scientist Julius Robert Mayer, one of the four co-discoverers in the early 1840s of the law of the conservation of energy. In a paper entitled "The Motion of Organisms and their Relation to Metabolism" Mayer argued, in opposition to Liebig, that the notion of "vital force" was unnecessary, and that metabolism (*Stoffwechsel*) was explicable entirely in terms of a scientific materialism emphasizing energetics (the conservation of energy and its exchange). Hence, the whole notion of metabolism came to be linked in this way with the more general shift toward energetics in science, and was thus essential for the development of "quantitative ecology." Marx's own use of the concept in the 1860s in order to explain the relation of human labor to its environment was consistent with this general shift toward energetics in science.⁵²

Nor was this merely fortuitous, since Marx was well aware of these scientific debates. He was a close follower of the work of the British physicist John Tyndall, who championed Mayer's work in the 1860s. Engels was also familiar with Mayer's contributions and the general scientific discussions in this area, no doubt imparting some of this knowledge to Marx. In addition, Marx in 1864 had studied, and was deeply impressed by, the work of the German physiologist Theodor Schwann, who in 1839 had introduced the notion of cellular metabolism, thereby influencing Liebig, Mayer, and others.⁵³

Beginning in the 1840s down to the present day, the concept of metabolism has been used as a key category in the systems theory approach to the interaction of organisms to their environments. It captures the complex biochemical process of metabolic exchange, through which an organism (or a given cell) draws upon materials and energy from its environment and converts these by way of various metabolic reactions into the building blocks of growth. In addition, the concept of metabolism is used to refer to the specific *regulatory processes* that govern this complex interchange between organisms and their environment. Eugene Odum and other leading system ecologists now employ the concept of "metabolism" to refer to all biological levels, starting with the single cell and ending with the ecosystem.⁵⁴

Given all of this, it is somewhat surprising to discover that in his *Concept of Nature in Marx* (1962) Alfred Schmidt claimed that Marx simply took over the German chemist Jakob "Moleschott's theory of metabolism," though not without changing it somewhat. As his evidence for this, Schmidt quoted from a work by Moleschott, authored in 1857, in which Moleschott stated that

The name "metabolism" has been given to this exchange of material [between different forms of life]. We are right not to mention the word without a feeling of reverence. For just as trade is the soul of commerce, the external circulation of material is the soul of the world.... I make no bones about stating this: the pivot about which the wisdom of the present-day world turns is the theory of metabolism.⁵⁵

Yet, Schmidt's inference here, with respect to Moleschott's direct influence on Marx, has little actual basis in logic or evidence. The term "metabolism" (*Stoffwechsel*) was already well established in the scientific literature by the time Moleschott wrote this. Although Marx was aware of Moleschott's work (in London he attended lectures by Moleschott as well as Liebig, Tyndall, and Thomas Huxley), and this may have played into his use of the term, there is no evidence that he took it particularly seriously.⁵⁶ In contrast, Marx studied Liebig closely, and was undoubtedly familiar with his earlier, more influential use of the concept. Moreover, in his use of the concept in *Capital* Marx always stayed close to Liebig's argument, and generally did so within a context that included direct allusions to Liebig's work. Given Moleschott's tendency to shift back and forth between mechanistic materialism and mysticism, Marx is unlikely to have found his analysis congenial.

The widespread use of the concept of metabolism during these decades—a usage that cannot be attributed to any one thinker, although Liebig clearly played an important role—was pointed out by Engels in *Anti-Dühring* (1877–1878). The fact that "metabolism" or "the organic exchange of matter," Engels wrote, "is the most general and characteristic phenomenon of life has been said times without number during the last thirty years by physiological chemists and chemical physiologists." Later he added in *The Dialectics of Nature*—in a discussion of Liebig, Helmholtz, and Tyndall, all of whom had contributed to the shift to energetics in science in the 1840s and 1850s—that "Life is the mode of existence of protein bodies, the essential element of which consists in *continual metabolic interchange with the natural environment outside them*, and which ceases with the cessation of this metabolism, bringing about the decomposition of the protein." (For Engels, such metabolic exchange constituted a

primary condition of life, even in a sense its "definition"—"but neither an exact nor an exhaustive one." Moreover, exchange of matter was also encountered in the absence of life.) There would therefore seem to be no genuine basis for assuming that Marx, in employing this concept in the late 1850s and 1860s, was drawing primarily on Moleschott (or indeed on Moleschott at all).⁵⁷

More peculiar still, Marina Fischer-Kowalski, basing her remarks on Schmidt's interpretation, has stated that, "according to Schmidt, Marx drew much of his understanding of metabolism from this source [Moleschott] and imported a notion of trophical hierarchy, food chains and nutrient cycling rather than an organismic, biochemical interpretation of metabolism." The fact that Marx's analysis in this area was primarily derived from Liebig (and was undoubtedly influenced by Mayer, Tyndall, and Schwann), however, contradicts the claim that his analysis was neither biochemical nor organismic in nature. Indeed, it is undoubtedly a mistake to try to separate issues such as "nutrient cycling" from "the biochemical interpretation of metabolism," as Fischer-Kowalski has done, since the former is part of the metabolic process in the life of organisms. Thus Marx referred to "man's natural metabolism" when discussing the complex, interdependent biochemical process involved in the intake of nutrients and the production of human wastes or excrement.⁵⁸

More usefully, Marina Fischer-Kowalski has recently referred to the concept of metabolism as "a rising conceptual star" within socio-ecological thought because of the emergence of cross-disciplinary research on "industrial metabolism"—dealing with the regulatory processes governing the throughput of materials and energy for a given industrial complex.⁵⁹ Further, the concept of metabolism is frequently employed in a more global context to analyze the material interchange between city and country, in much the same fashion as Liebig and Marx used the concept. For scholars working in these areas, it is now common to recognize, as Fischer-Kowalski has stated, that "within the nineteenth-century foundations of social theory, it was Marx and Engels who applied the term 'metabolism' to society."⁶⁰

Environmental theorists working with the concept of "industrial metabolism" in recent years have often insisted that, just as the materials that birds use to build nests are commonly viewed as material flows associated with the metabolism of birds, so analogous material flows within human production can be seen as constituting part of the human metabolism. For example, Fischer-Kowalski includes "as part of the metabolism of a social system *those material and energetic flows that sustain the material compart-*

ments of the system."⁶¹ Nevertheless, how such a system is regulated, particularly in the case of human society, is the big question. In Marx's case the answer was human labor and its development within historically specific social formations.

Marx's analysis of sustainability

An essential component of the concept of metabolism has always been the notion that it constitutes the basis on which the complex web of interactions necessary to life is sustained, and growth becomes possible. Marx employed the concept of a "rift" in the metabolic relation between human beings and the earth to capture the material estrangement of human beings within capitalist society from the natural conditions which formed the basis for their existence—what he called "the everlasting nature-imposed condition[s] of human existence."

