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Introduction by the Authors
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CHAPTER THREE

BOURGEOIS IDEOLOGY AND THE ORIGIN OF DETERMINISM

It is hard to realize today the extent to which primary social relations in early feudal European society, lay between person and person rather than between persons and things. The relationships between lord and vassal, seigneur and serf, entailed mutual obligations that did not depend on an equitable exchange but were absolute on each party separately. Relations to material things—to wealth, land, tools, products, and the range of social activity of each individual, including work obligations, freedom of movement, and freedom to buy and sell—were an indissoluble whole determined for each person by the single fact of status relation. Serfs were tied to the land, but lords could not eject them because their connection to the land flowed from their social status. Once renewable at the death of either lord or vassal, fiefdoms gradually became hereditary and the arrangement they dictated inescapable.

Underlying this social system and legitimizing it was the ideology

of grace and, later, of divine right. People held their position in the social hierarchy as the result of the conferral or denial of God's grace; kings claimed their absolute right to rule on the same basis. As grace was inherited through blood, the conferral of grace on the founder of a line was a sufficient *primum mobilum*, guaranteeing grace to biological heirs (although only if legitimate) and insuring stable social and economic relations within and between generations. Changes in position in the social hierarchy, like that of the noble Norman house of Bellême, which arose from a crossbowman of Louis d'Outre-Mer, were explained as being the result of conferrals or withdrawals of grace. Charles I was king of England, *Dei gratia*, but, as Cromwell wryly observed, grace had been removed from him, as evidenced by his severed head.

This static world of social relations legitimated by God reflected, and was reflected by, the dominant view of the natural world as itself static. Unlike the more modern view of an essentially progressive and changing world, the feudal universe was conceived as being held in an ever revolving daily and seasonal dance, with the sun, moon, and stars rotating like bright lights fixed to a series of crystal spheres at the center of which was our earth, on which humans themselves were the central part of God's creation. Nature and humanity existed in order to serve God and God's representatives on earth, the lords temporal and spiritual.

In such a world, social and natural change alike were to be discouraged. Just as the heavenly spheres were fixed, so was the social order. People knew their place, were born and lived in it; it was natural and, like nature itself, ever changing on the mundane, quotidian level and yet basically immutable in the larger scheme. In this precapitalist world, not yet dominated by the metaphor of the machine (in which all phenomena are reduced to their component cogs and pulleys, linked in linear chains of cause and effect), it was possible to be much more tolerant of apparently contradictory or overlapping explanations. The causes of events did not have to be mutually consistent. Sickness could be a natural phenomenon in its own right or a visitation from the Lord. Objects were not individual, atomistic, and separate but fluid and varied, and could be transformed one into another. People could become wolves, lead transmute into gold, fair foul and foul fair. It was possible to believe, at one and the same time, both that living forms had each been created separately according to Biblical myth and had ex-

isted unchanged since those Edenic days, *and* that individuals were mutable. Myths abounded of hybrid beasts, half horse, half human; and of women who gave birth to monsters as a result of impressions fixed by some event during pregnancy.

Humanity's relationship to nature was not one of domination—because the appropriate machinery of domination did not exist—but rather of coexistence, which demanded respect for and integration with the natural world within which human lives were embedded. This nature was static in the long run and capricious in the short, and any understanding of it, then, could not be based in the end on constant manipulation and transformation, the active techniques of scientific experimentation, but had to be expressed as passive appreciation. Explanations therefore were couched in terms of appeals to the authority of ancient writings, Biblical or Greek, and not on empirical data.

The Rise of Bourgeois Society

It is clear that feudal society was quite unsuited to a growing mercantile, manufacturing, and eventually capitalist system. First, social and economic life had to become disarticulated so that each individual could play many different roles, confronting others sometimes as buyer, sometimes as seller; sometimes as producer, sometimes as consumer; and sometimes as owner, sometimes as user. The particular role played came to depend upon a momentary relation to objects of production and exchange, not upon lifelong social relations.

Second, individuals had to become "free," but only in particular senses. Ties to specific places or persons had to be eliminated, freeing workers to leave land and lord in order to become manufacturing laborers and to move about in commerce. Reciprocally, landowners had to be free to alienate the land, ejecting inefficient and unproductive systems of production. The enclosure acts that began in Britain as early as the thirteenth century and reached a peak in the late seventeenth and eighteenth centuries were designed to concentrate large tracts of land into intensively cultivated and grazed holdings. A consequence of the dispossession of tenants was the creation of a large mobile army of prospective wage laborers for a growing industry. Freedom also had to come in terms of the ownership of one's own body, what Macpher-

son calls "possessive individualism."¹ Large-scale industrial production is carried out by wage workers who sell their labor power to the owners of capital. For such a system to work, laborers must have possession of their own power of work; they must possess themselves and not be the possession of others.

Note, however, that such workers were predominantly male. To work efficiently under these new conditions, the old divisions of labor between men and women needed to be reinforced. Men worked outside the home as productive laborers, women inside as reproductive laborers. Their task was to provide constantly for the male worker the renewal, the re-creation his conditions of work demanded, as well as to rear the next generation of young workers. Only sometimes could women function directly as productive wage laborers in addition to their reproductive work. As the nineteenth century wore on, this division of labor was steadily strengthened. By contrast with feudal society, men were no longer the possession of others; however, if they possessed nothing else, they possessed their women. The social order was not merely capitalist but patriarchal as well.

