Marxism and Scientific Method

by Abe Bloom and Steve Bloom

"Life is short, the art [of healing] long, opportunity fleeting, experience treacherous, judgment difficult"—Hippocrates

"Truth emerges more readily from error than from confusion"—Francis Bacon

"Doubt everything"—Karl Marx

Preface: Why the present text and authors?

Let us begin dialectically, with an apology that is not really an apology. The two authors of this paper (father and son) are, in some ways, not the ideal people to be writing on the subject of Marxism and scientific method. We are not scientists, nor have we been able to take the time to bring ourselves up to date on the latest thinking about the history and philosophy of science—an area where much research and discussion has taken place in recent decades. We recognize full well that our present effort will probably be deficient on that account, at least in some respects.

On the other hand (and this is why we do not really apologize) we believe that we bring something to this presentation which most academics who have had the time to study the history and philosophy of science cannot—a collective 11 decades (more or less) of activist experience in the struggle for social change in the United States, combined with a serious, if amateur, interest in problems of science and scientific method. (Abe enjoys a formal training in mathematics and engineering as well).

And because of our interest in science something has struck both of us in the course of our activism—even though it has been in different milieus of the socialist movement. While Marxists have, since the time of Marx and Engels, referred to the approach we try to pursue as "scientific socialism," the actual practice of our movement has often violated important principles of scientific discourse and investigation. In addition, we are immodest enough to think that our better appreciation of a genuine scientific method (how to gather and analyze data, what kinds of inferences are legitimate in particular circumstances and what kinds are not, etc.) has been of some assistance to us in trying to understand political events and act intelligently in relation to them.

We therefore consider it completely valid for us to try and contribute a few thoughts on the general topic of Marxism and scientific method. More broadly, it's our hope that by making this attempt we can generate a broader discussion that will fill in any gaps and correct any errors that might exist in this presentation. That is one reason why we are developing our thoughts in the form of a "working paper," and not as a final and definitive statement of position.

There are other reasons why we feel it is valid for people like us to write on a subject which some might want to reserve for "experts" in more academic discussions about the history and philosophy of science. Marxism is (or at least *should* be), above all, a discipline for activists. In our experience, however, much of the academic discussion tends to become so abstract that it is virtually impossible for anyone to understand it unless they are willing to devote full-time to the study. And yet, if to *really* understand basic problems in the philosophy of science one must approach it in this way—and essentially give up activist pursuits as a result—then the understanding can have little practical value.

So one of our goals is to begin to develop an appreciation of scientific method with a real practical utility for activists, which means it must be relatively brief and accessible to the average intelligence. We consider this particularly important today because it becomes clearer and clearer that many young people join the socialist movement with little real understanding in this area, a fact which seems to be increasingly true as the American education system (we cannot speak from experience about other countries) puts less and less emphasis on science, and as more and more pop notions are confused with real science by the general public. Sections II, III, and IV of the present paper are specifically included here with this task in mind.

Another goal we have is to respond to those within the Marxist movement who have questioned the validity of calling our approach "scientific socialism" because it is not as precise as "science" in making predictions and determining what the effect will be of any particular action we might take. This, we will argue, simply reflects a misunderstanding about the diverse nature of scientific inquiry and scientific knowledge in general. We speak to this in sections I, IV and VI.

We also consider it necessary to respond to the opposite problem, which dominated the thinking of the Stalinist movement for so long. This school rationalized its behavior by reasoning that since Marxism is, by definition, scientific socialism, Marxists can therefore act with the absolute precision and infallibility of "science" in dealing with social and political problems. This, of course, makes the same error about the nature of science and scientific inquiry, and especially misunderstands the limitations of social science. The relevant issues will be taken up mostly in sections I and VI.

Section VI also begins to develop a whole series of conclusions about how the Marxist movement should organize discussions and handle problems which arise in the course of our political activity. To some extent these may reflect simple, practical conclusions which one could (and some have) come to without a specific study of scientific method. But we feel that by looking at the problem from this vantage point we can contributing something that will improve and deepen our understanding.

Finally, we end with two more speculative sections (VII and VIII), taking up questions we think ought to be given some serious consideration. Here we simply hope to stimulate further thought and discussion.

Our goals, then, are multiple and it would be impossible for a paper of this length to fully achieve any of them individually, let alone all of them together. And yet, if we waited until we could produce an "adequate" study we have the sense that it would probably never happen—given all the other issues and problems we have chosen to concern ourselves with. If we saw someone else addressing this set of concerns in a way that seemed reasonable then we would probably defer to them. But we do not. So we present this effort in the hope of helping to stimulate a process which will, over time, and with the help of others, move the consciousness of the Marxist movement in the right direction.

We would like to thank the many friends and comrades who contributed comments and thoughts about an earlier draft of this paper. Their suggestions have been extremely useful. In particular we would like to single out Justin Schwartz, for his serious critical judgments which forced us to think through a number of problems more rigorously, and Peter Downs, from whom we have borrowed, wholesale, a couple of paragraphs.

I. Marxism as "scientific socialism"

A concern with the general question of how Marxist politics relates to more general problems of philosophy and science is as old as Marxist politics itself. Marx was a deep student of philosophy and wrote extensively about the theories of the German philosopher Hegel, along with many others. Engels (*Anti-Duhring*), Lenin *(Materialism and Empirio-Criticism*), and Trotsky (*In Defense of Marxism*) all wrote a good deal on questions of science and philosophy.

As noted in our preface, from the time of Marx and Engels the approach that they developed in the sphere of revolutionary politics has been known as "scientific socialism." But, like many ideas developed during the early days of our movement which were subsequently abused and misapplied, this term has also generated much confusion. The basic issue can be posed simply enough: how can anything as fraught with uncertainties and with such a penchant for erroneous prediction be called scientific?

One aspect of our problem arises from those, mostly in the Stalinist or sectarian traditions, who seem to believe (and sometimes explicitly state) that since they are students of Marxism, and since Marxism is scientific, they can therefore make some absolute claim to know "the truth." Of course, that claim is absurd. But it's absurd not because Marxism fails the test as a scientific discipline. Rather, it is absurd because it reflects a caricatured and unscientific notion about science itself. No real scientist would ever express such an idea—in any field whatsoever.

It is essential to look at this in more detail.

When most lay people think of science what springs to mind is the hard, experimental disciplines such as chemistry or physics. Here the truth or falsity of specific propositions can generally be tested through controlled experiments. But science actually includes a wide variety of different areas of study, and scientific method must therefore include a variety of different approaches for testing the validity of specific propositions. It is not only the social sciences—which Marxism concerns itself with—that proceed through means other than controlled experiments. That is also the case in natural sciences such as meteorology, astronomy, cosmology, geology, oceanography, and many more.

Indeed, what can we say about a field such as medicine? The quote from Hippocrates with which we began this paper (couldn't we say the same about the art of revolution?) describes the dilemma, despite all of the advances in knowledge and experience since the time that he lived. Physicians are still often stumped by particular patients. They make wrong diagnoses and prescribe wrong treatments. New diseases, and new manifestations of old diseases, constantly arise. Does this mean that there is no scientific basis for the practice of medicine, even if it is also an art? Should it surprise us that Marxists, who have a far smaller base of experience from which to draw our conclusions than do physicians (far fewer revolutions and social upheavals than medical patients) can also make wrong diagnoses and propose incorrect approaches to specific problems from time to time? It would, in fact, be amazing if this were not the case.

But if we can learn to approach our work in the same spirit as a really good physician then each mistake will become the basis for an improvement in our knowledge and understanding. That, too, is simply one aspect of scientific method which we will discuss below.

Unlike other revolutions in human history, the socialist transformation requires a conscious intervention of human beings armed with an understanding of the scientific laws of social change. A brief comparison with the bourgeois-democratic revolution will illustrate why this is true.

First, the bourgeoisie, emerging within feudal society, gained economic ascendancy long before it began to contest for political power. That made the conquest of political power a *relatively* simple task. The working class, on the other hand, will remain economically subservient to the bourgeoisie until *after* it conquers political power. It's political tasks are, therefore, far more difficult and require a far higher degree of human consciousness in order to succeed.