To insist that large-scale capitalist society created such a metabolic rift between human beings and the soil was to argue that the nature-imposed conditions of sustainability had been violated. "Capitalist production," Marx observed, "turns towards the land only after its influence has exhausted it and after it has devastated its natural qualities." Further, this could be viewed in relation not only to the soil but also to the antagonistic relation between town and country. For Marx, like Liebig, the failure to return to the soil the nutrients that had been removed in the form of food and fiber had its counterpart in the pollution of the cities and the irrationality of modern sewerage systems. In the third volume of *Capital* he noted that "In London ... they can do nothing better with the excrement produced by 4 1/2 million people than pollute the Thames with it, at monstrous expense." Engels was no less explicit on this point. In addressing the need to transcend the antagonistic division of labor between town and country in *The Housing Question*, he referred, following Liebig, to the fact that "in London alone a greater quantity of manure than is produced by the whole kingdom of Saxony is poured away every day into the sea with an expenditure of enormous sums." It was therefore necessary, he argued, to reestablish an "intimate connection between industrial and agricultural production" together with "as uniform a distribution as possible of the population over the whole country" (an argument that Marx and Engels had made in *The Communist Manifesto*). Writing in volume 3 of *Capital*, Marx was adamant in insisting that the "excrement produced by man's natural metabolism," along with the waste of industrial production and consumption, needed to be returned to the soil, as part of a complete metabolic cycle.⁶²

For Marx, the metabolic rift associated at the social level with the antagonistic division between town and country was also evident on a more global level: whole colonies saw their land, resources, *and soil* robbed to support the industrialization of the colonizing countries. Following Liebig, who had contended that "Great Britain robs all countries of the conditions of their fertility" and had pointed to Ireland as an extreme example, Marx wrote, "England has indirectly exported the soil of Ireland, without even allowing its cultivators the means for replacing the constituents of the exhausted soil."⁶³

Hence, it is impossible to avoid the conclusion that Marx's view of capitalist agriculture and of the metabolic rift in the nature-imposed relations between human beings and the soil led him to a wider concept of ecological sustainability—a notion that he thought of very limited practical relevance to capitalist society, which was incapable of applying rational scientific methods in this area, but essential for a society of associated producers.

The way that the cultivation of particular crops depends on fluctuations in market prices and the constant changes in cultivation with these price fluctuations—the entire spirit of capitalist production, which is oriented towards the most immediate monetary profits—stands in contradiction to agriculture, which has to concern itself with the whole gamut of permanent conditions of life required by the chain of human generations.⁶⁴

Marx's emphasis on the need to maintain the earth for the sake of "the chain of human generations" (an idea that he had encountered in the early 1840s in Proudhon's *What is Property?*) captured the very essence of the present-day notion of sustainable development, famously defined by the Brundtland Commission as "development which meets the needs of the present without compromising the ability of future generations to meet their needs." Or, as Marx, capturing the same essential idea, put it at another point, the "conscious and rational treatment of the land as permanent communal property" is "the inalienable condition for the existence and reproduction of the chain of human generations."⁶⁵ Indeed, in a truly remarkable passage in *Capital*, 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 the 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].⁶⁶

These issues became increasingly important to Marx near the end of his life, when, as a result of his investigations into the revolutionary potential of the archaic Russian commune, he developed the argument that it would be possible to form an agricultural system "organized on a vast scale and managed by cooperative labor" through the use of modern "agronomic methods" not fully or rationally employed under capitalism. The merit of such a system, he contended, would be that it would be "in a position to incorporate all the positive acquisitions devised by the capitalist system" without falling prey to the purely exploitative relation to the soil, that is, the robbery, that characterized the latter. Marx's focus on the literature of the Russian populists near the end of his life, and his growing conviction that revolution against capitalism would emerge first in Russia—where economic, and more specifically agricultural, abundance could not be taken for granted—compelled him to focus on agricultural underdevelopment, and the ecological requirements of a more rational agricultural system.⁶⁷

Marx did not believe, though such views are commonly attributed to him, that the answer to problems of agricultural development was simply to increase the scale of production. Rather his analysis taught him the dangers of large-scale agriculture, while also teaching him that the main issue was metabolic interaction between human beings and the earth. Hence, agriculture could occur on a fairly large scale only where conditions of sustainability were maintained—something that he believed was impossible under large-scale capitalist agriculture. "The moral of the tale," Marx wrote in volume 3 of *Capital*, "...is that the capitalist system runs counter to a rational agriculture, or that a rational agriculture is incompatible with the capitalist system (even if the latter promotes technical development in agriculture) and needs either small farmers working for themselves or the control of the associated producers." Marx and Engels consistently argued in their writings that large landholders were invariably more destructive in their relation to the earth than free farmers. Thus Engels wrote in *Anti-Dühring* that in North America "the big landlords of the South, with their slaves and their rapacious tilling of the land, exhausted the soil until it could only grow firs."⁶⁸

Although focusing to a considerable extent on the contradictions of the second agricultural revolution and its relation to the antagonistic division between town and country, Marx and Engels's materialist conception of nature meant that they also addressed (though much more briefly) other ecological problems, including the depletion of coal reserves, the destruction of forests, and so on. As Engels noted in a letter to Marx,

"the working individual is not only a stabiliser of the *present* but also, and to a far greater extent, a squanderer of *past*, solar heat. As to what we have done in the way of squandering our reserves of energy, our coal, ore, forests, etc., you are better informed than I am."⁶⁹ Marx himself referred to the "devastating" effects of "deforestation" and viewed this as a long-term, historical result of the exploitative relation to nature that had characterized all civilization, not just capitalism, up to that point: "the development of civilization and industry in general," he wrote, "has always shown itself so active in the destruction of forests that everything that has been done for their conservation and production is completely insignificant in comparison."⁷⁰ Marx also decried the fact that the forests in England were not "true forests" since "the deer in the parks of the great are demure domestic cattle, as fat as London aldermen"; while in Scotland "the so-called "deer forests" that had been set up for the benefit of huntsmen (at the expense of rural laborers) encompassed deer but no trees."⁷¹ Under the influence of the ancient materialists and Darwin, Marx and Engels repudiated the age-old conception that had placed human beings at the center of the natural universe. Thus Engels professed "a withering contempt for the idealistic exaltation of man over the other animals." There is no trace in Marx and Engels of the Cartesian reduction of animals to mere machines.⁷²

In recent years ecological economics has focused heavily on energetics and the entropy law. In this context it has sometimes been argued that Marx and Engels were in error in refusing to acknowledge the importance of energy and material flows for a theory of economic value, in the context of their rejection of the work of the early ecological economist Sergei Podolinsky, who, beginning in 1880, had made some pioneering contributions in this area, and who considered himself a follower of Marx. This criticism has been leveled in particular by Juan Martinez-Alier in a series of works.⁷³

Nevertheless, the entire body of "evidence" offered for this interpretation consists of two letters that Engels wrote to Marx, at the latter's request, assessing Podolinsky's analysis, three months before Marx's death. In these letters Engels accepted the general scientific basis upon which Podolinsky's analysis was erected, but criticized the shortcomings of his analysis of energy transfers, which failed to take into account energy transferred by fertilizers in agriculture and the importance of fossil fuels. In general, Engels believed that the obstacles to calculating accurately the energy transfers involved in economic transactions were so enormous as to make them impractical. This was far from constituting a rejection of the entropy law.

Marx himself never replied to this letter from Engels nor commented on Podlinsky's work, and, given the fact that he died a few months later, even his silence tells us nothing.⁷⁴ If Marx was thus unable to take advantage of Podolinsky's work, however, the same was not true with respect to his incorporation of Liebig's insights into his analysis. Hence, it is significant that some ecological economists have seen Marx's work, in line with Liebig's, as offering the essential elements of a thermodynamic critique of capitalist agriculture.⁷⁵

A more prominent criticism of Marx, deriving from a failure to understand his approach to the question of sustainability, is that he allegedly denied the role of nature in the creation of wealth by constructing a labor theory of value that saw all value derived from nature, and by referring to nature as a "free gift" to capital.⁷⁶ Yet this criticism is based on fundamental misunderstanding of Marx's economics. The idea that the earth was a "gift" of nature to capital was propounded by Malthus long before Marx. Marx, while accepting this as a reality of capitalist production, nonetheless was aware of the social and ecological contradictions embedded in such a view. In his *Economic Manuscript of 1861-63* he repeatedly attacked Malthus for falling back on this "physiocratic notion" that the environment was "a gift of nature to man," while failing to perceive how this was connected to historically specific social relations brought into being by capital.⁷⁷

Nevertheless, this tenet of classical liberal political economy was carried forward into neoclassical economics in the work of the great economic theorist Alfred Marshall and persisted in neoclassical economics textbooks well into the 1980s. Hence the tenth (1987) edition of a widely used introductory textbook in economics by Campbell McConnell states the following: "Land refers to all natural resources—all 'free gifts of nature'—which are usable in the production process." And further along we find: "Land has no production cost; it is a 'free and nonreproducible gift of nature.'"⁷⁸