The third requirement of developing economic relations was presumptive equality for the growing bourgeoisie. Entrepreneurs needed to acquire and dispose of both real and personal property, which required a legal system that would guarantee them redress against nobles and, above all, access to political power. In practice, this was achieved by the supremacy of a parliament of commoners.

The changing mode of production which the emergent capitalist order of the seventeenth century represented demanded solutions to a wholly new range of technical problems. A mercantile and trading society required new and more accurate navigational techniques for merchants' ships, new methods of extraction of raw materials, and new processes of handling these materials when extracted. The techniques for generating solutions to these problems, and the body of knowledge that accumulated as a result of solving them, represented one of the fundamental transitions in the history of humanity, the emergence of modern science, an emergence that can be dated surprisingly precisely to northwestern Europe in the seventeenth century.

The new scientific knowledge, unlike the old precapitalist forms of knowledge, was not passive but active. Whereas in the past philosophers had contemplated the universe, for science in the post-Newtonian world the test of theory was practice, a credo given ideological

form by the writings of Francis Bacon. A steady acquisition of facts about the world and its experimental manipulation in the light of those facts were integral to the new theories. No longer was it adequate merely to quote the authority of the ancients; and if the ancient words of wisdom were not in accord with today's observations, they must be discarded. The new science, like the new capitalism, was part of the liberation of humanity from the shackles of feudal serfdom and human ignorance (the links are beautifully displayed in Brecht's *Galileo*). Even the most abstract pronouncements of physics, such as Newton's laws of motion, could be seen as arising out of the social needs of an emergent class.² Science was thus an integral part of the new dynamic of capital, even though the fuller articulation of the links between them would take another two centuries to develop.³

The Articulation of Bourgeois Scientific Ideology

It is relatively easy to see the social determinants of science and to show the forces that urge particular problems forward and retard others as thus expressive of social needs as perceived by a dominant class. What is less clear, however, is how the nature of scientific knowledge is itself structured by the social world. And yet some such correspondence must exist. To view the universe and to extract explanatory principles and unifying hypotheses from the rich confusion of phenomena and processes, one must systematize and use tools for systematization that are derived from the experience of the social world and of one's fellow students of the natural world.

It is precisely at this point that the concept of ideology becomes of paramount importance in making transparent the ways in which human understanding becomes refracted by the social order in which that understanding develops. To understand the concerns and modes of explanation of bourgeois science, one must understand the underpinnings of bourgeois ideology.

The radical reorganization of social relations that marked the rise of bourgeois economy had, as a concomitant, the rise of an ideology expressive of these new relations. This ideology, which dominates

today, was both a reflection onto the natural world of the social order that was being built and a legitimizing political philosophy by which the new order could be seen as following from eternal principles. Long in advance of the revolutions and regicides of the seventeenth and eighteenth centuries that marked the final triumph of the bourgeois order, intellectuals and political pamphleteers were creating the philosophy to which these revolutions looked for justification and explanation.

It is hardly surprising, then, that the philosophical principles enunciated by the philosophers of the Enlightenment should turn out to be just those that corresponded with the demands of bourgeois social relations. The emphasis of the new bourgeois order on the twin ideas of freedom and equality provided the revolutionary rhetoric of the new class struggling to throw off the grips of church and aristocracy. It was a rhetoric that was to be liberatory, and yet finally, once the victory of the bourgeois class was assured, was to contain within itself the contradictions with which the bourgeois order is faced today.

The eighteenth-century accord between the bourgeois order and its ideology of scientific rationality is typified by the clandestinely published French *Encyclopedie*. Its editor was the physicist and mathematician d'Alembert, and the emphasis throughout was on a secular, rational analysis of both the physical world and human institutions. The motif of scientific rationality, as opposed to the religious themes of faith, the supernatural, and tradition, was obviously a primary requirement for the development of productive forces based on new technological discoveries. Labor, too, had to be reorganized and relocated, in workshops whose productive activities were based on calculations of efficiency and profit, not customary relations. The machine model of the universe gained intellectual hegemony, ceasing to be regarded as merely a metaphor and becoming, instead, the "self-evident" truth about how to look at the world.

The Bourgeois View of Nature

Thus the bourgeois view of nature shaped and was shaped by the science that it developed, organized along certain basic reductionist principles. The rise of modern physics, first with Galileo and then

particularly with Newton, ordered and atomized the natural world. Beneath the surface world in all its infinite variety of colors, textures, and varied and transient objects, the new science found another world of absolute masses interacting with one another according to invariant laws that were as regular as clockwork. Causal relationships linked falling bodies, the motion of projectiles, the tides, the moon, and the stars. Gods and spirits were abolished or relegated merely to the "final cause" which set the whole clockwork machinery in motion. (Actually Newton himself remained both religious and mystic throughout his life, but that is one of the minor quirks of personal history: The effect of Newtonian thought was the reverse of Newton's personal philosophy.) The feudal world's universe thus became demystified and, in a manner, disenchanted as well.

This change did not occur without a struggle against those interests that the rising world view opposed. The threat to the Church when astronomers like Copernicus and Galileo sought to replace an earth-centered model of the motion of the heavenly bodies by a sun-centered one was not about cosmology alone, for the Church perceived it as a challenge to a Church-centered world order on earth which mirrored the heavens above. The astronomers, in the spirit of the new capitalism, were challenging heavenly and earthly understanding simultaneously, which was why Bruno, who was most explicit about this, was burned, while Galileo was allowed merely to recant and Copernicus to be published with a little proviso that heliocentrism was merely a theory that made calculations easier but which should not be confused with reality.