Second, because of their wealth and power members of the bourgeoisie had the leisure and education to participate in intellectual pursuits themselves, and the money to buy the services of the most talented writers, philosophers, scientists, and others. They were therefore able to begin shaping the ideological assumptions of society long before, and as a precursor to, gaining political control over it. The working class, on the other hand, enjoys precious little leisure time, often suffers from a second-rate education (at best), and faces an incredibly powerful ideological onslaught from an intellectual establishment that is owned, body and soul, by the present ruling class.

So working class revolutionaries must take special measures to overcome these problems. That means, above all, an application of the *scientific socialist* methodology first introduced by Marx and Engels which, in turn, should include an active study of scientific method. Only if we apply to ourselves the same rigorous standards that we would to any scientific endeavor will we be able to properly correct our mistakes and forge Marxism as an adequate tool for the tasks we have set ourselves.

Yet the study of scientific method is an area which Marxist education has traditionally ignored. We hope, through this working paper, to begin to correct that situation.

II. Some thoughts about western science from prehistory through the present day

Our goal in this section is to take a brief look at the ways in which society's approach to science and knowledge has changed over time, and some of the social, economic, and material factors which have influenced that process. This is important in terms of understanding how our present conception of scientific method evolved, and how this process of evolution in our understanding is continuing, even today. It will help us appreciate the need to both use the tools it places at our disposal, and simultaneously look for ways to sharpen and improve those tools.

The first thing to note is that a scientific effort to understand scientific method is a relatively recent historical development—although people have been doing science for a very long time. Human beings often do things before we have a thorough understanding of what we are doing. A baby will start to say words and then put them together into proper sentences. But if you ask the child to explain the structure of language or the grammar of a sentence s/he won't know what you are talking about. People were doing science long before they thought consciously about what scientific method actually is.

Humans like us have been on earth for some hundreds of thousands of years. During the overwhelming majority of that time they lived by means of hunting, fishing, and gathering. And the only materials known for the production of tools to help in this process were those placed easily at hand by nature—things like stone, wood, and bone.

Gradually people learned how to forge and shape other kinds of materials: pottery, bronze, gold and silver, for example. When humans learned how to domesticate animals and—even more importantly—plants, they were able to settle down in one location and make their living in a new way, through agriculture. How did people acquire the knowledge that made it possible to carry out this revolution in production? What was their scientific method?

By the time of the first recorded history, about 3OOO BC, we find great civilizations flourishing in Egypt, Mesopotamia, China, India, and Central America almost simultaneously. People had acquired a great deal of knowledge. They knew about fire, handling animals, how to carry on agriculture, handicrafts like weaving and pottery and working with metals. They knew about astronomy. The Babylonians and Egyptians could predict eclipses. They developed that wonderful tool the written language.

We properly stand in awe of these great achievements. How did they do it? Remember, it took hundreds of thousands of years, but these first important pieces of knowledge came the hard way, from life experience, without any *conscious* method. Much of it was by accident. We can guess that fire could have been discovered, for example, when lightning struck a tree which began to burn.

Myths and folk tales deal with questions of learning. There is the story in Greek mythology of Prometheus, who because he was half god and half human took pity on humans and taught them how to make fire, for which he was punished by the angry gods. The Bible tells about Adam and Eve eating the fruit from the Tree of Knowledge—and again they were punished by God. The American Indian tale where God teaches humans how to plant corn is a gentler story.

These myths indicate how early humans thought that knowledge was either derived from the gods or learned by accident. There was no conception of the search for knowledge as a conscious and systematic activity. Today we can conjecture that through life experience and the sharing of these experiences with others, through the transmission of what was known from one generation to the next, and the building up in that way of an accumulated wisdom over a very long period of time, great achievements were possible.

So, this was the hard beginning. But a "Great Leap Forward" was made by the Greeks. If we study Aristotle and Euclid we find that they, along with other Greek philosophers, dealt systematically for the first time with an important aspect of thinking—Logic.

Consider Euclid first and his work in the field of geometry. Before Euclid the Egyptians and the Greeks had made many discoveries in geometry. The Egyptians particularly had to learn how to make land measurements because the regular flooding of the Nile required a constant redivision of the land among its users. So they made many discoveries in a practical way, particularly with respect to triangles and circles.

Euclid's breakthrough was to discover that this geometric knowledge could be organized in a systematic manner. Pieces of knowledge were not separate in themselves but were connected to each other. By starting with a set of twelve statements, which he called axioms, all the other knowledge of geometry could be derived.

The process of implication, that knowledge of (A) leads to knowledge of (B), is not so surprising today. We are accustomed to this kind of thinking and are aware of it as a conscious process. It has become part of our every day life. If Ethel is older than Anne, and Anne is older than Selma, we know that Ethel must be older than Selma. From one bit of knowledge we can infer other knowledge. The whole science of implication establishes the rules for this process—how to derive new knowledge from preexisting knowledge. You don't have to rediscover truths on each occasion.

A complete exposition of the rules of logic—not to mention a discussion of the difference between formal and dialectical logic—is beyond the scope of this paper (though we do hope to develop a companion paper at some point which will deal with the question of dialectical logic and its relationship to all of this). But it is essential to note how a conscious application of logic has come to play such a crucial role in all modern scientific work, and the importance of the fact that different truths are not separate entities but are interconnected. If you know ABCD you can infer EFGH. We also need to remember that this tool of a systematic logic was not always at the disposal of human beings. It had to be discovered and consciously developed.

Aristotle went beyond Euclid by extending the idea of implication to all fields of knowledge, not just to geometry. He developed laws of logic that were universally applicable. Even as late as the 193Os, when courses in logic were taught, they were not very different from what Aristotle had formulated in 3OO BC. That's quite an achievement for a single human brain. So it is legitimate to give Aristotle credit as one of the outstanding thinkers in human history. (Of course there have been some very important advances in the field: the development of symbolic logic and the work of Bertrand Russell, for example. These advances are beginning to play a major role today, especially in computer science.)

So with the conscious development of logic a great step was made in the pursuit of science. But a strange thing happened. This discovery led, in a certain sense, to the deterioration of learning rather than its advance. What accounts for this contradiction? It resulted from the character of Greek society, where a schism existed between mental activity and practical work in an economic system based on slavery. The job of thinking and the search for knowledge was in the hands of the slave-owning aristocracy which did not have to do any real work. Once they had this tool of logic and could develop new ideas from accepted principles, there was a strong temptation for philosophers to spin whole systems of knowledge from already established truths—with no consideration of whether the real world had anything to do with the theories they were elaborating.

Earlier in Greek history, around 700-600 BC, there was an explosion of inventions and interest in the experimental method. That period was short-lived, however. It was a time when laborers and artisans in Greek society were still largely free men. Even the oarsmen on their boats were free and formally full citizens in their society. Within a couple of centuries, however, Greek society became more hierarchical and the system based on slavery became dominant. Respect for science and inventiveness declined. This is when it became acceptable to think about things, but not to apply those thoughts to the material world. The great engineer Archimedes, for example, when he refused to write a handbook on engineering, gave as his reason that everything which would make life easier was ignoble and vulgar.

Aristotle himself was not completely free of the tendency to spin theories based on previous theories, without really checking them against experience—but he was better than most. He wrote on a variety of subjects: physics, chemistry, politics, esthetics, and ethics. Because he wrote so much and was so highly respected he became an authority. Eventually (by the middle ages) things even got to the point where, if people wanted to know whether a particular idea was true or false they wouldn't have to check it against practical experience. They could simply go to the writings of Aristotle to find out. (Can we note a parallel with the way many who would consider themselves Marxists treat the works of leaders like Marx, Engels, Lenin, and Trotsky?)

After the Greeks came the Romans, who looked to Greece for their science and carried on the same traditions in this field. Rome failed to develop any great scientific thinkers of its own. There was also a freeze on the development of new technology. On the periphery of the empire there was more openness to invention and, presumably, scientific thought. A Danish carpenter developed roller bearings for wagon wheels. Farmers in Gaul used a mechanical harvester pushed by oxen. An unknown inventor developed a paddle wheel driven ship, powered by oxen hooked to a capstan. Such devices are too complex to be simple "happy accidents." Their development had to be informed by some amount of theory and experimental method. But they remained purely local developments and eventually disappeared.

