NEWTON / MAXWELL / MARX

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Newton, Maxwell, Marx: three pillars of our western intellectual inheritance, yet each more celebrated in encyclopaedias and histories than read. It is the thesis of this new volume forthcoming from the Green Lion Press that there is much to be gained from a fresh reading of these authors. Three extensive essays are collected here, each reflecting a re-reading of a work of one of these authors: respectively, Newton's *Principia*, Maxwell's *Treatise on Electricity and Magnetism,* and Marx's *Capital.* A commentary has been added, linking them and proposing a dialectical thread that begins in the 17th century, and develops an unfolding vision of science still challenging in our own time.

The account begins with the recognition that Newton's *Principia* constitutes overall a polemic against mechanism, and specifically a refutation of Descartes' vision of nature as a mathematical machine. Newton embraces, certainly, the conviction that the natural world is mathematical throughout, but he distinguishes from the outset what is inert—as all nature is for Descartes—from a second principle that he calls active force. Newton in this way opens spaces throughout the Cartesian plenum in which spirit, this second principle, can operate. It is difficult today, in our world of universal engineering, to see again with Newton's eyes the significance of this distinction, and to recognize that a law of force, though strictly *mathematical*, is not thereby rendered *mechanical.* Newton shapes his geometrical mathematics as a rhetorical instrument rich in meaning; in such a world the statement that a system is mathematical throughout is by no means a reductive proposition. This distinction is of first importance to Newton, as it may well be for us, since it becomes clear that within the realm of nature the scope of the *Principia* is altogether universal. Thus the justly celebrated *System of the World*, Newton's account of the heavenly motions, becomes hardly more than an example, a first instance of the new system. *Force* is exactly the domain of what alchemy calls *spirit*, and Newton as master alchemist, as we now know him to have been, is surely on the track of the ultimate of the spirits in nature, the vital force. We once approached the *Principia* as the founding work of modern physics; now we see it as the culminating work of serious alchemy—a mathematical biology of all natural functions, inclusive of the very cause of life itself—and indeed, as Newton's *book of life.* The unity of Newton's thought may astound us, as we ourselves try to piece together in our own time a coherent picture of the world; thus, the *Principia* holds a central place in Newton's theology, since the concept of force restores scope for God's active presence in the world, a presence crucial to Newton's faith, for which mechanism had left no room.

Newton's successors have not of course understood his project in the terms he intended. The term *force* soon became a mere tool in the engineering of the industrial revolution, retaining nothing of Newton's sense of spirit. By the time James Clerk Maxwell had embarked on the study of natural philosophy in the middle of the 19th century, he was confronted at Cambridge University with a challenging but sterile mental discipline, in which a Newtonian law of force appeared merely as the blank formalism of an action-at-a-distance. Maxwell was at heart a Scotsman, curiously out of place at

Cambridge for all his ironic skill at mastering the English ways, and his own revolution, more fundamental perhaps than is often realized, began with a dramatic turn away from this sterile system. Maxwell embraced in its place the apparently naïve insights of Michael Faraday, who as a commoner with virtually no formal education, represented to all appearances, and indeed in his own terms, the most unmathematical of natural philosophers. Yet Maxwell maintained, publicly and to the end of his life, that of them all it had been Faraday who was the real mathematician!

The nature of mathematics, and of mathematical physics, is seriously in question here. Maxwell carefully shaped his own electromagnetic theory, and the symbolic structure of the vector calculus, to reflect as fully as possible the patterns that Faraday was perceiving in the magnetic lines of force traced by his iron filings. It was the *field* as a whole that had become primary, caught in its totality by the intuitive mind, with symbolic mathematics following behind. Maxwell was openly delighted when, well into his scientific career, he first encountered Lagrange's equations of motion, which characterize, in terms of energy rather than force, the motion of a *connected system as a whole*. Maxwell retained a deep concern for metaphysics, and this primacy of the whole is clearly a matter of first importance to him. He made certain to derive his own system of equations by beginning with Lagrange's, and from them moving toward electromagnetism by carefully specifying the values of the coefficients that would apply in this case.