In the new world that emerged after Newton, once again heavenly and earthly orders were in seeming harmony. The new physics was dynamic and not static, as were the new processes of trade and exchange. The old world view was replaced with a set of new abstractions in which a series of abstract forces between atomistic and unchanging masses underlay all transactions between bodies. Drop a pound of lead and a pound of feathers from the Leaning Tower of Pisa and the lead will arrive at the ground first because the feathers will be more retarded by air pressure, frictional forces, and so forth. But in Galileo's and Newton's equations the pound of feathers and the pound of lead arrive simultaneously because the *abstract* pound of lead and pound of feathers are equivalent unchanging

masses to be inserted into the theoretical equations of the laws of motion.

Sohn-Rethel⁴ has pointed out how these abstractions paralleled the world of commodity exchange in which the new capitalism dealt. To each object there are attached properties, mass, or value which are equivalent to or can be exchange for objects of identical mass or value. Commodity exchange is timeless, unmodified by the frictions of the real world; for example, a coin does not change its value by passing from one hand to another, even if it is slightly damaged or worn in the process. Rather, it is an abstract token of a particular exchange value. It was not until the nineteenth century that this view could become fully dominant. The demonstration by Joule that all forms of energy and heat, electromagnetism and chemical reactions were interchangeable and related by a simple constant, the mechanical equivalent of heat (and the later demonstration by Einstein of the equivalence of matter and energy), corresponded to an economic reductionism whereby all human activities could be assessed in terms of their equivalents of pounds, shillings, and pence.*

Humans themselves ceased to be individuals with souls to be saved but became merely hands capable of so many hours of work a day, needing to be stoked with a given quantity of food so that the maximal surplus value could be extracted from their labor. Dickens described that epitome of the nineteenth-century rising capitalist, Thomas Gradgrind of Coketown, as a man

"with a rule and a pair of scales, and the multiplication table always in his pocket, sir, ready to weigh and measure any parcel of human nature, and tell you exactly what it comes to. It is a mere question of figures, a case of simple arithmetic. . . . Time itself for the manufacturer becomes its own machinery: so much material wrought up, so much food consumed, so many powers worn out, so much money made."⁵

*Lest there be any doubt, we should emphasize again that there are two types of criteria for understanding the scientific process. That we can show the social determinants of a particular view of the world, how and why it emerges, says nothing about the truth claims or otherwise of the scientific statements. That Joule's mechanical equivalent of heat or Einstein's matter/energy equivalence were developed in a particular facilitating social framework does not entitle one to conclude that they are thereby by definition either true or false. Criteria for judging the truth of Joule's or Einstein's claims lie between science and the real world, not between science and the social order. We are not committing the "genetic fallacy."

For bourgeois society, nature and humanity itself had become a source of raw materials to be extracted, an alien force to be controlled, tamed, and exploited in the interests of the newly dominant class. The transition from the precapitalist world of nature could not be more complete.⁶

So far we have discussed science in general, or rather physics as though it were all of science. But how did the new mechanical and clockwork vision of the physicists affect the status of living organisms? Just as modern physics starts with Newton, so modern biology must begin with Descartes—philosopher, mathematician, and biological theorist.

In Part V of his *Discourses* of 1637, Descartes analogizes the world, animate and inanimate, to a machine (the *bête machine*). It is this Cartesian machine image that has come to dominate science and to act as the fundamental metaphor legitimating the bourgeois world view, whether of individuals or of the “solid machine” in which they are embedded. That the machine was taken as a model for the living organism and not the reverse is of critical importance. The machine is as much the characteristic symbol of bourgeois productive relations as the “body social” was of feudal society. Bodies are indissoluble wholes that lose their essential characteristics when they are taken into pieces.

Life following life through creatures you dissect,
You lose it in the moment you detect.⁷

Machines, on the contrary, can be disarticulated to be understood and then put back together. Each part serves a separate and analyzable function, and the whole operates in a regular, lawlike manner that can be described by the operation of its separate parts impinging on each other.

Descartes's machine model was soon extended from nonhuman to human organisms. It was clear that many—in fact most—human functions were analogous to those of other animals and therefore were also reducible to mechanics. However, humans had consciousness, self-consciousness, and a mind, which for Descartes, a Catholic, was a soul; and by definition the soul, touched by the breath of God, could not be mere mechanism. So there had to be two sorts of stuff in nature: matter, subject to the mechanical laws of physics; and soul, or mind,

a nonmaterial stuff which was the consciousness of the individual, his or her immortal fragment. How did mind and matter interact? By way of a particular region of the brain, Descartes speculated, the pineal gland, in which the mind/soul resided when incorporated, and from which it could turn the knobs, wind the keys, and activate the pumps of the body mechanism.

So developed the inevitable but fatal dysjunction of Western scientific thought, the dogma known in the case of Descartes and his successors as "dualism." As we shall see, some sort of dualism is the inevitable consequence of any sort of reductionist materialism that does not in the end wish to accept that humans are "nothing but" the motion of their molecules. Dualism was a solution to the paradox of mechanism that would enable religion and reductionist science to stave off for another two centuries their inevitable final contention for ideological supremacy. It was a solution compatible with the capitalist order of the day because in weekday affairs it enabled humans to be treated as mere physical mechanisms, objectified and capable of exploitation without contradiction, while on Sundays ideological control could be reinforced by the assertion of the immortality and free will of an unconstrained incorporeal spirit unaffected by the traumas of the workaday world to which its body had been subjected. Today as well, dualism continually reemerges in persistent and various manners from the ashes of the most arid of mechanical materialism.