Later, during the Middle Ages in Europe, another set of documents, the biblical texts, became an additional source of revealed truth. At this point it was considered perfectly acceptable scholarship to start either with Aristotle or the scriptures, and then use logic to prove almost anything. No one had to examine the real world in all its complexity. Of course there were, even during the middle ages, counter trends, scholars and scientists who tried to do things in a way that we would consider more consistent with the proper (that is, experimental) practice of science. Our point is simply that this was not seen as a *necessary* part of the pursuit of knowledge, and it wasn't particularly encouraged by the ruling classes. The dominant approach tended to rely more on simple logical deduction flowing from previously revealed truths.

Today it seems obvious to us that this process had serious limitations. But it took an act of genius to change the prevailing pattern, a good illustration of how thinking is inevitably constrained by the social and philosophical assumptions of any culture. The break with medieval thinking came at the beginning of the Renaissance, which coincided with the emergence of merchant capitalism as a significant social force. For our study of scientific method there are two names that are outstanding in this period: Galileo in Italy and Francis Bacon in England. Both of them contributed the same simple idea: that theories about what is true could not be proved by logic alone. They had to be tested against experience.

It was being taught in the schools at this time, as a result of Aristotle's writings, that if a heavy weight and a light weight were dropped from the same height, the heavy weight would reach the ground first. Galileo did a very remarkable thing. He asked: Is this really true? And he decided to do a test to find out. He went to the top of the Tower of Pisa (at least, that is how the popular story goes, and for our purposes it doesn't really matter whether it is literally true or not) and dropped a heavy weight and a light weight. They both reached the ground at the same time. This was a truly remarkable achievement—a breakthrough scientific experiment, and one that challenged a highly respected authority.

Actually, as we have noted, learning through interaction with the real world was the only method people had before Aristotle. Galileo simply returned in a conscious way to this earlier process, which had taken a back seat for centuries because of the great respect people had for the achievements of the Greek thinkers, particularly Aristotle. Galileo took a step backward, in this sense, in order to move forward to a more powerful method, one in which science could incorporate *both* real world experience and the advantages to be derived from the use of logic. The power of his contribution was in this synthesis. Galileo never tried to minimize the importance of logic as part of a scientific approach, while at the same time working hard to overcome the stagnation which had been brought about by an overdependence on it.

Francis Bacon (1561-1625) lived at the same time as Galileo (1564-1642) and William Shakespeare (1564-1616). He advocated a new method of seeking knowledge, by emphasizing a direct appeal to nature and to a study of facts through the observation of phenomena. he even tried to set up rules for making scientific discoveries, some of which had an important influence on later thinking about the subject.

Bacon counterposed his approach to two prevailing attitudes toward science: One asserted that everything which needed to be known already was, in fact, known and all that remained was to elaborate and explain based on the Greek texts. A second argued that the subject of science was simply too vast, and therefore essentially unknowable. In his work, *Novum Organum,* Bacon described these two schools which "must be dismissed." (We cite this here because we will have reason to return to Bacon's insight later, when discussing the implications of all this for the Marxist movement):

> The first were the speculative or logical philosophers, who fashion nature according to preconceived ideas and who employ in their investigation syllogisms and abstract reasoning. The second class, equally offensive, consists of those who practiced blind experience, which is mere groping in the dark, who occasionally hit upon good works or inventions, which like Atalanta's apples distracted them from further steady and gradual progress toward universal truth.

Bacon also attempted to study and consciously classify the different sources of error that could creep into a scientific investigation as a result of human prejudices, perceptual and linguistic limitations, and logical fallacies.

European society at this time was still mainly medieval. But, as noted, merchant capital was beginning to make its power felt. The wealth that accumulated in the Italian city states produced a flourishing of the arts which still ranks among the great wonders of the world. The rising power of merchant capitalism moved from Italy into Holland and then to England, where it laid the basis for the Elizabethan period.

This new social force had different material needs from those of the feudal nobility. The old aristocracy got along perfectly well without a science that went much further than what was written in the bible and the old Greek texts. The mercantile class, on the other hand, needed to get out and discover the world—if for no other reason than to find spices and other exotic products which could be sold, thereby increasing their personal fortunes. This was the primary force behind the great explosion of navigational efforts by Europeans around that time, which by itself fueled a whole range of scientific enterprises and discoveries.

Another factor in the development of scientific knowledge during this period was the need for improved means of waging war. To some extent, of course, this was an age-old pursuit of the human race. But the rising capitalist class also stimulated that effort because of its even greater need for conquest in order to profit from the exploitation of other nations—as well as the increased danger of confiscation by being conquered.

As we know, once capitalism got its initial foothold in Europe it grew stronger and stronger, developing through a series of stages into industrial capitalism. This process made great demands on all branches of knowledge. Industry in particular requires improvements in technology which cannot be accomplished without a better understanding of the chemical, physical, and mechanical processes involved.

In particular, the industrial revolution was made possible by Isaac Newton's great contributions in the field of mechanics, which placed this science on a sound experimental and logical foundation. It was now possible to understand the mathematics of why Aristotle was wrong about the speed at which different weights would fall, and why Galileo's experiment turned out as it did (though a physical explanation of this was still lacking).

Today we are familiar with the idea of a chain reaction. That's what began to happen in many scientific disciplines. An explosion of knowledge took place—particularly in the fields of physics and chemistry which are most closely related to industrial processes. As a matter of fact we might even say that today there is an overproduction of scientific knowledge—beyond what people are able to deal with. It has been some time since any mathematician, for example, could know anything about most branches of mathematics. It is now all s/he can do to keep up with developments in a tiny specialized discipline. The same is true in virtually every field. And in certain areas—as diverse as nuclear technology and genetic research—society as a whole finds itself completely unable to deal with the potential consequences of new scientific discoveries.

III. Truth, observation, and logic in the scientific process

Along with this increase in our knowledge of science there has also come a greater awareness and codification of the methods by which scientific discoveries can be made. We are now ready to discuss a number of specific approaches to the solving of scientific problems. They all combine observation of real world experiences with the use of logic, but the weight given to each aspect will vary considerably depending on the particular science and the specific question that is being investigated.

Let us consider the relevant problem in its simplest terms: How do we know when something is true? Those who followed Aristotle would say that we know a truth because we derived it from a known truth. But this is a never ending process. How do you know the first truth? There must be another source of truth, because we cannot begin to learn from nothing.

The solution to this problem, as we have seen, lies in our examination of the world in which we live and the accumulation of empirical experience as a result of our interaction with it. From this we derive those initial facts which can then be used to supply the logical process with the raw material it needs. But when we start studying the world we run into some problems. We rarely have the certainties that we would like to have, or that those who derive their "knowledge" from sheer reason often believe that they do. We have to sacrifice the comforts of absolute truth and learn to live with a more uncertain reality.

While aware of all the limitations inherent in assigning things to rigid categories, it seems reasonable for our purposes to consider four different kinds of statements that present four different kinds of problems when we try to prove whether they are true or false. We are aware that various writers on this subject have proceeded in different ways, and there is no one approach which is right while all others are wrong. However, the method outlined here is one that we find both simple and practical for pursuing the goals of this paper.

Let us divide statements about the world up in two different ways:

First we can make a distinction between those which we will call "particular" and those that are "general." Particular statements deal with very specific things—for example, an individual sweater, a book, a box etc. General statements speak about all of something, like all human beings. Proving a general statement is a very different problem from proving a particular one.

Then, both particular and general statements can be divided on the basis of whether the phenomenon we are studying can be directly observed or not. For example, If I say this flower is red, I can look and see if that is true. If I say this cloth is black with gold trim, it can be tested by observation.

On the other hand, the statement that "water is made up of two hydrogen atoms and one oxygen atom" represents an example of something which we can state with conviction, even when it is not directly observable. Until very recently there were no microscopes powerful enough to resolve things down to the atomic level. Yet the chemical composition of water was established long ago. To determine it scientists had to apply different criteria than those that we use when we can actually look directly and see whether or not a thing is true. (All historical data is of this type. Consider the statement: "Napoleon lost the battle of Waterloo." We cannot travel back in time to actually observe the battle.)

By combining these two divisions we come up with four different kinds of statements: type I—those about a particular observable; type II—those about a particular unobservable; type III—general statements about particular observables; and type IV—general statements about particular unobservables. It is probably safe to say that every scientific assertion falls into one of these four classes, and each requires a different method to test its validity.