Maxwell's equations, which result from this process, speak to the field as a whole. The individual bodies and the forces between them with which Newton had begun are for Maxwell the last, and indeed most problematic, concepts to appear. By way of the field and its patterns Maxwell makes electromagnetism intuitively accessible to every inquiring mind; his entire approach constitutes an inversion of the concept of science which undercuts at once both the primacy of mathematical symbols and the necessity of an aristocratic formal education. It was surely meant as his gift to Faraday, and more largely to what has been termed the *democratic intellect.* In our faltering efforts to comprehend whole systems in their entireties, whether environmental systems or the global human community, and in the austerity with which we still treat mathematics and the sciences as matters reserved only for specialists, it is clear that we have not altogether caught the significance of the revolution Maxwell was undertaking in our behalf. We should note, incidentally, that Maxwell's revolution is against the specter of Newton, not against Newton himself. For all their evident differences, in truth a deeper concern for the unfolding human spirit unites them. Newton's notion of the human spirit, expressed in a paradigm of law and obedience derived ultimately from the Old Testament, we might think of as essentially feudal; Maxwell perhaps reflects the larger course of human history when with equal concern he carries this same human spirit to the level of its democratic manifestation. Newton describes a layered world, of command, and obedience at a distance. Maxwell fills all the gaps. Each of his field equations applies everywhere equally, and as a set, they speak to a coherent cosmos. They are, in a sense, the very image of a restored and democratic social whole.

An understandable reaction to the title of this volume, *Newton / Maxwell / Marx* might be, "Why Marx?", since, in this country at least, Marx is not often thought of as a serious scientist. In truth, however, *Capital* in one giant step carries forward the very trajectory

of the concept of science we have been tracing. If Faraday and Maxwell have made the science of nature accessible to the democratic mind, Marx in effect invites his readers to turn this new light upon the study of society itself. To an extent that is not often remarked, *Capital* analyzes the system of capitalism in ways strikingly parallel to Newton's analysis of the motions of the planets in the *System of the World*. Thus, as Newton begins with *mass* as the measure of undifferentiated matter, so Marx with extreme care defines a corresponding social quantity, the *undifferentiated labor hour*. And *Capital*, similarly, builds upon a universal law of motion, the *law of surplus value*, delineated with precision, whose operations Marx tracks scrupulously through the phenomena of the system of capital—profit, interest, and rent. It is, of course, not a system Marx loves, nor in his view one destined to endure. Surplus value, and with it profit and the driving force of capitalism, arises only through the fact that labor is never paid at its actual value. Further, since laborers sell what belongs most essentially to them, their very power of free human activity, Marx sees this as a system based on a the universal *alienation* of the human.

This perception, though it introduces a tone of moral judgment that is sustained throughout the work, is never allowed to relax its strictly scientific character. In this sense, *Capital* never descends into ideology. Instead, Marx reasons with scrupulous care from the system that lies before him, to an analysis of its future trends. He demonstrates the existence of certain secular tendencies that are fraught with consequence for the system itself. Once again, it is striking that Newton in the *Principia* followed a similar path. In one magnificent proposition, to which perhaps too little attention has been paid, Newton directly confronts the fact that a universe that contains more than two bodies cannot sustain the perfect order which he has so carefully described. This *three-body problem* inherently defies solution, but, undaunted, Newton traces its consequences through argument inevitably blending the qualitative with the quantitative. Out of it he draws, almost magically, his theory of the tides, the precession of the equinoxes, and more largely, the prediction of an ultimate demise of the original order.

Marx, similarly, defines motions within capitalism that must work to undo its original order. He has shown how the law of surplus value inexorably leads every manufacturer, wherever possible, to substitute machinery for human labor. With real awe Marx has depicted the growth of large industry and the development of machines which ingeniously replicate human skills. The other side of this coin, however, is the fact that labor, the sole source of surplus value, is everywhere extruded from the system. In the long run, therefore, the rate of profit, and with it the life of the system, must tend to fail.