The Development of a Materialist Biology

For the confident and developing science of the eighteenth and nineteenth centuries, dualism was but a stepping stone toward more thoroughgoing mechanical materialism. Although the analogies changed and became more sophisticated as physical science advanced—from clockwork and hydraulic to electrical and magnetic, and onward to telephone exchanges and computers—the main thrust remained reductionist. For the progressive rationalists of the eighteenth century, science was about cataloguing the states of the world. If a complete specification of all particles at a given time could be achieved, everything would become predictable. The universe was determinate, and

the laws of motion applied precisely across a scale ranging from the atoms to the stars. Living organisms were not immune from these laws. The demonstration by Lavoisier that the processes of respiration and the sources of living energy were exactly analogous to those of the burning of a coal fire—the oxidation of foodstuffs in the body tissues—was perhaps the most striking vindication of this approach. It was the first time that a programmatic statement that life must be reducible to molecules could be carried into practice.

But progress in the identification of body chemicals was slow. The demonstration that the substances of which living organisms are composed are only “ordinary,” albeit complicated, chemicals came early in the nineteenth century. The intractability of the giant biological molecules—proteins, lipids, nucleic acids—to the available analytical tools remained a stumbling block. The mechanists could make programmatic statements about how life was reducible to chemistry, but these were largely acts of faith. Not until a century after the first nonorganic synthesis of the simple body chemicals did the molecular nature and structures of the giant molecules began to be resolved (and really not until the 1950s did progress become very rapid). The last remaining faith that there would be some special “life force” operating among them which distinguished them absolutely from lesser, nonliving chemicals lingered until the 1920s.⁸

Nonetheless, a radically reductionist program characterized the statements of many of the leading physiologists and biological chemists of the nineteenth century. In 1845 four rising physiologists—Helmholtz, Ludwig, Du Bois Reymond, and Brucke—swore a mutual oath to account for all bodily processes in physiochemical terms.⁹ They were followed by others: for instance, Moleschott and Vogt, thoroughgoing mechanical materialists who claimed that humans are what they eat, that genius is a question of phosphorus, and that the brain secretes thought as the kidney secretes urine; and Virchow,^{*} one of the leading figures in the development of cell theory, who was also part of a long

^{*}Virchow's arguments worked both ways: His emphasis on “the body politic” also implied an argument that diseases of individuals were essentially socially caused rather than caused by, for instance, germs. Virchow's emphasis on social medicine, with its progressive and nonreductionist implications, is part of the contradiction between the radical social intent of much of this physiological thought in the nineteenth century and its ultimately repressive ideology.

tradition of social thought which argued that social processes could be described by analogy with the workings of the human body.

It is important to understand the revolutionary intentions of this group. They saw their philosophical commitment to mechanism as a weapon in the struggle against orthodox religion and superstition. Several of them were also militant atheists, social reformers, or even socialists. Science would alleviate the misery of the poor and strengthen the power of the state against the capitalists—and even, to some measure, help democratize society. Their claims were part of the great battle between science and religion in the nineteenth century for supremacy as the dominant ideology of bourgeois society, a fight whose outcome was inevitable but whose final battlefield was not to be physiological reductionism but Darwinian natural selection. The best-known philosopher of the group was Feuerbach, and it was against his version of mechanical materialism that Marx launched his famous theses.¹⁰

The theses on Feuerbach proved the starting point for Marx's own—and more explicitly Engels's—long-running attempts to transcend mechanical materialism by formulating the principles of a materialist but nonreductionist account of the world and humanity's place within it: dialectical materialism. But within the dominant perspective of biology in the Western tradition, Moleschott's mechanical materialism was to win out, stripped of its millenarian goals and, by the late twentieth century, revealed as an ideology of domination. When today biochemists claim that "a disordered molecule produces a diseased mind,"¹¹ or psychologists argue that inner city violence can be cured by cutting out sections of the brains of ghetto militants, they are speaking in precisely this Moleschottian tradition.

To complete the mechanical materialist world picture, however, a crucial further step was required: the question of the nature and origin of life itself. The mystery of the relationship of living to nonliving presented a paradox to the early mechanists. If living beings were "merely" chemicals, it should be possible to recreate life from an appropriate physico-chemical mix. Yet one of the biological triumphs of the century was the rigorous demonstration by Pasteur that life only emerged from life; spontaneous generation did not occur. The resolution of this apparent paradox, which had led to many confused polemics between chemical reductionists and the residual school of biological

vitalists who continued to oppose them, awaited the Darwinian synthesis, which was able to show that although life came from other living organisms and could not now arise spontaneously, each generation of living things changed, evolved, as a result of the processes of natural selection.

With the theory of evolution came a crucial new element in the understanding of living processes: the dimension of time.¹² Species were not fixed immemorially but were derived in past history from earlier, "simpler" or more "primitive," forms. Trace life back to its evolutionary origins and one could imagine a primordial warm chemical soup in which the crucial chemical reactions could occur. Living forms could coalesce from this prebiotic mix. Darwin speculated about such origins, although the crucial theoretical advances depended on the biochemist Oparin and the biochemical geneticist Haldane in the 1920s (both, incidentally, consciously attempting to work within a dialectical and nonmechanist framework). Experiments only began to catch up with theory from the 1950s onward.