It is interesting that over time certain names have come into use with respect to scientific statements. Although no one has consciously attempted to assign specific names to our four types, particular names have tended to be used for each of them as follows: Statements about particular observables (type I), once they are verified as true, are called “facts,” or “data.” Statements about particular unobservables (type II) are called “hypotheses” before they are tested, and “truths” after they have been verified. Well established general statements about particular observables (type III) are called "laws." (The "law of gravity" would be an example.) And general statements about particular unobservables (type IV), even when they are widely accepted as true, tend to be referred to as "theories" (as in "Darwin's theory of evolution by natural selection" or "Einstein's theory of relativity").

It is essential to note that dictionary definitions and some common uses of these terms differ. (To a certain extent, at least, this reflects the various approaches used by different writers on this general subject which we mentioned earlier.) For example, some will use "hypothesis" and "theory" interchangeably. General statements about particular observables (type III) also tend to be called "theories" until they are properly established. Still another use of the term "theory" is exemplified by the "Theory of Euclidean Geometry." Euclid starts by defining a set of terms—point, line, plane and angle—and then assumes as true a set of propositions (statements) also called axioms, from which all the remaining propositions are logically derived. The axioms may be type III or IV in our classification. In this meaning, "theory" refers to the entire set of propositions that form the basis for further deduction of new truths.

This may seem very confusing, but in general one can adequately judge the meaning of these terms as they are used in particular cases, from the context.

We are now ready to take each of our statement types and see how we test them to see if they are true.

The simplest one to discuss is type I, the particular observable, which will become our basic fact or item of data. Take as an example: Mike has brown eyes. If the light is good enough we can just take a look and see. If it turns out that Mike has blue eyes, or black eyes, or any color other than brown, then we know that the statement is false. Here a proof is achieved by taking a look, or touch, or whatever might be required to make the observation.

We should be aware that many factors can effect observations: temperature, kind of light, etc. So we have to make repeated observations under a variety of conditions in order to be sure of our result. We also have to remember that we are looking at the “specific observable” in a particular context of time and space. Perhaps on another planet, or galaxy, or universe, our observation might turn out differently. And of course everything depends on your definition of “brown.” That is why good observation is an art, and why even with such a simple question some logic has to be applied and a little uncertainty is inherently part of the process even after repeated and rigorous testing.

Next we can consider the type II statement, our hypothesis about some particular unobservable. How was it determined that water is made up of hydrogen and oxygen? Scientists could not see the water molecule directly, but they could see what happens when we take water and go through certain processes which will break it into its component parts. We end up with hydrogen and oxygen. Likewise, we find that we can combine these two elements and come up with water. Once again we have to think of every possible variable that might affect our result—the source of the water, chemical composition of our apparatus, etc.—and try our experiments in many variations.

But after a while we can say that we have proven the truth of a statement that is Type II, a particular unobservable, by amassing a body of evidence based on things we can observe (a series of type I statements) and fitting that evidence into a logical pattern. The statement that water is made up of hydrogen and oxygen is consistent with all of the facts which we can observe to be true about the chemical composition of water. It is the only such statement about which this can be said. We can therefore confidently assert that it is true.

We have not really studied logic sufficiently to do a strictly rigorous test. But most people have, from their own experience, developed some logical know-how that they depend on as a guide. At this point it is sufficient to note that logic plays an essential role in our proofs of type II statements.

We can also see that there is a connection between the two kinds of statements we have taken up so far. The particular observable is proved by direct observation and gives us a mass of facts or data. The particular unobservable can be proved by accumulating sufficient facts or data, and then establishing—through logic—that what we can't observe must be true since it is the only reasonable explanation for those things which we can observe.

A word of caution is essential at this point. No science is completely immune from the influence of social assumptions and individual prejudice on "logical" judgment—a problem which Francis Bacon recognized in the 16th century and which still has not gone away. We could cite many historical examples where scientists have "proven" things which were, in fact, not true at all—but were nevertheless ideologically reassuring to them at the time. Sometimes this is accomplished by finding an excuse to omit uncomfortable data from the calculation in question, or by simply ignoring it entirely. In other cases the result is achieved by insisting that a particular logical conclusion is the only possible one when, in fact, that isn't the case at all. Thus people are frequently able to believe what they want to believe, ignoring the existence of contrary information and reasonable alternative explanations. This difficulty exists not only with statements which we here designate “type I” and "type II," but also, and to an even greater extent, with types III and IV which, as we shall see, also depend heavily on logic for their proofs.

This brings us to the more difficult kind of statements, general ones—which involve the concept of "all." First let us take up the general statement (type III) in which a particular instance is observable. An example of this, used in every book on logic, is: "All humans are mortal."

You know your Aunt Millie died. You know your grandmother died. Etc. So any particular example of this statement can be tested by direct observation. But we are not just talking about specific individual cases. We are saying "all." This creates a real problem because it is impossible to prove this simply by observing individual instances. The exception might always be the very next case which has not yet been observed. So how do we make the transition to "all"? Again, we have to make tests in every possible different situation that we can think of. Maybe all American humans die but not non-Americans. So we must apply our test to non-Americans. Maybe people who live in the mountains do not die, only those who live at the seashore. So we have to check over and over, but not just repeated checks of the same situation. And we have to change things until we have exhausted every possible variation that we can imagine.

But even so, as noted, we cannot possibly test *all* variants (which is what we want to prove) and once again we have to apply logic to the question. We have some knowledge of the biological processes of aging and the way the body begins to progressively break down. We know about the prevalence and the impact of disease. We know the probability of any individual undergoing a fatal accident. So, combining this knowledge with our empirical tests we can look at the situation and say that the universality of human mortality is a *sufficiently overwhelming probability* that it can be *treated as if* it were definitively established.

Let's take another example. We know that if you take ordinary table salt, add some to a glass of water and stir it, it will dissolve. But can we say that all salt dissolves in water? We only did one test. Suppose you took the salt from a different package, would it dissolve? Suppose we raise the temperature of the water, or lower it, would the salt still dissolve? Suppose there is already a lot of salt dissolved in the water? Again we see the need to imagine every conceivable variation of the test and proceed to try it. Then we combine the results of these experiments with what we know about the chemistry of water and salt and we are able to come to some reasonable conclusions.

This kind of proof is carried out by experiment, varying it in every conceivable way, buttressed by general information about the processes at work. But even after we have done this kind of exhaustive proof there might still be some aspect that we did not account for. Some other experimenter might come up with a variation that never occurred to us and prove that we are wrong. So while we always try to establish our conclusions with as much power of evidence as possible we also have to remain open to the possibility of something new, something that might require an adjustment in what we think, or even a whole new way of thinking.

Keep in mind, however, that even when that sort of development takes place, when seemingly well established scientific laws are overturned by new discoveries, they are not necessarily disproven in an absolute sense. They often turn out to be *essentially* true for a specific subset of the phenomena which they had been attempting to describe universally. When this is the case they will be incorporated into any new general set of laws as a useful component part, even if the way they are expressed has to be modified to fit the new theory. The most famous example of this process is what happened to Newton's laws of motion when Einstein showed that other equations were necessary to explain the behavior of matter as it approaches the speed of light. Einstein's new formula actually confirmed Newton's laws as basically accurate for objects traveling at lesser velocities—though the new mathematics took account of the more precise conceptions developed by Einstein.

Let us now consider our final kind of statement, type IV. How do we prove a statement that is general, that deals with "all," and where the particular is not observable (a statement to which we have given the name "theory"). As an example let's take the atomic theory of matter, the statement: "All matter is made up of atoms." As with the question of the composition of water, this was established long before there were microscopes powerful enough to make atoms directly observable. What made scientists so sure?

Their certainty came because if they assumed the truth of the statement about matter and atoms, logic could then be used to derive a number of consequences. A whole variety of these consequences which *were* observable could be tested, by means of experiment. If it is discovered that the theory predicts facts or truths in a wide variety of situations it becomes reasonable to conclude that the generalization is also true.

Once again this cannot create certainty. It is only possible to disprove a theory if the consequences it predicts turn out to be false and there is no good reason to question a well-established appreciation of reality on which it is based. If your experiments do not come up with the expected result then you know that your theory is inadequate and needs to be adjusted, or discarded entirely. As it stands, we can simply say that if test after test turns out as expected and no instance arises which is contrary to the theory, the level of confidence can become very high. At a certain point, as with our general statement about human mortality (a type III statement), we can for all *practical* purposes treat a theory (or type IV statement) as scientifically established.