To be sure, Marx agreed with classical liberal political economy that *under the law of value of capitalism* nature was accorded no value. "The earth," he wrote, "...is active as an agent of production in the production of a use-value, a material product, say wheat. But it has nothing to do with producing the *value of the wheat*."⁷⁹ The *value* of the wheat, as with any commodity under capitalism, arose from labor. For Marx, however, this merely pointed to the very narrow, limited conception of wealth associated with capitalist commodity relations and a system built around exchange value. Genuine wealth, he argued, consisted of use values—the

characteristic of production in general, transcending its specifically capitalist form. Indeed, it was the contradiction between use value and exchange value engendered by capitalism that Marx considered to be one of the foremost contradictions of the entire dialectic of capital. Nature, which contributed to the production of use values, was just as much a source of wealth as labor—even though its contribution to wealth was neglected by the system. Indeed, labor itself was ultimately reducible to such natural properties—a proposition deeply embedded in the materialist tradition going back as far as Epicurus. “What Lucretius says,” Marx wrote in *Capital*, “is self-evident: *nil posse creari de nihilo*, out of nothing, nothing can be created. ‘Creation of value’ is the transposition of labour-power into labour. Labour-power itself is, above all else, the material of nature transformed into a human organism.”⁸⁰

“Nature,” Marx wrote, “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*; the power of knowledge, objectified.” Hence, human beings through their production give new form, that is, actively transform, already existing material nature. “Labour is the living, form-giving fire; it is the transitoriness of things, their temporality, as their formation by living time.”⁸¹ (Here Marx was building on Epicurus’ notion of the transitory nature of things, of matter as mere “embodied time,” as Marx had put it in his doctoral thesis; see Chapter Two above.)

In line with this conception, which took into account both material nature and the transformative role of human labor, Marx insisted that “labour,” as he stated at the beginning of *Capital*, “is not the only source of material wealth, i.e. of the use-values it produces. As William Petty says, labour is the father of material wealth, the earth is its mother.” In the *Critique of the Gotha Programme* Marx offered a trenchant criticism of those socialists such as Ferdinand Lassalle who had attributed what Marx called “*supernatural creative power* to labour” by viewing it as the sole source of wealth and setting aside nature’s contribution.⁸² Under communism, he insisted, wealth would need to be viewed in far more universal terms, as consisting of those material use values that constituted the foundations for the full development of human creativity, “the development of the rich individuality which is all sided in its production as in its consumption”—expanding the wealth of connections allowed for by nature, while at the same time reflecting the complex and changing human metabolism with nature.⁸³

An even more important criticism frequently leveled at Marx in this area is that he had an extremely optimistic, cornucopian view of the conditions that would exist in post-capitalist society due to the development of the forces of production under capitalism. In this interpretation Marx relied so much on the assumption of abundance in his vision of a future society that ecological considerations such as the scarcity of natural resources and external limits to production simply vanished. Thus Alec Nove has contended that Marx believed that "the problem of production had been 'solved'" by capitalism, and that the future society of associated producers would not have to "take seriously the problem of the allocation of scarce resources," which also implied that there was no need for an "ecologically conscious" socialism.⁸⁴

Yet, rather than arguing, as Nove contends, that natural resources were "inexhaustible" and that ecological abundance was simply assured by the development of capitalist forces of production, Marx insisted again and again that capitalism was beset with a chronic problem of production in agriculture, which could ultimately be traced to the unsustainable way in which production was organized. Agriculture in general, Marx argued, "when it progresses spontaneously and is not *consciously controlled* ... leaves deserts behind it—Persia, Mesopotamia, etc., Greece."⁸⁵

Within industry Marx was aware of the enormous waste generated, and stressed the need for the "reduction" and "re-use" of waste, especially in a section of volume 3 of *Capital* entitled "Utilization of the Refuse of Production." Further, he gave every indication that these difficulties would continue to plague any society attempting to construct socialism or communism. Thus, although some critics, such as Andrew McLaughlin, argue that Marx envisioned "a general material abundance as the substratum of communism," and hence saw "no basis for recognizing any interest in the liberation of nature from human domination," this is contradicted by overwhelming evidence from Marx's texts themselves, where he demonstrates a deep concern for issues of ecological limits and sustainability.⁸⁶

Further, there is simply no indication at any point in Marx's vast intellectual corpus that he believed that a sustainable relation to the earth would come about automatically with the transition to socialism. Rather he stressed the need for planning in this area, beginning with measures aimed at the elimination of the antagonistic division of labor between town and country. This included the more even dispersal of population, the integration of industry and agriculture, and the restoration and improvement of the soil through the recycling of soil nutrients. All of this obviously required a revolutionary transformation in the human relation

to the earth. Capitalism, Marx 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.⁸⁷

Toward the society of associated producers

For Marx, capitalism was a class society characterized by an extreme division of the population within society, which was rooted in a no less extreme division of the population from the earth. "All production," under all forms of society, he wrote in the *Grundrisse*, "is appropriation of nature on the part of an individual within and through a specific form of society." Yet, the system of capitalist private property, as distinguished both from communal property and from private property rooted in individual worker-farmer proprietorship over the land, arises through the severing of any direct connection between the mass of the population and the earth—often by forcible removal. Hence, a "presupposition" for the development of capitalist wage labor "is the separation of free labour from the objective conditions of its realization—from the means of labour and the material for labour. Thus, above all, release of the worker from the soil as his natural workshop." The very existence of capital, for Marx, therefore presupposed "a process of history which dissolves the various forms in which the worker is a proprietor, or in which the proprietor works. Thus above all (1) *Dissolution* of the relation to the earth—land and soil—as natural condition of production—to which he relates as to his own organic being.... (2) *Dissolution of the relations* in which he appears as *proprietor*." This dissolution of the organic relation between human labour and the earth took the form of what the classical economists, including Marx, called "original," "primary," or "primitive" accumulation. In this process lay the genesis of the capitalist system.⁸⁸

At the end of *Capital*, volume 1, Marx devoted Part 8 of his book, consisting of eight chapters, to the description of "So-Called Primitive Accumulation," in which he described the lengthy historical process, beginning as early as the fourteenth century, whereby the great mass of the population was removed, often by force, from the soil and "hurled onto the labour-market as free, unprotected and rightless proletarians." Moreover, this historical process of "the expropriation of the agricultural

producer, the peasant," went hand in hand with the genesis of the capitalist farmer and the industrial capitalist.⁸⁹

In England, where this process had reached its highest development at the time that Marx was writing, and which he took therefore as the classic form of primitive accumulation, the nobility, which had metamorphosed early on into a moneyed nobility, made "transformation of arable land into sheep-walks ... its slogan." The process of dispossessing the peasantry took the form of enclosures of common lands, thus separating the free agricultural laborers from the means of their production, turning them into paupers and proletarians who could survive only by selling their labour power in the towns. In developing his critique of this historical movement, Marx gave pride of place to Bacon's criticism of the "depopulating inclosures" in his *The Reign of Henry VII*, and to Thomas More's *Utopia*, where it was said that England was a "curious land where 'sheep ... swallow down the very men themselves.'" The Reformation, and the seizure of church lands, gave new impetus to this whole process. "The Catholic church," at the time of the Reformation, was, Marx remarked, "the feudal proprietor of a great part of the soil of England." With the seizure of church lands, innumerable peasants were driven out. So great was the increase in pauperization that Queen Elizabeth was forced to acknowledge it directly by the introduction of the poor rate—the beginning of the Poor Laws. "In fact, the usurpation of the common lands and the accompanying revolution in agriculture," Marx noted, "had such an acute effect on the agricultural labourers that ... their wages began to fall below the minimum between 1765 and 1780, and to be supplemented by official Poor Law relief."⁹⁰