In one sense, evolutionary theory itself represents the apotheosis of a bourgeois world view, just as its subsequent development reflects the contradictions within that world view. The breakdown of the old static feudal order and its replacement with a continually changing and developing capitalism helped introduce the concept of mutability into biology. The age-old daily and seasonal rhythms and the "simple" movement of life from birth through maturity to death had characterized feudalism, but now each generation experienced a world qualitatively different from that of its predecessors. This change was, for the rising eighteenth-century bourgeoisie, progressive. Time's arrow pointed forward irreversibly; it did not loop back upon itself. Understanding of both the earth and life upon it was transformed. Geology slowly came to recognize that the earth had evolved, rivers and seas had moved, layers of rock had been laid down in time sequences atop one another—not in accord with the Biblical myth of creation and the flood but in a steady and uniform sequence over many thousands or millions of years. The principle of uniformitarianism in the hands of such early nineteenth-century geologists as Lyell destroyed the Biblical date for the creation of the earth, 4004 B.C.

And what of life itself? The resemblances and differences of species, their apparent grading virtually one into the other, seemed to imply

more than mere coincidence. The discovery of fossils in rock formations whose ages could be estimated implied that some species that had once existed were no longer extant, while new ones had emerged. The doctrine of evolutionism had become an inevitability. At first, in the hands of eighteenth- and early nineteenth-century zoological philosophers like Lamarck and Erasmus Darwin, evolution itself was progressivist, but not in discord with a higher godly design. For Lamarck, species perfected themselves by striving, by modifying their properties to environmental demands and passing these modifications on to their offspring, just as humans were no longer "fixed" in place but could ascend a social hierarchy by virtue—in the liberal myth—of their own efforts. For the elder Darwin evolution was change onward and upward, steadily toward an always more perfect and harmonious future.

It was for Charles Darwin, and the dourer context of the mid-nineteenth century, to frame the mechanisms for evolutionary change in terms of natural selection. Drawing on ideas earlier expressed in the human context by Malthus, he saw that the fact that individuals produced more offspring than survived, and that those better adapted to their environment were more likely to survive long enough to breed in their turn, provides a motor for evolutionary change. Further, Darwinian evolution by natural selection applied not merely to nonhuman species but, it was immediately apparent, to humans as well. It was this observation that set the stage for the final conflict of science with religion, despite the reluctance of many on both sides of the debate to get drawn into it. For, far more than the programmatic statements of the physiological mechanists, Darwinian theory was a direct challenge to the residual hold of Christianity as the dominant ideology of Western society and was seen as such by friend and foe alike.

In retreat since Newton, orthodox Christianity had fallen back into the belief in a God who was first cause of the natural world and still remained the day-to-day controller of life—and especially of human destiny. Darwinism wrested God's final hold on human affairs from his now powerless hands and relegated the deity to, at the best, some dim primordial principle whose will no longer determined human action.

The consequence was to change finally the form of the legitimating ideology of bourgeois society. No longer able to rely upon the myth of a deity who had made all things bright and beautiful and assigned

each to his or her estate—the rich ruler in the castle or the poor peasant at the gate—the dominant class dethroned God and replaced him with science. The social order was still to be seen as fixed by forces outside humanity, but now these forces were natural rather than deistic. If anything, this new legitimator of the social order was more formidable than the one it replaced. It has, of course, been with us ever since.

Natural-selection theory and physiological reductionism were explosive and powerful enough statements of a research program to occasion the replacement of one ideology—of God—by another: a mechanical, materialist science. They were, however, at best only programmatic, pointing along a route which they could not yet trace. For example, in the absence of a theory of the gene, Darwinism could not explain the maintenance of inherited variation that was essential for the theory to work. The solution awaited the development of genetic theory at the turn of the twentieth century with the rediscovery of the experiments done by Mendel in the 1860s. This in turn produced the neo-Darwinian synthesis of the 1930s and the recurrent attempts to parcel out biological phenomena into discrete and essentially additive causes, genetic and environmental: the science of biometry.

The Quantification of Behavior

Moleschott's claim that the brain secretes thought as the kidney secretes urine was perhaps the most extreme of the materialist claims of the nineteenth century, but it expresses at the same time the ultimate goal of the philosophy. It was not merely life, but consciousness and human nature itself which must be brought within the reach of rulers, scales, and chemical furnaces. To achieve such a goal it was necessary first to have a theory of behavior, which was no longer seen as a continuous and only partially predictable flow of human action arising from the demands of the soul, of free will, and of the vagaries of human character, stuff for the novelist rather than the scientist; instead, behaviors—now in the plural—had to be seen as a series of discrete and separable units, each of which could be distinguished and analyzed. It was no longer enough to see the body alone as a machine; the role of

the brain in organizing and controlling behavior became the center of research attention.