And, as with scientific laws, once such a stage has been achieved even if the theory is eventually shown to be flawed it is unlikely to be overturned in its entirety. It will probably remain true as a component part of any newer, and more comprehensive understanding.

As an example of this, the atomic theory of matter was not the last word. It was later found that things could be extended further. The atoms themselves are built up from smaller particles, which behave in certain ways as described in quantum theory. Again we cannot observe these particles directly, but the consequences of quantum theory have been very successfully verified.

We have now gone through all four of the different kinds of statements which we try to prove, and you will notice the interaction between practical experience with the real world and the mental processes of reason and logic applied to it in each case. Scientific method is so powerful today, compared with what our early ancestors had to go through in order to learn by sheer experience, because we can be more conscious of how we use the tool of logic. It should also be clear (if indeed there were any question in our minds about this) how today's scientific method is superior to the spinning of empty theories by taking truths from Aristotle or the scriptures instead of studying the motion and interaction of matter and energy in the real world.

IV. Some ways in which the social and other non-experimental sciences differ

So far, in considering how to prove specific scientific assertions experimentation has played a key role. But some of the natural sciences, along with all the social sciences—including those to which we try to apply our Marxist appreciation of the world—fall into a category where experimentation is rarely if ever possible. This creates special problems, and it means that the degree of uncertainty and an openness to new possibilities has to be greater. Nevertheless, the same general principles can be applied.

Clearly, type I statements will exist in every sphere of knowledge and they can be proved or disproved by simple observation. But what about our other types?

We have already noted that assertions about historical fact fall into the category of type II, the specific unobservable. The method of determining their accuracy is no different in essence. How do we know that Napoleon lost the battle of Waterloo? Well, we read it in history books. Do we believe everything we read in books? If we look for alternative history books that report the facts differently we are unable to find them. So it turns out that this is accepted as true by virtually all historians. On the other hand, those of us who have some knowledge of Marxism have often found ourselves believing things which go against what is generally accepted. We reject the idea that such a question can be settled by majority vote and we can still be skeptical. So we will go back and look directly at some original documents in order to get additional information—French newspapers of that period, or other archives. But then the French view might be biased, so we should really do the same in England. Etc.

Ultimately we will find that the statement "Napoleon lost the Battle of Waterloo" is consistent with all the available factual material that we are able to collect, which cannot be said of any other statement about the battle's outcome. We therefore conclude that it is true. The process of amassing directly observable facts (type I statements—what is said in all of the history books and historical records) and then fitting it into a logical pattern is essentially the same as scientists went through to determine that water was, indeed, made up of hydrogen and oxygen. We simply accumulated our data through a process other than controlled experimentation.

Consider another example, not from the realm of science at all, that we have all encountered if we like to read detective stories. A crime is committed. Who did it? No one observed the deed and the detective's job is to accumulate evidence. Some of the evidence says that the butler did it. Some points to the lord of the manor, etc. The detective must continue the search for more and more facts until the clues, taken as a whole, point to only one logical conclusion.

This is actually an application of scientific method.

A real-life example of this is what happens in the criminal courts. People often say that someone was convicted only on the basis of circumstantial evidence, as if this proves that the case against them was weak. But that isn't necessarily true. Here is another example of the particular unobservable at work. How can we prove in court that a particular person is guilty of a particular crime when no one saw it happen? The lawyer for the prosecution must present enough evidence so that the guilt of the accused is the only reasonable way to make all the facts fit into a logical whole.

Both society and the natural world provide a host of processes (experiments, if you will) through which people can gather data and draw valid conclusions—though these are not comparable to experiments carried out in a laboratory, where all variables except one can be controlled. It is thereby possible to formulate and test the validity of propositions that require the use of logic—hypotheses/truths, general laws, and theories—in many areas.

As previously noted, Marxists gather data by studying past revolutions and social upheavals, as well as the day-to-day workings of class society in more peaceful times. Other social scientists apply a similar method for accumulating basic information. It is essential to stress that this is not, somehow, less scientific than controlled experiments. It is a widely accepted approach. Astronomers must wait for nature to present them with the occasional supernova before they can test their theories about what drives this celestial phenomenon. Geologists cannot create earthquakes or volcanoes at will in order to study their dynamics. Meteorologists cannot command tornadoes to form in the laboratory. And many similar examples could be cited.

The caution we gave earlier about the application of "logic" which can never be *purely* objective is particularly important to keep in mind as we consider the social sciences. Perhaps even more than in the natural sciences prevailing ideological prejudices can badly affect our judgment, because different social theories are more often *direct* weapons in the class struggle which provide ideological support to one social grouping or another. They are therefore commonly accepted or rejected not due to the weight of scientific evidence at all, but strictly because they serve, or fail to serve, the needs of the ruling class.

As revolutionaries, however, it is in our interests to know the true nature of the society we are trying to change. Nothing short of this will help us to achieve our goal. So while it is impossible to be totally free from preconceptions and partisanship, we must constantly guard against allowing these things to override our scientific judgment. We must be brutally honest with ourselves. The essential test must always be: What actually corresponds to reality? Only by answering this question correctly can we make our practical work as productive as possible.

V. Scientific paradigms

At this point we make a slight digression in order to introduce a topic that will prove useful when we discuss how all of this applies specifically to the Marxist movement. In a landmark work *The Structure of Scientific Revolutions*, in 1962, Thomas Kuhn introduced the idea that the accumulation of scientific knowledge does not proceed gradually, step by step from one truth to the next—as most textbooks taught—but through conflicts between broad theoretical systems in a particular field, which he called "paradigms," and the victory of one such system over all other possible contestants. Once established, a paradigm tends to define the range of thought and investigation within any particular discipline in a particular and relatively narrow way as long as it reigns supreme. Eventually, however, data accumulates which cannot be made to fit into the prevailing mode of thought and this can lead to the emergence of a new paradigm. Kuhn called this a "paradigm shift" or "scientific revolution."

Today the idea of paradigms continues to be a generally accepted model for how science works, and we would tend to agree. But from a Marxist perspective we would be critical of Kuhn's specific approach on at least two levels.

First, He treats paradigms as essentially arbitrary constructs of human intelligence (i.e., he approaches the problem in an essentially idealist manner) and he specifically rejects the idea that such theoretical concepts could actually correspond, to a greater or lesser degree, with the material world. So it is first necessary to view the problem from a firm materialist footing, and understand that the most successful scientific paradigms gain their power precisely because they represent at least partially accurate attempts to describe the world as it exists.

This leads us to a second disagreement with Kuhn. We asserted in our discussion of general theories or laws (type III and IV statements above) that new theories must be able to incorporate those aspects of the old which were, indeed, true—thus creating a higher synthesis and not a pure negation of previously prevailing ideas. Since Kuhn denies any correspondence between theory and reality he is able to specifically deny this necessity.

From a materialist perspective we must insist on our own approach. If a scientific theory is, in fact, successful in describing something which is true about the material world, then any subsequent theory that displaces it because it is more successful in doing so must be able to include that subset of explanations which made the first theory even reasonably satisfactory to begin with.

We want to stress one point on which we would agree with Kuhn, however: Scientists do not abandon a particular system of beliefs (a particular paradigm) simply because it can be shown to be flawed in one way or another. They will continue to apply it even if it gives only partially correct answers unless and until a better overall theory emerges. We think that this approach has particular importance for the Marxist movement today, and we will discuss it further in the next section.

From the point of view of the authors of this paper (though not from that of Kuhn, who consciously refrains from using the idea of "truth" at all), a look back at the quote from Francis Bacon at the beginning of this article will help us to understand one reason why this should be. Maintaining the old paradigm may lead to error, but it is precisely these errors, accumulating in a *systematic* way, which help to reveal a new and more inclusive truth. Abandoning the old paradigm before that new truth emerges can lead only to confusion.

VI. Specific conclusions for Marxists

At the very beginning of this section we want to alert our readers to the fact that it is an unapologetic polemic. In our view the Marxist movement suffers today from two erroneous approaches to our discipline that are essentially analogous to the problems that plagued science some four hundred years ago, and to which Francis Bacon found it necessary to counterpose a new approach.