These changes also spelled the end of the yeomanry, which were, as late as the seventeenth century, much more numerous than the class of farmers, and had constituted the backbone of Cromwell's New Model Army. By the eighteenth century the yeomanry had simply disappeared. Numerous parliamentary "Bills for Inclosure of Commons" were introduced to make lawful the seizure of the common lands. "By the nineteenth century, the very memory of the connection between the agricultural labourer and communal property had ... vanished."⁹¹ The process of enclosure, however, continued into the nineteenth century. "As an example of the method used in the nineteenth century," Marx wrote,

the "clearings" made by the Duchess of Sutherland will suffice here. This person, who had been well instructed in economics, resolved, when she succeeded to the headship of the clan, to undertake a radical economic cure, and to turn the whole county of Sutherland, the population of which had already been reduced

to 15,000 by similar processes, into a sheep-walk. Between 1814 and 1820 these 15,000 inhabitants, about 3,000 families, were systematically hunted and rooted out. All their villages were destroyed and burnt, all their fields turned into pasturage. British soldiers enforced this mass of evictions, and came to blows with the inhabitants. One old woman was burnt to death in the flames of the hut she refused to leave. It was in this manner that this fine lady appropriated 794,000 acres of land which had belonged to the clan from time immemorial. She assigned to the expelled inhabitants some 6,000 acres on the sea-shore—2 acres per family. The 6,000 acres had until this time lain waste, and brought in no income to their owners. The Duchess, in the nobility of her heart, actually went so far as to let these waste lands at an average rent of 2s 6d. per acre to the clansmen, who for centuries had shed their blood for her family. She divided the whole of the stolen land of the clan into twenty-nine huge sheep farms, each inhabited by a single family, for the most part imported English farm-servants. By 1825 the 15,000 Gaels had already been replaced by 131,000 sheep. The remnant of the original inhabitants, who had been flung onto the sea-shore, tried to live by catching fish. They became amphibious, and lived, as an English writer says, half on land and half on water, and withal only half on both.⁹²

All of this meant that it became possible to "incorporate the soil into capital," while creating the necessary army of surplus labor to feed urban industry.⁹³

However, "where," Marx asks, "did the capitalists originally spring from? For the only class created directly by the expropriation of the agricultural peasant is that of the great landed proprietors." Marx divides his answer to this question into two parts: the origin of the capitalist farmer and the origin of the industrial capitalist. The former emerged slowly, and can be said to have emerged out of the earlier form of the bailiff in the second half of the fourteenth century. It is at this point that the landlord begins providing seed, cattle, and farm implements so that the farmer can carry on the real work of agriculture. Eventually this takes the form of the developed system based on ground rent. The whole process was greatly facilitated, moreover, by the agricultural revolution that began in the late fifteenth century, and the enclosures. "The usurpation of the common lands allowed the farmer to augment greatly his stock of cattle, almost without cost, while the cattle themselves yielded a richer supply of manure for the cultivation of the soil."⁹⁴

The degree of the division of labor is, as Adam Smith had pointed out, partly dependent on the extent of the market. For Marx, the "genesis of the industrial capitalist" was a story not so much of English history as of world history. It took place not gradually but all at once. This took the form of the pillage of the non-capitalist world and the creation of the triangle trade of the trans-Atlantic slave system. As Marx famously put it:

The discovery of gold and silver in America, the extirpation, enslavement and entombment in mines of the indigenous population of that continent, the beginnings of the conquest and plunder of India, and the conversion of Africa into a preserve for the commercial hunting of blackskins, are all things which characterize the dawn of the era of capitalist production. These idyllic proceedings are the chief moments of primitive accumulation.⁵⁵

The trade in scalps promoted by the British and the Puritans of New England, the slave trade in Java, the conquest and plunder of India, the opium trade, and so on, were all means in which capital created a world system under its control that extracted wealth and raw materials for capitalist industry for the benefit of Europe, while destroying communal systems of property elsewhere. All of this is part of the larger, global expropriation that provided the primary accumulation for the genesis of industrial capital. Hence, in Marx's words, it was "not without reason" that Carey accused England "of trying to turn every other country into a purely agricultural nation, whose manufacturer is to be England." Within England itself, soon to be known as "the workshop of the world," the change was profound. It transformed "at one pole, the social means of production and subsistence into capital, and at the opposite pole, the mass of the population into wage-labourers, into the free 'labouring poor,' that artificial product of modern history."⁵⁶

Primitive accumulation ("so-called") constitutes the prehistory and the precondition of capital. The metamorphosis that it represents ushers in the system of capitalist appropriation, which rests on the exploitation of alienated, but formally free labor. And from this arises the whole historical tendency of capitalist accumulation—its "immanent laws" of development. For Marx, this is expressed most succinctly in terms of the new laws that govern population itself under these conditions, that is, what he calls the "absolute general law" of capitalist accumulation: the tendency of capitalist class society, built on the exploitation of the proletariat, to polarize so that more and more wealth is concentrated in fewer and fewer hands, while the great mass of the population, kept down by the continual reproduction of an industrial reserve army of the unemployed, finds itself in a situation of relative impoverishment and degradation. As Marx himself puts it:

The greater the social wealth, the functioning capital, the extent and energy of its growth, and therefore also the greater the absolute mass of the proletariat and the productivity of its labor, the greater is the industrial reserve army.... But the greater this reserve army in proportion to the active labour-army, the greater is the mass of a consolidated surplus population, whose misery is in inverse ratio to the amount of torture it has to undergo in the form of labour.

The more extensive, finally, the pauperized sections of the working class and the industrial reserve army, the greater is official pauperism. *This is the absolute general law of capitalist accumulation.* Like all other laws, it is modified in its working by many circumstances, the analysis of which does not concern us here.⁹⁷

In this way Marx points, in the last two parts of volume 1 of *Capital*, to laws of population—though ones very different from the transhistorical (and essentially non-developmental) form which they take in Malthus's theory. The precondition of capitalism is the removal of the mass of the population from the soil, which makes possible the historical development of capital itself. This takes the form of the increasing class polarization of the population between rich and poor, the antagonistic separation of town from country (replicated on a world scale by the fact that some countries are turned into mere agricultural feeding grounds, mere sources of raw materials for the industrial development at the center of the system).

For Marx, all of this was inseparable from, and indeed is a logical outgrowth of, what he called the "*differentia specifica*" of the system of capitalist private property—the fact that it was built on systematic alienation from all forms of naturally based need. Hence, under the artificial regime of capital it is the search for exchange value (that is, profit), rather than the servicing of genuine, universal, natural needs, which constitutes the object, the motive, for production. The resulting extreme polarization between wealth that knows no bounds, at one pole, and an alienated, exploited, degraded existence which constitutes the denial of all that is most human, on the other, creates a contradiction that runs like a fault-line through the capitalist system. Eventually the capitalist "integument" that so distorts and restricts the development of social labor "is burst asunder, the knell of capitalist private property sounds. The expropriators are expropriated."⁹⁸

In all of this, however, Marx continually insists that the alienation from the earth is *sine qua non* of the capitalist system. Thus in his frequently disregarded last chapter to volume 1 of *Capital*, "On the Modern Theory of Colonization," Marx points to Edward Wakefield's theory of colonization, whereby Wakefield argued that the only way in which to maintain a cheap proletarian workforce for industry in the colonies was to find a way of artificially raising the price of the land. Otherwise workers would quickly leave industry for the land and set themselves up as small proprietors. For Marx, this pointed to the contradiction of the separation and estrangement of the population from the land that constituted the foundation on which the whole system of formally free labor rested. The transformation of

property in the land by capital, Marx wrote in the *Grundrisse*, "'clears,' as Steuart says, the land of its excess mouths, tears the children of the earth from the breast on which they were raised, and thus transforms labour on the soil itself, which appears by its nature as the direct wellspring of subsistence, into a mediated source of subsistence, a source purely dependent on social relations." The transformation of capitalism, the abolition of wage labor, and the creation of a society of associated producers thus necessitated the abolition of this alienation of human beings from the earth.⁹⁹