For one school, the brain was an integrative organ whose properties were in some way holistic functions of the entire mass of tissue. For another, these functions were atomized and localized in different regions. This latter was essentially the claim made by the phrenological school of Gall and Spurzheim beginning in Germany and France at the end of the eighteenth century. All human faculties, it claimed, could be broken down into discrete units—abilities such as mathematics or propensities such as love of music or of producing children (philoprogenitiveness).¹³ Further, these different abilities and propensities were located in different regions of the brain, and their extent could be assessed from outside by looking at the shape of an individual head or skull. Despite a period of high fashion, phrenology's empirical claims were laughed out of court by the orthodox science of the mid-nineteenth century, but a crucial series of fundamental claims remained intact. These were of the existence of discrete measurable traits that could be localized to specific brain regions. By the end of the nineteenth century the localization school of neuropsychology was clear that different regions of the brain controlled different functions; clear as a result of the postmortem examination of brains of patients whose disabilities had been studied before death; by the somewhat macabre investigations of the behavior of soldiers dying of brain injuries in the battlefields of the Franco-Prussian War; and by experiments with animals. There were brain regions associated with sensory, motor, and association functions; with speech, memory, and affect. It followed that differences in behavior between individuals might be accounted for in terms of differences in structure of different brain regions. There was much dispute as to whether brain size as measured in life by head circumference, or after death by directly weighing, might be associated with intelligence or achievement—an obsession of a number of distinguished nineteenth-century neuroanatomists who anxiously surveyed their colleagues, and left their own brains for analysis by posterity. The systematic distortion of the evidence by nineteenth-century anatomists and anthropologists in attempts to prove that the differences in brain size between male and female brains were biologically meaningful, or that blacks have smaller brains than whites has been devastatingly exposed in a detailed reevaluation by Stephen J. Gould.¹⁴

The obsession with brain size continued well into the twentieth century. Both Lenin's and Einstein's brains were taken for study after death. Lenin's had an entire institute of brain research founded for its study; years of work could find nothing unusual about the brain, but the institute remains as a major research center. The point is that there are no sensible questions that neuroanatomy can address to the dead brain of however distinguished a scientist or politician.* There is virtually no observable relationship between the size or structure of an individual brain measured after death and any aspect of the intellectual performance of its owner measured during life. There are exceptions: In cases of specific brain damage due to illness, lesions, or tumors, or the brain shrinkage of senile dementia or alcoholism, though even here there are counterexamples.¹⁵ But in general, once the effects of height, age, etc. have been allowed for, brain weight is related to body size. The search for the seat of differences in performance between individuals must move beyond the simple examination of brain structures.

Despite this, there remains a common assumption that there is a relationship between large heads and high brows and intelligence, an assumption that was made the basis of a criminological theory of types by the Italian Cesare Lombroso in the late nineteenth century. According to Lombroso, in an extension of the phrenological theorizing of the early part of the century, criminals could be identified by certain basic physiological features:

The criminal by nature has a feeble cranial capacity, a heavy and developed jaw, projecting [eye] ridges, an abnormal and asymmetrical cranium . . . projecting ears, frequently a crooked or flat nose. Criminals are subject to [color blindness]; left-handedness is common; their muscular force is feeble. . . . Their moral degeneration corresponds with their physical, their criminal tendencies are manifested in infancy by [masturbation], cruelty, inclination to steal, excessive vanity, impulsive character. The criminal by nature is lazy, debauched, cowardly, not susceptible to remorse, without foresight, . . . his handwriting is peculiar . . . his slang is widely diffused. . . . The general . . . persistence of an inferior race type . . .¹⁶

*Any more than there are useful questions to be asked of the sperm of a septuagenarian Nobel laureate, despite Dr. William Shockley's enthusiasm for donating these fruits of his loins to a "genetic repository" in California where it may be used to inseminate the hopeful bearers of "high IQ" children.

Lombroso and his followers attempted to establish a system whereby a predisposition to engage in antisocial behavior could be predicted on the basis of physical characteristics; from surveys conducted in prisons he concluded among other things that murderers have "cold, glassy, blood-shot eyes, curly abundant hair, strong jaws, long ears and thin lips"; forgers are "pale and amiable, with small eyes and large noses; they become bald and grey-haired early"; and sex criminals have "glinting eyes, strong jaws, thick lips, lots of hair and projecting ears."¹⁷

A rational criminology thus became possible, a theory of criminal faces that was the obvious forerunner to today's belief in criminal chromosomes. The strength of Lombroso's typology is that it drew from current myths about the criminal and gave them apparent scientific support. The myths found their way routinely into mass culture, as in Agatha Christie, for instance. In an early book we find her clean-cut young upper-class English hero secretly observing the arrival of a Communist trade unionist at a rendezvous: "The man who came up the staircase with a soft-footed tread was quite unknown to Tommy. He was obviously of the very dregs of society. The low beetling brows, and the criminal jaw, the bestiality of the whole countenance were new to the young man, though he was a type that Scotland Yard would have recognised at a glance."¹⁸ Lombroso would have recognized him too.

Implicit in such criminology is the belief that individual behaviors can be located as the fixed properties of individuals, as characteristic as their height or hair color. Also implicit within the research program that such a reductionist biological determinism maintains is the claim that it is possible to compare the behaviors of different individuals across some appropriate scale. Behaviors are not all-or-none. Like height, they are continuously distributed variables; individual A is more aggressive than individual B, or less so than C. If one could devise appropriate scales, like rulers for height, one should be able to plot the distribution of the entire population on a scale for aggression, criminality, or whatever. It is the belief in such a distribution that provides the rationale for thinking about IQ tests as measures of intelligence, which is discussed in Chapter 5. If all individuals within a population can be placed, for any particular trait, along a linear distribution, the famous bell-shaped "normal" curve is produced. Individuals who fall outside the majority portion of this distribution are abnormal, or deviant.