Some seem willing to simply repeat over and over that the world is very complex, treating it as essentially unknowable. They are content to practice "blind experience, which is mere groping in the dark." Applying such a methodology the socialist movement might "occasionally hit upon good works or inventions," but it will ultimately prove incapable of systematically developing the basis of our scientific knowledge.

On the other hand, we also have our share of those who claim that all we need to know has already been revealed by the great thinkers of the past. These "Marxists" are content to look for the answers to contemporary problems somewhere in the pages of the great books, which means that they must inevitably "fashion nature [the political world] according to preconceived ideas." They talk as if our only task is to grasp what is already written and learn how to apply it.

The viewpoint outlined below represents what we see as a positive alternative to both of these one-sided methodologies.

A) General Parameters

Marxism, like any other endeavor based on a scientific understanding, depends on a body of basic knowledge. This knowledge has developed as a result of accumulating information about human societies and the process of social change throughout history, and through attempting to synthesize these facts into a general system of thought (or paradigm) which captures more or less accurately the real dynamics of social change in the material world. Our attitude toward the knowledge we have accumulated, and the general system of beliefs which help us make sense of that knowledge, should be similar to that which we would take toward the accumulated wisdom in any other field—even accepting the greater uncertainty we have concerning basic propositions in our discipline than in the physical (and even in some of the social) sciences.

Although the terminology is not completely parallel, and the precision considerably less, there are a number of programmatic and theoretical generalizations about reality (that is, laws and theories, or statements of type III and IV in our system) which have historically come to be accepted as true by the revolutionary workers' movement. These should have, for us, a *relatively* secure status—similar to that enjoyed by equivalent generalizations in other disciplines.

There will probably be little controversy—at least among those who consider themselves Marxists—if we put into this category the idea that the history of all previous society is the history of class struggle. Indeed, we might even say that this is a basic summation of the Marxist paradigm. Similarly, such ideas as the labor theory of value, or that the state represents a political/military institution to preserve the rule of one class over another, remain central tenets for at least many currents within the Marxist movement. The same can be said for some concepts which may be more controversial—such as Trotsky's theory of permanent revolution.

Of course, as indicated above, we must always understand the limitations of our theoretical generalizations. Our degree of certainty is significantly less than it would be in an experimental discipline, or even in the non-experimental natural sciences. It is worth recapitulating the three basic reasons for this: 1) Social reality generally is confronted with far more variables than the natural sciences. 2) We cannot do experiments which control all variables except the one we are interested in, and see how the outcome of events might change. 3) The history of revolutions and social upheavals provides a very small base of experience from which to draw generalizations, and new tests of those generalizations—or of the conclusions we draw about the class struggle as a result of them—take place only infrequently.

B) The need to act in the context of uncertainty

At the same time, without our programmatic and theoretical generalizations Marxists would be unable to act at all, because we would have no tools with which to analyze particular events and crises that confront us in bourgeois society. How do we reconcile this apparent contradiction? How can we act decisively on the basis of laws and theories regarding the class struggle and still maintain a proper scientific skepticism about those same ideas?

It seems to us that there are at least three key elements which will help us to solve this puzzle.

First we have to recognize that even though doubt is inherent in our discipline, as indeed it is in all areas of human knowledge, our doubt is never absolute. It comes in degrees, and we must always consider what degree of uncertainty we have in any particular case. That is, clearly, the way in which Marx approached his own most famous dictum, quoted at the beginning of this paper. He never allowed his own doubt to paralyze action.

It is worth looking more closely at how this works. As noted above we maintain a certain measure of doubt even that all humans are mortal. But our doubt is extremely slight. Concerning the basic propositions of Marxism our doubt must be greater. But there remains a whole body of theory about which we can be reasonably confident. Our doubt is relatively slight. Some of the points which the authors of this paper put in that category were indicated above. They reflect significant lessons which have been confirmed time and again by history. When confronted with real-life problems that require a judgment about these things we cannot hesitate when action is required.

But what do we do when doubt is more substantial—either because our data is not extensive enough to let us draw conclusions with confidence, or because more than one theoretical explanation is possible for the facts that we can actually see, or because different possible interpretations of our theory make conclusions less than obvious?

Here it is again useful to take a clue from the field of medicine where we will find similar difficulties. Even established therapies occasionally fail to work in particular patients—with easily diagnosable and usually treatable conditions. Often no one can explain why. Where symptoms are ambiguous, or point to more than one possible cause, deciding on a treatment can be difficult. And yet, as in the practice of revolution, medicine often calls for rapid and decisive intervention to preserve the life or well-being of a patient, even without any certainty about what is wrong or how to cure it.

The problem can be solved by weighing, in each case, the dangers of acting, and of each particular kind of possible action, against the risks entailed in a failure to act.

Sometimes there is a clear answer: If the physician does nothing the patient will die, or suffer irreparable damage. So even if we cannot be exactly sure what is causing the problem, or what therapy will be effective, it is necessary either to assume what seems most likely and treat the disease accordingly, or else find a treatment which may work, and will at least do no irreparable harm if it turns out to have been incorrect.

At other times there is no clear answer. It is simply a matter of judgment—and different physicians may well come to different conclusions when confronted with the identical medical emergency. Each of them would be able to cite perfectly valid and logical reasons for their choice. Marxists are constantly confronted by similar situations, which is why the practice of revolution, like the practice of medicine, can rightly be considered as much an art as a science.

There is a third factor involved in overcoming the contradiction between doubt and the need to act. In many situations it is only by acting, and seeing what the result of our actions is, that we will ultimately gain the information we need to accurately judge the state of things. In this sense our activity in the class struggle represents a kind of experiment that we conduct. Even if our initial hypothesis may be wrong it is better to act, and thereby discover that we are wrong (and if possible why we are wrong), than it is to do nothing and never know.

We can see this process at work in a time-honored tradition of the Marxist movement: the drawing of balance sheets after a period of experience in a particular struggle. We start out by looking at an emerging situation. We choose an approach toward participation based on what information we have available and a (hopefully) logical theory about what might be taking place. After a reasonable period of time we take a step back to see if we can confirm the validity of what we are doing. Usually we will at least have to make some adjustments to our theory and to our practice. Perhaps we will conclude that we were completely off base. Such a reassessment is possible because of the extensive new data which has emerged only as a result of our decision to get involved in the first place.

This approach is firmly grounded in scientific method. It represents the generation of a hypothesis about what is happening, a logical "if-then" statement about how our participation will affect the process assuming our hypothesis is correct, a process of action (or experiment), and finally an honest look at the result to see whether what we originally thought was really true.

C) Discussion and polemic as a truth-seeking (scientific) process

Discussion and polemic within the revolutionary movement have often been abused in factional and bureaucratic ways. How can we avoid this? We believe that an understanding of scientific method can help by shedding some light on the legitimate goals of the discussion process.

The debating of different ideas by revolutionaries must be seen as one of the tools through which we investigate reality and arrive at a proper course of action—in order to test our hypotheses and general theories as described above. All too often, however, individuals who consider themselves Marxists seem to engage in "discussion" for the sole purpose of self-justification, or to "prove" a point through the clever manipulation of words rather than through the application of proper scientific principles. (It is interesting to note that polemics among natural scientists—and even more so among bourgeois social scientists—can play the same destructive role at times.)

If discussion and polemic are going to be used properly then we need to keep some basic principles in mind. These will no doubt seem familiar to those who have followed the argument developed so far in this paper:

1) Our experience with the real world, not what is written in old texts, is the measure against which we test any ideas and theories—whether they be our own or those proposed by other people.

2) We must be scrupulously honest in discussing ideas. No scientific purpose can be served by the distortion or misrepresentation of viewpoints, or in the misrepresentation of reality in order to justify what we might believe, or want to believe.

3) We must remember that even our best theories can never be true in any absolute sense. They will almost always contain at least incidental errors, or areas where they do not completely describe reality. The converse is also true. Even theories which are, on the whole, unsatisfactory can often give us insights into the world which we might not otherwise have obtained. It is, therefore, almost always possible to learn something from those who disagree with us—especially when the discussion is carried out by both sides (all sides) according to our first two principles.

Of course, stating these rules is much easier than putting them into practice. Even when we try our best to accurately portray the meaning of other people's words, honest misunderstandings are almost inevitable—since words themselves are imprecise instruments for conveying meaning. This problem can be overcome, however, if everyone involved makes a real effort to listen, and to reconsider their own arguments in the process of any discussion in order to resolve misunderstandings that do arise.