Hence, from the 1840s on, both Marx and Engels insisted on the need to transcend this form of alienation from nature upon which capitalism rested. Always their argument involved the abolition of the antagonistic relation between town and country through the integration of agriculture and industry, the dispersal of population, and what Marx referred to as "the restoration" of the metabolic relation between human beings and the earth. Marx quoted Hippolyte Colins as saying, "It is thanks to the individual appropriation of the soil that there exist men who only possess the strength of their arms.... When you put a man in a vacuum, you rob him of the air. You do the same when you take the soil away from him ... for you are putting him in a space void of wealth, so as to leave him no way of living except according to your wishes."¹⁰⁰

For Engels, following Liebig, the transcendence of the antagonism between town and country was expressed in ecological terms:

Abolition of the antithesis between town and country is not merely possible. It has become a direct necessity of industrial production itself, just as it has become a necessity of agricultural production and, besides, of public health. The present poisoning of the air, water and land can be put an end to only by the fusion of town and country; and only such fusion will change the situation of the masses now languishing in the towns, and enable their excrement to be used for the production of plants instead of for the production of disease.¹⁰¹

Hence, in their conception of a future society Marx and Engels proposed a higher synthesis in the relation between town and country that, as Bertell Ollman has observed, appeared "to involve moving some industries to the country as well as greatly expanding the amount of unencumbered land inside cities for parks, woodlands, and garden plots. I suspect, too, that Marx would like to see the number of people living in any one city reduced, and more small and medium size cities set up throughout the countryside."¹⁰²

The close connection between Marx's vision of communism and ecological sustainability is evident in the utopian conceptions of the acclaimed nineteenth-century English artist, master-craftsperson, designer, poet, and

socialist activist William Morris (1834–1896), who was not only a firm advocate of Marxian socialism but also one of the formative Green thinkers in the English context. In his celebrated utopian novel *News from Nowhere* Morris described a society in which the overthrow of the World Market had led to the demise of wasteful forms of economic production geared to artificial necessities for the sake of profit, and the subsequent reorganization of production in such a way that “nothing *can* be made but for genuine use.” Free time for the pursuit of intellectual inquiry and independent craftsmanship was more readily available—because society had given up its narrowly defined, instrumentalist ends—whereas work itself was seen as serving the needs of both human creativity and the fulfillment of social needs. In this postrevolutionary utopian social order, Morris wrote in the spirit of Marx, “the difference between town and country grew less and less.” Initially, following the revolution, people had flocked from town to country but “yielded to the influence of their surroundings, and became country people”—with the population of the country more numerous than that of the towns. England in the nineteenth century, it was explained, had become “a country of huge and foul workshops, and fouler ganbbling-dens, surrounded by an ill-kept, poverty-stricken farm, pillaged by the masters of workshops. It is now a garden, where nothing is wasted and nothing is spoilt, with the necessary dwellings, sheds, and workshops scattered up and down the country, all trim and neat and pretty.” The existence of this garden did not, however, preclude the preservation of wilderness areas, which were maintained for their intrinsic value. Population, meanwhile, had stabilized and been spread about (part of the program enunciated by Marx and Engels in *The Communist Manifesto*).¹⁰³

Morris's vision, so close to that of Marx (whom he read and reread), reminds us of the fully revolutionary character of Marx's analysis, which, from his very earliest writings on, took account of the alienation of human beings from the earth under capitalism, as a precondition for alienation within the regime of capital accumulation. Marx never moved very far in this respect from the Epicurean notions that nothing came from nothing and nothing could be reduced to nothing, that is, that all human production involved the transformation and conservation of matter.¹⁰⁴ Likewise he adhered consistently to the proposition, arising from this analysis, that the land needed to be conserved and cultivated—for the sake of future generations. These constituted naturally imposed conditions of human production and existence, and the most general expression of the alienation of capitalism from the conditions of production in general. The revolution

against capitalism required therefore not only the overturning of its specific relations of exploitation of labor, but also the transcendence—through the rational regulation of the metabolic relation between human beings and nature by means of modern science and industry—of the alienation from the earth: the ultimate foundation/precondition for capitalism. Only in these terms does Marx's frequent call for the "abolition of wage labor" make any sense.

- Up-to-Date is the ‘Communist Manifesto?’” *Monthly Review*, vol. 50, no. 6 (November 1998), 20.
84. Francis Bacon, *Novum Organum* (Chicago: Open Court, 1994), 43.
85. Marx and Engels, *The Communist Manifesto*, 11.

5. The Metabolism of Nature and Society

1. The following analysis does not address, except tangentially, the relation of Marx’s economic-value analysis in *Capital* to his conception of nature since this has already been accomplished by Paul Burkett in his *magnum opus*, *Marx and Nature: A Red and Green Perspective* (New York: St. Martin’s Press, 1999). Rather the concern here is with the more direct ecological analysis in *Capital*, associated with the concepts of metabolic rift and sustainability—and the relation of these to Marx’s materialist conceptions of nature and history. For a greater understanding of how the argument here relates to Marx’s critique of political economy the reader is therefore encouraged to turn to Burkett’s book.
2. Karl Marx, *Capital*, vol. 1 (New York: Vintage, 1976), 283; Karl Marx, *Capital*, vol. 3 (New York: Vintage, 1981), 949–50, 959.
3. Karl Marx, *Grundrisse* (New York: Vintage, 1973), 604–8.
4. *Ibid.*
5. On Anderson’s origination of the classical rent theory, see Joseph A. Schumpeter, *A History of Economic Analysis* (New York: Oxford University Press, 1951), 263–66.
6. James Anderson, *An Enquiry into the Nature of the Corn Laws; with a View to the New Corn Bill Proposed for Scotland* (Edinburgh: Mrs. Mundell, 1777), 45–50, and *Observations on the Means of Exciting a Spirit of National Industry* (Edinburgh: T. Cadell, 1777), 376.
7. David Ricardo, *Principles of Political Economy and Taxation* (Cambridge: Cambridge University Press, 1951), 67.
8. James Anderson, *Essays Relating to Agriculture and Rural Affairs* (London: John Bell, 1796), vol. 3, 97–135. The conflict between tenant farmer and landed proprietor over investment in agricultural improvements, which was to become a central element of Marx’s critique of capitalist agriculture in Britain, was already visible in Engels’s 1844 “Outlines.” See Friedrich Engels, “Outlines of a Critique of Political Economy,” in Karl Marx, *Economic and Philosophical Manuscripts of 1844* (New York: International Publishers, 1964), 209–10.
9. James Anderson, *A Calm Investigation of the Circumstances that Have Led to the Present Scarcity of Grain in Great Britain: Suggesting the Means of Alleviating that Evil, and Preventing the Recurrence of such a Calamity in the Future* (London: John Cumming, 1801), 73–75.
10. *Ibid.*, 12, 56–64; Edwin Cannan, *A History of Theories of Production and Distribution in English Political Economy from 1776 to 1848* (New York: Augustus M. Kelley, 1967), 114–15.
11. Karl Marx and Friedrich Engels, *Historisch-Kritische Gesamtausgabe (MEGA)*, part 4, vol. 9 (Berlin: Dietz Verlag, 1991)
12. Karl Marx, *Theories of Surplus Value*, part 2 (Moscow: Progress Publishers, 1968), 147–48.