Because we take the concept of deviance so easily for granted, be-

cause it seems so "natural," it is important to remember how recently it has appeared in the history of bourgeois society. The concepts of criminality, madness, and indeed illness itself—their treatment by seclusion, in prisons, asylums, and hospitals—only developed slowly from the seventeenth century and with accelerating pace through the nineteenth century.¹⁹ It is not that prior to the bourgeois revolution there was no theory of human nature. Typological theory argued that human temperament was fixed as a sort of titration of the four basic types—phlegmatic, bilious, choleric, and sanguine. Concepts of the fixity of human evil and of original sin clashed with the possibility of redemption through faith or good works. Certainly criminal codes existed, as did madness and disease. But medieval and early capitalist society tolerated a far greater range of human variation than was to be acceptable later. Peddlers and vagabonds, rogues and eccentrics were part of life's stage: consider the characters in a Breughel or Hogarth painting, or an eighteenth-century picaresque novel. The reductionist materialism of the nineteenth century sought to control, regularize, and limit this variation. Or think of the transition between the multitudinous richness of characters of an early Dickens novel like *Pickwick Papers* and the later accounts of the conformity of the new bourgeoisie portrayed in *Dombey and Son* or *Hard Times*. The social institutions of an industrial society could decreasingly tolerate deviance, which became a meaningful concept only when there was a norm, a concept of the average, from which people could be argued to deviate.*

The Origin of Behavior

Behaviors, then, in the reductionist view, may be quantified, distributed in relationship to a norm, or located in some way "in the

*Indeed, in writing this book we have become aware of the extent to which there are still large cross-cultural differences in how norms are viewed. The U.S. educational system, it appears to us, is far more interested in categorizing the children that pass through it as "within the normal range" or alternatively as deviant from it; American parents are more likely to be told that their child falls "outside the norm" than in England, where perhaps a greater range of behavior in children is taken for granted—or less is expected of them.

brain." But how do they arise? This too was a major concern of nineteenth-century theorizing. We have shown how the inheritance of behavior, of human nature, forms a major theme of the Victorian novelists from Disraeli to Dickens and Zola. The theory that behaviors, even trivial ones, are inherited rather than acquired was clearly articulated by Charles Darwin in his book *The Expression of Emotion in Man and Animals*. In it, for instance he notes:

A gentleman of considerable position was found by his wife to have the peculiar trick, when he lay fast asleep on his back in bed, of raising his right arm slowly in front of his face up to his forehead, then dropping it with a jerk so that the wrist fell heavily on the bridge of the nose. . . . Many years after his death his son married a lady who had never heard of the family incident. She however, observed precisely the same peculiarity of her husband, but his nose not being particularly prominent has never as yet suffered from a blow. . . . One of his children, a girl, has inherited the same trick.^{20*}

While Darwin was collecting anecdotes, Galton was measuring, quantifying, and attempting to define the laws of ancestral inheritance of such behaviors. The inheritance or otherwise of such foibles as Darwin records was not, of course, the central question. In genetic studies from Darwin's day to the present, most of the attention directed to human behavior has been concerned with two major themes: the inheritance of intelligence and the inheritance of mental illness or criminality. One of the major purposes of the collection of psychometric evidence (to be discussed in relation to IQ in Chapter 5) was to measure the degree to which any given behavior was inherited rather than environmentally shaped. The spurious dichotomization of nature and nurture begins here.

While the techniques used in *Hereditary Genius*²¹ were crude, the questions asked and the methodology developed soon after were to

*How would *we* explain such an anecdote? For us, it is analogous to some of the stories of amazing coincidences among separated identical twins popular today—or the search for explanations for ESP, UFOs, and bent spoons. We begin by being skeptical of the phenomena. And we point out that scientific research and explanation are concerned above all with the understanding of regularities and repeatable phenomena, not exceptions and flukes, many of which, like the apparent coincidence of behavior of long-separated identical twins, simply disappear on closer analysis.

remain practically unchanged for the century dividing Darwin and Galton from the modern generation of biological determinists. The sorry history of this century of insistence on the iron nature of biological determination of criminality and degeneracy, leading to the growth of the eugenics movement, sterilization laws, and the race science of Nazi Germany has frequently been told.²² It is not our purpose here to retrace that history. Rather, we are concerned with the way in which the philosophy of reductionism, and its intimate intertwining with biological determinism, developed into the modern synthesis of sociobiology and molecular biology.

The Central Dogma:

The Core of the Mechanistic Program

The nineteenth-century themes of the chemicalization of physiology, the quantification of behavior, and the genetic theory of evolution would have remained only programmatic insights without the explosive growth of biological theory and method of the last thirty years. To substantiate them turned out to require more than slogans and mathematics. What were needed were the powerful new machines and techniques for the determination of the structure of the giant molecules, for observing the microscopic internal structure of the cells, and, above all, for studying the dynamic interplay of individual molecules within the cell. By the 1950s it had begun to be possible to describe and account for, in the mechanistic sense, the behavior of individual body organs—muscles, liver, kidneys, etc.—in terms of the properties and interchange of individual molecules: the mechanist's dream.

The grand unification between the concerns of the geneticists and those of the mechanistic physiologists came in the 1950s—the “crowning triumph” of twentieth-century biology, the elucidation of the genetic code. This required a theoretical addition to the mechanistic program, to be sure. Hitherto it had been sufficient to claim that a full accounting for the biological universe and the human condition was possible by an understanding of the trio of *composition*—the molecules the organism contains; *structure*—the ways these molecules are ar-

ranged in space; and *dynamics*—the chemical interchanges among the molecules. To this now needed to be added a fourth concept, that of *information*.