It is also difficult, since political discussions can legitimately arouse passionate feelings, to give credit to an opponent for having some insight into a problem, and to adjust one's own thinking accordingly. But this, too, can be done if a conscious effort is made.

Above all, these things can be accomplished if we maintain a strong commitment to our first principle: that experience in the real world of social struggle, not what has been written down in the great books (and certainly not the ideas which come out of our own heads) is the ultimate test in any debate. If we truly internalize the fact that this test is essential for the advancement of Marxism as a scientific endeavor then it becomes possible to disengage our individual egos and try to discuss objectively.

We want to make one point almost in passing. Nothing we say here should be taken to indicate that quotations from previous generations of Marxists have no place in our consideration of present-day problems. It simply means that we have to define their proper place. They can never be used in order to prove that a particular theory corresponds with reality. But they can demonstrate what previous Marxists did or did not think about the reality of their own time—and this is often an important reference point for our own discussions. They can also help illustrate the utility, or lack thereof, of a particular methodology—that is, the process by which we draw logical inferences from reality in the course of a discussion.

It would also be wrong to conclude that if only we all follow these simple rules then we will all agree (if we are good Marxists) about what reality has told us. That is a caricature of scientific method, and rarely happens in any field of human inquiry. There are many reasons for this—ranging from the already acknowledged ambiguity of the real world and the imprecision of theories created by human beings, down to the level of personal and philosophical inclinations of individuals.

As noted, in the field of medicine, two physicians faced with the same patient might legitimately propose two quite different courses of treatment, or even no treatment at all. And it is not necessarily a question of right or wrong, but may simply be a matter of good and better, or bad and worse. Sometimes there will be positive and negative results to each approach which balance each other out, or prove impossible to choose between in any absolute sense. And so the success or failure of one approach need not prove or disprove the case. The conviction might still be held that an alternative would have worked better (faster, with less expense, or less pain and suffering) or that the patient would have died anyway (with greater expense, greater suffering, and less chance of recovery).

The Marxist movement is also prone to facing the same kinds of problems. Occasionally, to be sure, there are legitimate battles with individuals or currents that are in the process of breaking with a revolutionary praxis. But other disagreements arise because different currents see the same reality from different vantage points, and therefore stress different aspects of it. Or we may legitimately disagree about which of two or three possible solutions to a problem would be most effective.

So even good Marxists, all attempting to apply the kind of approach to their discussions which we suggest here, may still have strong disagreements. That is merely one more confirmation of the imperfect world in which we live. Over time, with repeated experience in similar situations, generally accepted laws and theories can and do emerge from this process of ferment and debate. And there is no other route through which they can emerge. That is why complete freedom of thought and discussion is such an essential prerequisite for the revolutionary workers' movement (as it is for any other scientific movement), and why the bureaucratic model of a monolithic party, dictated to by a single—and supposedly infallible—leader can never serve our needs.

D) Properly posing questions for debate

We believe that the reality just described suggests a different way to pose at least one kind of question that is frequently debated by Marxists. Most often, when looking back historically at a particular experience—or even in assessing it contemporaneously—we will divide up into sharply counterposed camps, each marked by either a fierce advocacy of the particular strategy that was followed (as the only correct one that could possibly have been followed) or else a sharp criticism of it (even going so far as to label it a betrayal).

As indicated, sometimes such a sharp counterposition is justified. But we think it should be clear at this point why this is not always (and perhaps not even most often) the case.

Perhaps a recent example might illustrate the point. Ever since the Nicaraguan revolution in 1979 there has been a debate about the general strategy of the Sandinistas: making substantial concessions to both the Nicaraguan bourgeoisie and imperialism in order to create some breathing space and a sufficient material base to carry through with the goals of their revolution.

The Sandinistas even gambled on their ability to beat the bourgeoisie in its own electoral game. Had they been successful it is quite likely that they would have severely curtailed the ability of the U.S. to wage its contra war. But the Nicaraguan revolutionaries lost their electoral gamble—in large part because of the very concessions they had made to a bourgeois market economy, since these contributed far more to the export of capital than to Nicaragua's economic development.

The leftist critics of the Sandinistas insist that this defeat should lead to a definitive conclusion: The Sandinista strategy was wrong.

But if we look at the general problem discussed above—of drawing inferences in situations where all variables cannot be controlled—we at least have to place a question mark over such an assertion. It remains possible (to the authors of this paper, even likely) that the alternative approach advocated by our leftist critics would have faced its own set of unyielding contradictions and might well have had even more disastrous results: a bloodbath by triumphant reaction against the Nicaraguan workers and peasants. At least in the aftermath of the electoral defeat a certain level of mass organization and struggle was maintained.

If this dilemma looks familiar it is because it represents precisely the same problem which earlier faced our two physicians, arguing over what the proper treatment should be—or should have been—for a patient when all of the potential choices are/were fraught with uncertainty and a degree of risk.

The idea that an alternative policy by the Sandinistas would have achieved a different outcome rests on a necessarily unprovable premise: that a more positive outcome was, in fact, attainable for a revolution in an extremely weak and economically backward country, faced with a concerted onslaught by imperialism, and with little material assistance from the outside world.

So it is necessary to determine, first, what question we can legitimately pose in trying to draw the lessons of the Nicaraguan experience. We would suggest that this is not: "Were the Sandinistas right or wrong in their strategic choices?" Rather we should ask: "Did the Sandinistas make a reasonable choice given the constraints they faced?"

Please note: we are talking in all of this about general strategies. It is always possible to make particular criticisms of particular actions no matter how correct and proper a general strategy might be. Nothing we have said here should make anyone hesitate from raising critical questions about any aspect of the Sandinista's approach. We are merely suggesting that the usual search for ideological certainty, for an absolutely clear and unambiguous balance sheet, would seem to be impossible in this case.

And we do not believe that the Nicaraguan situation is the only one where this insight might be useful. There are other times when we ought not to pose our historical judgments—whether of revolutions or of local and partial struggles—in absolute terms ("Was the policy right or wrong?") but ask instead: "Was the policy, even if unsuccessful, a reasonable response given what was knowable about the general situation at the time? What factors might have pointed to an alternative? And can we be sure that such an alternative would have been qualitatively more likely to bring success?"

Posing the issues that arise in such situations in this less absolutist way might give us a deeper insight into the actual process of decision-making which confronts revolutionaries at decisive moments. When it is impossible to determine absolutes of right and wrong we have to know how to weigh various options, all of which will have both positive and negative consequences. Understanding that this is, in fact, what is often at stake in the course of a struggle can help to cut across those dogmatic tendencies which tend to cloud our judgment—precisely at moments when the greatest clarity is needed. (We could add some thoughts in this regard concerning the present debates about Bolshevik policies in the USSR after 1917, but we think the point is clear enough.)

E) Old truths and new ones

Finally, before closing this section, we would like to return, as promised, to the final point made during our discussion of scientific paradigms. Many have noted that recent changes in the world pose, or at least seem to pose, a significant challenge to some of the Marxist movement's well-established systems of belief. This has prompted more than a few individuals to abandon their old theoretical tools without offering a coherent set of ideas with which to replace them.

Although this is sometimes rationalized in the name of rejecting dogma, as an objective scientific response to our new world reality, we would suggest that it has little in common with a genuine scientific method. As with other activities based on scientific knowledge, Marxism is best served by holding onto and trying to apply our general theories—even while raising questions and noting contradictions that might help us to further improve on them, or even to find a higher synthesis that might replace them. Those interested in applying a scientific approach do not abandon their present paradigm, even in the face of a crisis, until a real alternative becomes available.

If our goal is, in fact, to find a new theory, it will emerge far more readily if we apply our old ideas (and observe the resulting errors) than from the confusion that inevitably prevails when we simply abandon one approach before there is anything coherent with which to replace it. And the authors of this paper, at least, remain convinced that any new and higher synthesis of revolutionary thought is unlikely to disprove most of the old Marxist truths in an absolute sense. Rather we expect to find that our traditional approach becomes largely incorporated into any new system, and remains applicable in many specific situations. It will simply not be quite so universally true as we once believed.