13. Anderson, *Essays Relating to Agriculture*, vol. 3, 97-135; Marx, *Capital*, vol. 3, 757; Marx, *Theories of Surplus Value*, part 2, 244.
14. Given the general neglect of Anderson's work, even in the nineteenth century, it is interesting to note that not only Marx but Darwin too drew extensively on Anderson—in Darwin's case Anderson was regarded as a reliable source of information on animal breeding and heredity, and was frequently cited in Darwin's *The Variation of Animals and Plants under Domestication*. See Charles F. Mullett, "A Village Aristotle and the Harmony of Interests: James Anderson (1739-1808) of Monks Hill," *The Journal of British Studies*, vol. 8, no. 1 (1968), 94-118.
15. James Anderson, *Recreations in Agriculture, Natural-History, Arts, and Miscellaneous Literature* (London: T. Bentley, 1801), vol. 4, 376-80.
16. Marx, *Capital*, vol. 3, 915-16. This point was prefigured by Marx (also on the basis of Liebig) in the *Grundrisse*, 754.
17. See the detailed summary and set of extracts from Liebig's long introduction to the seventh (1862) edition of his *Organic Chemistry in its Application to Chemistry and Physiology* in *The Chemical News*, vol. 7, no. 182 (May 30, 1863), 256-58; also vol. 7, no. 183 (June 6, 1863), 268-70; vol. 7, no. 165 (June 20, 1863), 292-94; vol. 7, no. 186 (June 27, 1863), 302-5. Translations of the "Preface" and "Introduction" to the seventh edition of Liebig's great work on agricultural chemistry were not published in English, even though all the rest of the book eventually was, and even though all of Liebig's previous editions had been issued in English only months after their appearance in German. The reason was that this "Introduction" (or "Einleitung") was seen as too critical of English high farming. The English publisher of Liebig's works actually destroyed the copy in his possession. (See William H. Brock, *Justus von Liebig* [Cambridge: Cambridge University Press, 1997], 177). Consequently, the only published translations in English were the lengthy excerpts in *The Chemical News* referred to above. An unpublished translation of the "Einleitung," however, was produced by Lady Gilbert, the wife of one of England's most distinguished agricultural chemists, Henry Gilbert, in January 1863, and has been maintained for many years in the archives of the Rothamsted Experimental Station (now IACR-Rothamsted) in Hertfordshire. This manuscript has been provided to me courtesy of the Institute Librarian, Mrs. S.E. Allsopp. In what follows I occasionally refer to this archival manuscript, cited as Liebig, "Einleitung." For the published version in German, see Justus von Liebig, *Die Chemie in ihrer Anwendung auf Agricultur und Physiologie*, vol. 1 (Brunswick, 1862), 1-156.
18. F.M.L. Thompson, "The Second Agricultural Revolution, 1815-1880," *Economic History Review*, vol. 21, no. 1 (1968), 62-77. Some parts of the subsequent discussion in this section have been developed previously in my article "Marx's Theory of Metabolic Rift: Classical Foundations for Environmental Sociology," *American Journal of Sociology*, vol. 104, no. 2 (September 1999), 373-78.
19. The classic argument for this is Thompson's "Second Agricultural Revolution," see previous note. Thompson stipulates that the second agricultural revolution occurred over the years 1815-1880, that is, beginning with the agricultural crisis that immediately followed the Napoleonic Wars (and which was the setting in which Malthus and Ricardo discussed the issue of differential rent).

- I have narrowed this down to 1830-1880 in order to distinguish the crisis that preceded the second agricultural revolution from that revolution proper, for which the turning points were the British Association for the Advancement of Science's commissioning of a work on the application of chemistry to agriculture from Liebig in 1837, the publication of his *Agricultural Chemistry* in 1840, and J.B. Lawes's building of the first factory for the production of synthetic fertilizer a few years later.
20. If the first agricultural revolution was bound up with the origins of capitalism (as Ellen Meiksins Wood has argued), the second agricultural revolution was bound up with the shift to industrial capitalism, and the third agricultural revolution with the rise of monopoly capitalism. See Wood, *The Origin of Capitalism* (New York: Monthly Review Press, 1999); and Fred Magdoff, Fred Buttel, and John Bellamy Foster, eds., *Hungry for Profit* (New York: Monthly Review Press, 1999).
 21. Marx and Engels, *Historisch-Kritische Gesamtausgabe (MEGA)*, part 4, vol. 9, 199-324. Marx's excerpts in his notebooks from Liebig and Johnston on agricultural chemistry and geology during the period 1850-1853 were very extensive. The extracts from Liebig take up around forty pages in *MEGA* (ibid., 172-213), while his extracts from Johnston take up around fifty-five pages (ibid., 276-317, 372-86).
 22. Lord Ernle, *English Farming Past and Present* (Chicago: Quadrangle, 1961), 369; Daniel Hillel, *Out of the Earth* (Berkeley: University of California Press, 1991), 131-32. Liebig contended that "the battle-fields of Leipzig, Waterloo and the Crimea" had been raided for bones. Liebig, "Einleitung," 85.
 23. This work is sometimes known as *Agricultural Chemistry* to distinguish it from Liebig's *Animal Chemistry* (1842), the title of which also referred to *Organic Chemistry*. In the following discussion *Agricultural Chemistry* (following this convention) is used as the short title for his first work on agriculture—primarily dealing with plants; while the title *Animal Chemistry* is used for his 1842 work on animal physiology and pathology.
 24. Brock, *Justus von Liebig*, 149-50.
 25. J.M. Skaggs, *The Great Guano Rush* (New York: St. Martin's Press, 1994) 225; Liebig, "Einleitung," 79.
 26. Margaret W. Rossiter, *The Emergence of Agricultural Science: Justus Liebig and the Americans, 1840-1880* (New Haven, Conn.: Yale University Press, 1975), 3-9; Karl Marx and Friedrich Engels, *Collected Works* (New York: International Publishers, 1975), vol. 38, 476; James F.W. Johnston, *Notes on North America* (London: William Blackwood & Sons, 1851), vol. 1, 356-65; Marx, *Capital*, vol. 3, 808.
 27. George E. Waring, Jr., "The Agricultural Features of the Census of the United States for 1850," *Bulletin of the American Geographical and Statistical Association*, vol. 2 (1857), 189-202 (reprinted in *Organization & Environment*, vol. 12, no. 3 [September 1999], 298-307); Henry Carey, *Letters to the President on the Foreign and Domestic Policy of the Union and its Effects as Exhibited in the Condition of the People and the State* (Philadelphia: M. Polock, 1858), 54-55. For a general assessment of Waring's work, see John Bellamy Foster, "Robbing the Earth of its Capital Stock," *Organization & Environment*, vol. 12, no. 3 (September 1999), 293-97.
 28. Henry Carey, *The Past, Present and Future* (New York: Augustus M. Kelley,