Both Newton and Marx have their eyes fixed on distant futures, therefore, and, remarkably, for neither is this bad news. Newton foresees a time, not perhaps so distant, when the Creator will once again exert His hand to reform the work. It is beyond the scope of *Capital*, and of the present study as well, to ask what prospect the demise of capitalism may hold for Marx. He realizes that the new machines might labor for us, yielding to everyone resources to live freely in directions which the individual human mind, released from alienation, could choose for itself. Yet though *Capital* delineates the grounds for this possibility, in this scientific work it appears as no more than a path which lies ahead, and the briefest glimpse of what Marx perceives as a light beyond.

Taken together, these readings constitute three windows on the evolution of the concept of science as we know it today, yet any suggestion of a single, linear progression would be misleading. These are complex works, each of lasting value in its own right, and their relationship is surely dialectical rather than simply linear. Thus though few today might be comfortable with Newton's own account of theology, nonetheless the breathtaking scope and unity of his work still reminds us that the human mind is ultimately one. That department of human activity we now attempt to isolate as *science* cannot finally exist in separation from the universe of our broader concepts and concerns. Similarly, Newton's sense of the rhetorical role of mathematics, worthy in his view to serve as a vehicle of spirit and human understanding, might startle us into a new line of thought about mathematics today. If after all mathematics is neither mechanical nor reductive, this insight may reassure us as we now tread so closely upon the full realization of Newton's original vision, the mathematization of all nature, not excluding ourselves in our natural being, and perhaps even of the very source of life itself.

In such a dialectical unfolding, the past is never left behind, but always incorporated in the new. Thus these overriding insights of Newton's do not dim as we approach that very different vision of Maxwell, that inversion contained in the idea of the *field*, in which the whole, whether social or natural, becomes primary and coherent. The idea of causality remains, even as the overall pattern becomes explanatory, and Newton's *force* becomes, literally, only a derivative concept. With this transformation, *science* itself becomes a significantly new concept, an instrument of intelligent, critical thinking intuitively accessible to all, and a crucial bond of any democratic society. Yet we are speaking of a vision of science which, though new a century ago, today exists in our society as no more than an unfulfilled goal. People in our time on the whole avoid the study of science and think of it still as a remote domain, reserved for experts. We have not yet risen in practice to the challenges of Maxwell's insight; we have not even quite caught the significance of our failure.

Finally, what are we to make of Marx? It is almost as if we had read *Capital* until now only as ideology, failing to confront the vastly expanded concept of science which Marx is proposing, in which society itself, its institutions and its practices, become objects of serious scientific thought. We apply, it is true, seemingly endless quantitative measures to society, proliferating sophisticated methods of descriptive mathematics, but we do not follow Marx in developing a *causal theory* comparable to that of the *Principia*, explaining how and why capitalism and its institutions work. It may be hard to deny outright the possibility of developing such a theory, if indeed we have in *Capital* a paradigm of the completed project. The issue is surely critical to the idea of science and its role in modern society, for it directly affects our social behavior. In matters concerning nature and technology, which belong to the world of what we do call *science,* we reason together dispassionately and submit disagreements to the forum of evidence and reason. In the social domain, by contrast, concerning matters which we say lie *outside* of science, we substitute opinion for truth, veil issues in obscurity, act in conflict rather than cooperation, and resolve disagreement through levels of violence worthy only of a barbaric age. Marx extends the scope of science, and would have us reason as a community, intelligently and cooperatively, in matters belonging to the social domain as we do in those of nature and technology.

Newton / Maxwell / Marx, in exploring these and other aspects of the concept of science, constitutes an invitation to fresh thought about these matters; it aims in particular to bring light to bear upon the most deeply underlying questions. This book shows a way in which serious study of the history of science can contribute importantly to our thinking about ourselves and about our world today.