The concept of information itself had an interesting history, arising as it did from attempts during the Second World War to devise guided missile systems, and, through the 1950s and 1960s, in laying the theoretical infrastructure for the computer and electronics industries. The understanding that one could view systems and their actions in terms not merely of matter and the energy flow through it but in terms of information exchanges—that molecular structures could convey instructions or information one to the other—shook up a theoretical kaleidoscope, and in one sense made possible Crick, Watson, and Wilkins's recognition that the double helical structure of the DNA molecule could also carry genetic instructions across the generations. Molecules, the energetic interchanges between them, and the information they carried provided the mechanists' ultimate triumph, expressed in Crick's deliberate formulation of what he called the "central dogma" of the new molecular biology: "DNA $\rightarrow$ RNA $\rightarrow$ protein."²³• In other words, there is a one-way flow of information between these molecules, a flow that gives historical and ontological primacy to the hereditary molecule. It is this that underlies the sociobiologists' "selfish gene" arguments that, after all, the organism is merely DNA's way of making another DNA molecule; that everything, in a preformationist sense that runs like a chain through several centuries of reductionism, is in the gene.

It is hard to overemphasize the ideological organizing function that this type of formulation of the mechanics of the transcription of DNA into protein fulfills. Long before Crick, the imagery of the biochemistry of the cell had been that of the factory, where functions were specialized for the conversion of energy into particular products and which had its own part to play in the economy of the organism as a whole. Some ten years before Crick's formulation, Fritz Lipmann, discoverer of one of the key molecules engaged in energy exchange within the body, ATP, formulated his central metaphor in almost pre-Keynesian economic terms: ATP was the body's energy currency.

•For Crick, "Once information has passed into protein it cannot get out again." For Monod, "One must regard the total organism as the ultimate epigenetic expression of the genetic message itself."²⁴

Produced in particular cellular regions, it was placed in an "energy bank" in which it was maintained in two forms, those of "current account" and "deposit account." Ultimately, the cell's and the body's energy books must balance by an appropriate mix of monetary and fiscal policies.²⁵

Crick's metaphor was more appropriate to the sophisticated economies of the 1960s in which considerations of production were diminishing relative to those of its control and management. It was to this new world that information theory, with its control cycles, feedback and feed-forward loops, and regulatory mechanisms, was so appropriate; and it is in this new way that the molecular biologists conceive of the cell—an assembly-line factory in which the DNA blueprints are interpreted and raw materials fabricated to produce the protein end products in response to a series of regulated requirements. Read any introductory textbook to the new molecular biology and you will find these metaphors as a central part of the cellular description. Even the drawings of the protein synthesis sequence itself are often deliberately laid out in "assembly line" style. And the metaphor does not merely dominate the teaching of the new biology: It and language derived from it are key features of the way molecular biologists themselves conceive of and describe their own experimental programs.

And not merely molecular biologists. The synthesis of physiology and genetics that an information theory containing a double helix provided was steadily extended upward from individuals to populations and their origins. The integrated reductionist world views presented by biologically determinist writings like those of E. O. Wilson (*Sociobiology: The New Synthesis*) or Richard Dawkins (*The Selfish Gene*) draw explicitly on molecular biology's central dogma to define their commitment to the claim that the gene is ontologically prior to the individual and the individual to society,* and equally explicitly on a set of transferred economic concepts developed in the management of the increasingly complex capitalist societies of the sixties and seventies: Cost benefit analysis, investment opportunity costs, game theory, system engineering and communica-

*For Jacques Monod, "You have an exact logical equivalence between these two—the family and the cells. This effect is entirely written in the structure of the protein which is itself written in the DNA."²⁷

tion, and the like are all unabashedly transferred into the natural domain.

Drawn from inspection of the human social order, they define sociobiology's world view, and, as we should expect and as happened with Darwinism earlier, they are then reflected back as a justifier for that social order—as, for instance, when economists describe monetarist theories as in accord with the biological condition of humanity.²⁴ We shall see this process amply exemplified in the chapters that follow. For now, we want only to emphasize how the very transparency and explicitness of Crick's formulation of the "central dogma," and his quasi-religious choice of language in which to cast it, seize and restate the essential ideological concern of this mechanist tradition.

For the mechanical materialists the grand program begun by Descartes has now in its broad outline been completed. All that remains is the filling in of details. Even for the workings of so complex a system as the human brain and consciousness, the end is in sight. Immense amounts are known about the chemical composition and cellular structures of the brain, about the electrical properties of its individual units, and indeed of great masses of brain tissue functioning in harmony. We know how the analyzer cells of the visual system or the withdrawal reflex of a slug given an electric shock may be wired up, and about regions of the brain whose function is concerned with anger, fear, hunger, sexual appetite, or sleep. The mechanists' claims here are clear. In the nineteenth century, Darwin's supporter T. H. Huxley dismissed the mind as no more than the whistle of the steam train, an irrelevant spin-off of physiological function. Pavlov, in discovering the conditioned reflex, believed he had the key to the reduction of psychology to physiology, and one strand of reductionism has followed his lead. In this tradition, molecules and cellular activity cause behavior, and, as genes cause molecules, the chain that runs from particular unusual genes, say, to criminal violence and schizophrenia is unbroken.

Much of what follows in this book will be an explanation of the inadequacy of the claims for these causal chains, both on theoretical and on empirical grounds, as well as an analysis of their ideological roles in the defense of biological determinist views of the human condition. Only then can we move on to show how these reductionist models may be transcended by a biology more fully in accord with the

reality and complexity of the material world. Before that, however, we must examine the contradictions of the other twin planks of bourgeois ideology: the necessity for freedom and equality in the social domain. To do this, we must retrace our steps to the emergence of bourgeois society from feudalism.