- 1967), 298-99, 304-08; originally published in 1847.
29. Henry Carey, *Principles of Social Science* (Philadelphia: J.B. Lippincott, 1867), vol. 2, 215, and *The Past, Present and Future*, 298-99, 304-8. Marx's relation to Carey was complex. By 1853 Marx had read all of Carey's major works up to that date, including *The Slave Trade Domestic and Foreign*, which Carey himself sent to Marx. Yet, he did not read Carey's *Principles of Social Science*, probably his most important work, until 1869, more than a decade after it was published. Marx was generally highly critical of Carey, whom he viewed as a "harmonizer" and as an indifferent economist. But he found his work useful in certain respects. Both Carey and Marx made similar points about the degradation of the soil and its relation to long distance trade and the urban-rural division; both relied extensively on the work of Liebig; both were highly critical of the Malthusian-Ricardian rent theory. Furthermore, Marx saw Carey as one of the main exponents (along with James Anderson) of the crucial concept of "earth-capital" (capital associated with human "improvements" on nature and thus part of the value calculus—a concept that Marx distinguished from earth-matter). On Marx's views on Carey, see especially Marx and Engels, *Selected Correspondence* (Moscow: Progress Publishers, 1975), 78-79, 212-15 (Marx to Engels, June 14, 1853; Marx to Engels, November 26, 1869); Marx, *Grundrisse*, 883-93. Marx, it is worth adding, had some influence on Carey, since in his work on the slave trade Carey quoted extensively in two places from Marx's writing in the *New York Daily Tribune*. The most detailed discussion of Marx's relationship to Carey is to be found in Michael Perelman, "Political Economy and the Press: Karl Marx and Henry Carey at the *New York Tribune*," Discussion Paper Series, no. 85-9, School of Behavioral and Social Sciences, California State University, Chico, 1985. Perelman demonstrates that Marx's famous articles on British rule in India in the *Tribune*, which have frequently been seen as advocating the thesis that imperialism was playing a progressive role by promoting industrialization in the periphery, were written expressly to counter Carey's entirely negative interpretation of Britain's international role and part of a struggle to gain theoretical hegemony within the *Tribune* itself. For a balanced assessment of Carey, see Schumpeter, *History of Economic Analysis*, 515-19. For a recent detailed treatment, see Michael Perelman, "Henry Carey's Political-Ecological Economics," *Organization & Environment*, vol. 12, no. 3 (September 1999), 280-92.
 30. Justus von Liebig, *Letters on Modern Agriculture* (London: Walton & Maberly, 1859), 175-78, 183, 220.
 31. Liebig, quoted in K. William Kapp, *The Social Costs of Private Enterprise* (New York: Schocken Books, 1971), 35.
 32. Liebig, quoted in Karl Kautsky, *The Agrarian Question* (London: Zwan, 1988), vol. 1, 53; Liebig, "Einleitung," 80.
 33. Justus von Liebig, *Familiar Letters on Chemistry*, (Philadelphia: T.B. Peterson, 1852), 44. Published as part of *Complete Works on Chemistry* (comprising a number of separate works bound under a single cover).
 34. Edwin Chadwick, *Report on the Sanitary Condition of the Labouring Population of Great Britain* (Edinburgh: Edinburgh University Press, 1965), 121-22; Friedrich Engels, *The Condition of the Working Class in England* (Chicago: Academy Press, 1969).

35. Justus von Liebig, *Letters on the Subject of the Utilization of the Metropolitan Sewage* (London: W.H. Collingridge, 1865); Justus von Liebig, *The Natural Laws of Husbandry* (New York: D. Appleton, 1863), 261.
36. Marx and Engels, *Collected Works*, vol. 42, 227; Marx, *Capital*, vol. 1, 638.
37. Marx's notebooks contain extensive extracts from two works by Liebig, including his *Agricultural Chemistry*, three works from the English soil scientist James F.W. Johnston, and numerous works in geology, including Charles Lyell's *Principles of Geology*. See E. Coleman, "Short Communication on the Unpublished Writings of Karl Marx Dealing with Mathematics, the Natural Sciences and Technology and the History of these Subjects," in Nikolai Bukharin et al., *Science at the Cross Roads: Papers Presented at the International Congress of the History of Science and Technology, 1931* (London: Frank Cass, 1971), 233-34.
38. Marx, *Capital*, vol. 3, 949-50.
39. Marx, *Capital*, vol. 1, 637-38. The need for the "restoration" of the constituents of the soil was a point that Marx took directly from Liebig's "Introduction" to the 1862 edition of his *Agricultural Chemistry*. Liebig, "Einleitung," 97.
40. Marx and Engels, *Collected Works*, vol. 11, 333.
41. Marx, *Capital*, vol. 1, 348.
42. Marx, *Grundrisse*, 527.
43. Marx, *Capital*, vol. 1, 283, 290.
44. Marx and Engels, *Collected Works*, vol. 30, 40.
45. Karl Marx, *Texts on Method* (Oxford: Basil Blackwell, 1975), 209; Marx, *Grundrisse*, 158, 361. Adolph Wagner had employed the concept of *Stoffwechsel* after Marx to argue that "The operation of the economic system leads necessarily to a continuous *exchange*, analogous in fact to the natural material exchange in the (natural) components of the mass of goods which are at the disposal of the economic system at a given time." Marx saw this as reflecting his views, which Wagner had quite likely lifted without attribution from his work. Marx, *Texts on Method*, 109.
46. The wider, social understanding of metabolism, drawn from the *Grundrisse*, has been powerfully developed by István Mészáros in *Beyond Capital* (New York: Monthly Review Press, 1995).
47. Karl Marx, *Early Writings* (New York: Vintage, 1974), 328.
48. Marx, *Grundrisse*, 489.
49. Tim Hayward, *Ecological Thought* (Cambridge: Polity, 1994), 116.
50. Marx, *Capital*, vol. 3, 959.
51. Justus von Liebig, *Animal Chemistry or Organic Chemistry in its Application to Physiology and Pathology* (New York: Johnson Reprint, 1964); Franklin C. Bing, "The History of the Word 'Metabolism,'" *Journal of the History of Medicine and Allied Arts*, vol. 26, no. 2 (April 1971), 158-80; Brock, *Justus von Liebig*, 193; Kenneth Caneva, *Robert Mayer and the Conservation of Energy* (Princeton, N.J.: Princeton University Press, 1993), 117.
52. Julius Robert Mayer, "The Motions of Organisms and their Relation to Metabolism," in Robert Bruce Lindsay, ed., *Julius Robert Mayer: Prophet of Energy* (New York: Pergamon, 1973), 75-145; Caneva, *Robert Mayer and the Conservation of Energy*, 262-65; Brock, *Justus von Liebig*, 312-13; Juan Martinez-Alier, *Ecological Economics* (Oxford: Basil Blackwell, 1987), 110. On "vital

- materialism," see Timothy Lenoir, *The Strategy of Life: Teleology and Mechanics in Nineteenth Century German Biology* (Boston: D. Reidel Publishing Co., 1982). Thomas Hall gives two reasons for seeing Liebig as a "vital materialist" rather than a vitalist: (1) the contention that behind the "vital force" lay chemical processes (to which the former was not however reducible); (2) the emergence of his "vital force" out of ordinary matter—suggesting an "emergentist" argument. Thomas S. Hall, *Ideas of Life and Matter: Studies in the History of General Physiology 600 B.C. to 1900 A.D.* (Chicago: University of Chicago Press, 1969), vol. 2, 269-71.
53. Y.M. Uranovsky, "Marxism and Natural Science," in Nikolai Bukharin et al., *Marxism and Modern Thought* (New York: Harcourt, Brace, 1935), 140; Lindsay, *Julius Robert Mayer*, 11-12; Hal Draper, *The Marx-Engels Glossary* (New York: Schocken Books, 1986), 189.
 54. Marina Fischer-Kowalski, "Society's Metabolism," in Michael Redclift and Graham Woodgate, ed., *International Handbook of Environmental Sociology* (Northampton, Mass.: Edward Elgar, 1997), 120; Eugene Odum, "The Strategy of Ecosystem Development," *Science*, vol. 164 (1969), 262-70.
 55. Alfred Schmidt, *The Concept of Nature in Marx* (London: New Left Books, 1971), 86-88.
 56. Paul Heyer, *Nature, Human Nature, and Society: Marx, Darwin and the Human Sciences* (Westport, Conn.: Greenwood Press, 1982), 12. Schmidt, it should be noted, acknowledges in a footnote that Liebig had applied the concept of metabolism to the social sphere, in his *Chemische Briefe*, as early as 1851, before Moleschott. Schmidt, *The Concept of Nature in Marx*, 218.
 57. Friedrich Engels, *Anti-Dühring* (Moscow: Progress Publishers, 1969), 99; Marx and Engels, *Collected Works*, vol. 25, 578-79, 601. The main context of Engels's discussion here was a critique of Liebig's speculation on the origins of life, which saw life as existing as long as matter.
 58. Fischer-Kowalski, "Society's Metabolism," 133; Marx, *Capital*, vol. 3, 195.
 59. Fischer-Kowalski, "Society's Metabolism," 119-20.
 60. *Ibid.*, 122.
 61. *Ibid.*, 121, 131.
 62. Karl Marx, *Theories of Surplus Value*, part 3 (Moscow: Progress Publishers, 1971), 301; Marx, *Capital*, vol. 3, 195; Engels, *The Housing Question* (Moscow: Progress Publishers, 1975), 92.
 63. Marx, *Capital*, vol. 1, 860; Liebig, "Einleitung," 85.
 64. Marx, *Capital*, vol. 3, 754.
 65. *Ibid.*, 948-49.
 66. *Ibid.*, 911.
 67. Marx and Engels, *Collected Works*, vol. 24, 356. See also Teodor Shanin, ed., *Late Marx and the Russian Road* (New York: Monthly Review Press, 1983).
 68. Marx, *Capital*, vol. 3, 216; Engels, *Anti-Dühring*, 211-13. Engels did not attribute the destruction of the soil resulting from large estates simply to capitalism but also mentioned its role in the Roman era, citing Pliny.
 69. Marx and Engels, *Collected Works*, vol. 46, 411.
 70. Marx and Engels, *Collected Works*, vol. 42, 559; Karl Marx, *Capital*, vol. 2 (New York: Vintage, 1978), 322.
 71. Marx, *Capital*, vol. 1, 892-93.
 72. Marx and Engels, *Selected Correspondence*, 102.