But it is also essential to recognize that there is an alternative possibility—and this, too, demonstrates the importance of not abandoning our theory simply because we might have some difficulty applying it in particular cases. Sometimes the crisis of a paradigm is resolved not through the victory of a new one but by a reaffirmation of the old. The discovery can be made that the seemingly anomalous data which is creating the crisis is not, in fact, anomalous at all. It turns out to be quite compatible with the old set of beliefs with only modest adjustments and amplifications in our overall understanding.

Such an outcome depends on the decision of at least a substantial group to resist the call for fundamental change and work furiously to incorporate any new data into their old system of beliefs. The authors of this paper acknowledge our own bias in favor of such an outcome as the proper solution to the present "crisis" of Marxist ideology which some perceive. That crisis seems to us to be a product of the pressures on our movement brought to bear by prevailing bourgeois ideology, especially bourgeois and petty-bourgeois distortions of Marxism itself, far more than it is a genuine crisis of Marxism.

VII. Marxist organization and the social process of science

As noted in the introduction, we end this paper with two more speculative sections. Each of these could be elaborated at length, and we invite others who might take an interest to contribute to such a process.

We see a connection between the explosion (even overproduction) of knowledge and information in the world today, which we touched on in part II of this paper, and two items of great importance for Marxists: 1) our approach to revolutionary organization, and 2) our critique of bourgeois society in general, and bourgeois science in particular. We will elaborate briefly.

One of the basic foundations of the revolutionary Marxist movement has always been our insistence on the need for socialist organization. This, we believe, is indispensable—and a convincing argument can be made on a number of levels, from the strictly empirical to the wholly theoretical. However, we would assert that the growing information explosion of recent decades adds an even greater urgency to this task.

As the 20th century has progressed it becomes more and more difficult for any individual, no matter how well educated and how dedicated they may be, to keep up with the flow of information. With the revolution in personal computers and communications technology over the last decade or two, this increasing difficulty took another qualitative leap. So far, the dramatic growth in our ability to produce and disseminate information—through desktop publishing and the internet for example—has not been matched by any technology which increases the ability of the human brain to absorb it. That still has to be done the old-fashioned way.

This intensifies, to an even greater degree than before, the need for the revolutionary movement to engage in a truly collective thought process. Many different individuals, each specializing in their own particular areas, must pool their knowledge and experience in order to react adequately to the world around us.

In the 1860s and '70s Frederich Engels could reasonably attempt to study and synthesize the most important scientific questions of his day and expound on their relationship to the materialist dialectic. (We say this abstracting from any consideration of how well anyone may believe he achieved his goals in this respect.) During the early part of the 20th century individuals like Lenin and Trotsky could be serious students of philosophy (and Trotsky also an acknowledged expert in the field of literature and the arts) while engaging in full-time work as revolutionary organizers.

Today, as previously noted, even full-time scientists cannot keep up with all of the major developments in their own disciplines. The same is certainly true in philosophy, literature and the arts, and any other field that we can think of. How much more difficult is it, then, for the revolutionary politician today. And yet our movement as a whole must continue to take an interest in every sphere of human endeavor if we are to be successful—not just in "revolutionary politics" narrowly defined. More importantly, we must deal with the interconnections between all of these fields.

We would like to suggest that the only possible solution lies in a deepening of our commitment to the revolutionary organization as a collective thinking tool which, taken as a whole, can try to create the kind of synthesis of knowledge which no individual or small group can possibly hope to achieve today.

This leads to the second aspect of the question: the problem of how Marxists should critique science as it is presently practiced in the U.S. and other industrialized capitalist countries.

It is, of course, not a new idea that the present competitive and compartmentalized nature of scientific investigation—combined with its control by for-profit corporations and a government which serves those corporations—puts severe constraints on the potential for human progress. Individual researchers, or small groups, each undertake their own projects, as much in pursuit of profit or practical military applications as in the effort to gain abstract knowledge per se. They do this not only in isolation from each other but even keeping their progress secret from each other. This is true because fame and fortune go only to those who "publish first," or who can patent their discoveries. This results in an incredible amount of wasted time, effort, and money. Even with the vast productivity of modern science in terms of new technology and new knowledge, we modestly suggest that without these constraints the results would be even more dramatic—and certainly more likely to serve the needs of society taken as a whole.

A general alternative is not hard to sketch—of a science driven by human need, not by profit. But it would be useful to describe how this science might work in more detail. And here, it seems to us, the approach we have just outlined for the revolutionary movement—as a collective thinking machine—could well provide the beginnings of such a concrete model for an alternative science.

Why not create a databank of research which could allow scientists to keep in touch instantly with what others were doing in their field, and of positive and negative data as it was produced? Why not conferences where people working in an area share not only the results of their research but new ideas for research, and divide up the tasks involved in that new research so that each can reinforce the work being done by others?

Such a collective process of scientific endeavor would focus on interaction and mutual stimulation, as well as on a pride in *collective* achievement. Once again, our own ability to build a revolutionary workers' movement—a scientific socialist collective thinking machine—could become living proof, even within the context of bourgeois society, that such an alternative process for human efforts (whether in politics or in science) is not a utopian pipe-dream.

VIII. An intriguing new area of scientific investigation

Finally we want to take up an area with which neither of the authors of this paper has more than a passing familiarity: chaos theory. And yet the passing familiarity which we do have indicates that those who might be more expert in this field could conceivably make a substantial contribution to Marxism.

Firstly, it seems to us, chaos scientists have rediscovered the dialectics of nature—though of course they do not call it by that name. Based on the considerations raised in section VII, it is obvious that no one could, today, undertake to do what Engels tried in the 19th century—develop a serious, unified, and comprehensive explanation of how dialectical logic can be derived from or illustrated by a wide range of contemporary results in the natural sciences. The one attempt that we know about to do this for an individual discipline was by Richard Levins and Richard Lewontin in their book *The Dialectical Biologist* (1985, Harvard University Press). This represents a model of how to proceed in other fields, and perhaps some similar works have already been written that we simply do not know about.

It would seem particularly compelling for someone with a reasonable familiarity with Marxist philosophy as well as a thorough understanding of Chaos theory to try and show how each of these things can help to illuminate the validity of the other. From a cursory knowledge, it appears to us that the basic laws of the dialectic can not only be illustrated with examples from Chaos theory, they are integral to its functioning. That is appropriate for a science which is, by its very nature, concerned with transitions from one kind of physical state to another—as well as the ways in which different parts of the natural world interact, rather than simply with a static picture focusing on isolated bits of reality.

And although it may seem a bit far-fetched, we also think that chaos theory could perhaps be useful for helping us to understand—even if only in a metaphorical sense—our own scientific efforts to promote revolution. We note three provocative points in particular. (For those who do not recognize the terms and concepts below we would recommend the book, *Chaos—Making a New Science,* by James Gleick):

First, a "butterfly effect" can obviously manifest itself in human society. No one can predict when imperceptibly small changes, seemingly unimportant in and of themselves, might, through a cascading series of events, generate dramatic transformations on a grand scale. Certainly this happens from time to time in the course of human events, and those times are of particular interest to revolutionaries.

Second, human society seems to closely resemble other natural systems which, while stable for long periods, can without apparent warning enter into extremely chaotic phases, only to return after some additional time to another period of stability.

Third, such cycles of stability and chaos in human society resemble the behavior of systems which can be described by "strange attractors"—never actually repeating exactly the same position or pattern, yet repeatedly going through similar episodes or phases.

Conceivably, any improved understanding of the laws by which these cycles of stability and chaos (revolutionary crisis in the social context) occur could provide insights for the revolutionary Marxist movement. At the very least, chaos theory can give us philosophical ammunition against those who declare the "end of history," validating the Marxist contention that revolutionary crisis is inevitable in class society—no matter how stable and seemingly successful a particular system may appear to be at any given time.

Final note: There is no section IX to this paper dealing with quantum theory and its apparent challenge to materialist philosophy. We would like to be able to write such a section, but in this case any significant contribution requires far more than the kinds of general suggestions that those with only a lay person's knowledge of the field can hope to provide. So we would urge others who are more conversant in this unfortunately somewhat technical problem to try and develop a discussion in the same spirit as we have approached the general problem of Marxism and scientific method here—that is, in a way that can include those not fully versed in all of the mathematics and abstract concepts, while at the same time trying to avoid a completely schematic and caricatured presentation.