73. Juan Martinez-Alier and J.M. Naredo, "A Marxist Precursor of Energy Economics: Podolinsky," *Journal of Peasant Studies*, vol. 9, no. 2 (1982), 207-24; Juan Martinez-Alier, *Ecological Economics* (Cambridge, Mass.: Basil Blackwell, 1987), 45-63, and "Political Ecology, Distributional Conflicts and Economic Incommensurability," *New Left Review*, no. 211 (May-June 1995), 71.
74. Marx and Engels, *Collected Works*, vol. 46, 410-13. See also Burkett, *Marx and Nature*, 131-32.
75. Kozo Mayumi, "Temporary Emancipation from the Land," *Ecological Economics*, vol. 4, no. 1 (1991), 35-56.
76. See Jean-Paul Deléage, "Eco-Marxist Critique of Political Economy," in Martin O'Connor, ed., *Is Capitalism Sustainable?* (New York: Guilford, 1994), 48; Ward Churchill, *From a Native Son* (Boston: South End Press, 1996), 467-68; Nicholas Georgescu-Roegen, *The Entropy Law in the Economic Process* (Cambridge, Mass.: Harvard University Press, 1971), 2. For a powerful response to these criticisms closely related to the one that follows, see Burkett, *Marx and Nature*, 79-98.
77. Thomas Malthus, *Pamphlets* (New York: Augustus M. Kelley, 1970), 185; Marx and Engels, *Collected Works*, vol. 34, 151-59.
78. Campbell McConnell, *Economics* (New York: McGraw Hill, 1987), 20, 672; Alfred Marshall, *Principles of Economics* (London: Macmillan, 1920).
79. Marx, *Capital*, vol. 3, 955.
80. Marx, *Capital*, vol. 1, 323; Lucretius, *On the Nature of the Universe* (Harmondsworth: Penguin Books, 1994), 13-14 (1.145-60).
81. Marx, *Grundrisse*, 706, 361. Marx's reference here to labor as "form-giving fire" can also be seen as related to what he frequently referred to in *Capital* as labor's "vital force." In this respect he seems to have adopted Liebig's notion of "vital force" as life-as-action, actively transforming matter and creating new organizational forms. This was consistent with Marx's own "emergentist" approach. See Hall, *Ideas of Life and Matter*, 269-71.
82. Marx, *Capital*, vol. 1, 134; Karl Marx, *Critique of the Gotha Programme* (Moscow: Progress Publishers, 1971), 11.
83. Marx, *Grundrisse*, 325; see also Michael Lebowitz, *Beyond Capital* (New York: St. Martin's Press, 1992), 96-100.
84. Alec Nove, "Socialism," in John Eatwell, Murray Milgate, and Paul Newman, eds., *The New Palgrave Dictionary of Economics*, vol. 4 (New York: Stockton Press, 1987), 399.
85. *Ibid.*; Marx and Engels, *Selected Correspondence*, 190.
86. Marx, *Capital*, vol. 3, 195-97; Andrew McLaughlin, "Ecology, Capitalism, and Socialism," *Socialism and Democracy*, vol. 10 (1990), 69-102.
87. Karl Marx and Friedrich Engels, *The Communist Manifesto* (New York: Monthly Review Press, 1998), 40; Marx, *Capital*, vol. 1, 637-38, and *Capital*, vol. 3, 959.
88. Marx, *Grundrisse*, 87, 471, 497.
89. Marx, *Capital*, vol. 1, 873-76.
90. *Ibid.*, 877-88.
91. *Ibid.*, 885-90.
92. *Ibid.*, 891-92.
93. *Ibid.*, 895.
94. *Ibid.*, 905-6.

95. *Ibid.*, 915.
96. *Ibid.*, 912, 925.
97. *Ibid.*, 798.
98. *Ibid.*, 769, 929.
99. *Ibid.*, 931–40; Marx, *Grundrisse*, 276. Marx had taken extensive extracts from Wakefield with vertical markings in the margins emphasizing precisely these points in his notebooks of 1850–1853. See Marx and Engels, *MEGA*, part 4, vol. 9, 486–91.
100. Marx, *Capital*, vol. 1, 939.
101. Engels, *Anti-Dühring*, 351–52.
102. Bertell Ollman, *Social and Sexual Revolution* (Boston: South End Press, 1979), 56–57.
103. William Morris, *News from Nowhere and Selected Writings and Designs* (Harmondsworth: Penguin Books, 1962), 244–46, 267; William Morris, “Three Letters on Epping Forest,” *Organization & Environment*, vol. 11, no. 1 (March 1998), 93–97.
104. Lucretius, *The Nature of the Universe*, 13–15 (1.145–225).

6. The Basis in Natural History for Our View

1. The term “tormented evolutionist” is taken from Adrian Desmond and James Moore, *Darwin: The Life of a Tormented Evolutionist* (New York: W.W. Norton, 1991). The term “reluctant revolutionary”—also used to describe Darwin—is taken from Michael Rose, *Darwin’s Spectre* (Princeton, N.J.: Princeton University Press, 1998).
2. In this respect Alfred Russell Wallace, as a socialist, did not face the same dilemma as Darwin.
3. Desmond and Moore, *Darwin*, 291–98.
4. *Ibid.*, 296.
5. Rose, *Darwin’s Spectre*, 49–50; Paul B. Sears, *Charles Darwin: The Naturalist as a Cultural Force* (New York: Charles Scribner’s Sons, 1950), 20; Henry Fairfield Osborn, *From the Greeks to Darwin* (New York: Charles Scribner’s Sons, 1927), 37–43, 57–63. Similar to Sears, but less far-reaching, Ernst Mayr contends that, “Nothing of any real consequence happened after Lucretius and Galen until the Renaissance.” Mayr, *The Growth of Biological Thought* (Cambridge, Mass.: Harvard University Press, 1982), 91.
6. Ernst Mayr, *One Long Argument: Charles Darwin and the Genesis of Modern Evolutionary Thought* (Cambridge, Mass.: Harvard University Press, 1991), 3, 13.
7. Desmond and Moore, *Darwin*, 341, 369.
8. Thomas H. Huxley, *Darwiniana* (New York: D. Appleton and Co., 1897), 13; Desmond and Moore, *Darwin*, 320–23; Loren Eiseley, *Darwin’s Century* (New York: Doubleday, 1958), 133; Ruskin, quoted in J.W. Burrow, “Editor’s Introduction,” in Charles Darwin, *The Origin of Species by Means of Natural Selection* (Harmondsworth: Penguin Books, 1968), 20.
9. Stephen Jay Gould, *Full House: The Spread of Excellence from Plato to Darwin* (New York: Three Rivers Press, 1996), 138.
10. Darwin, *The Origin of Species*, 68.
11. *Ibid.*, 116–17.