Reprinted from Contemporary Reflections on the Philosophy of Herman Dooyeweerd, Strauss and Botting, eds., The Edwin Mellen Press, copyright © MM, pages 239-271.

What is a Science?

Martin A. Rice, Jr.
The University of Pittsburgh
Johnstown, PA 15904

I. Popular Scientific Mythology.

A. Science and "Objectivity" vs. "Pseudo-Science" and Faith.

We all recognize the importance of this question--the question of just what constitutes a "science". The word 'science' has an aura of reverence surrounding it. To dub something "science" (or "scientific") is good. To proclaim something to be not "science" (or "unscientific") is bad. Even worse than being non-science is to be "pseudo-science," i.e., the non-science that dares to proclaim itself to be science. 'Pseudo-science' has a ring of deceit about it. Science gives us "knowledge." What is not science cannot give us knowledge, it cannot be trusted. Science is "objective," and that is good, it's part of the reason why science gives us "knowledge." What is not science is "subjective," perhaps rooted in "faith," and that is bad. Science deserves "funding" and equal time in the school curriculum. What is not science, does not deserve "funding." Pseudo-science does not deserve equal time in the school curriculum. I have been quick and dirty here in characterizing the popular mythology that surrounds 'science' to make a point about how important this issue is. This is mythology that we have all heard and imbibed at some time or other, mostly from people who, although they have been licensed to pontificate upon the issue, really know little about science.

Instantly we can see the importance of this issue for Christians. Where does religion and especially theology fall in the dichotomy of the scientific "good" as opposed to the unscientific "bad?" What happens when we mix religion and theology with science? Is the result "good" or is it "bad?" The prevailing mythology of science has an answer for both these questions. I think we know what that is--it is quite definitely "bad" in both cases and all accounts. Religion is not science, and one should not mix the impure with the pure. One should not mix knowledge with faith. That's the answer of the prevailing mythology. But, as Christians we agree with Scripture that "...fear of the Lord is the beginning of wisdom" (Proverbs 9:10). Scripture does not limit the word 'wisdom', so we must believe that our faith has something to do with getting our knowledge of the world right. The prophet Isaiah also points out that even the everday knowledge of farming results directly from faith in God:

> Doth the plowman plow all day to sow? doth he open and break the clods of his ground? When he hath made plain the face thereof, doth he not cast abroad the fitches, and scatter the cummin, and cast in the principal wheat and the appointed barley and the rie in their place? For his God doth instruct him to discretion, and doth teach him. For the fitches are not threshed with a threshing instrument, neither is a cart wheel turned about upon the cummin; but the fitches are beaten out with a staff, and the cummin with a rod. Bread corn is bruised; because he will not ever be threshing it, nor break it with the wheel of his cart, nor bruise it with his horsemen. This also cometh forth from the LORD of hosts, which is wonderful in counsel, and excellent in working. -- Isa. 28:24-29

Hence, the prevalent mythology of science throws us instantly into a dilemma. I wish to go some way towards resolving this dilemma by unmasking the prevalent mythology of science as a mythology. I also wish to chart a positive direction, by proposing an alternative account of what a science is that avoids many of the problems inherent in the current mythology, that does justice to the true nature of scientific practice, and that can be conformable to the words of Scripture like the portion of Proverbs that I quoted above.

B. Science as Method: The Inherited Aristotelian View.

The received view of science, holds to a division between knowledge and objectivity on the one hand, and faith along with subjectivity on the other. As such, there can be no fruitful connection between science and religion without doing irreparable harm to at least the scientific side of the dichotomy. The mainstay of this division is often thought to consist in a method that true science possesses, a method that embodies some canon of rationality and objectivity that religion cannot. The method supposedly guarantees the exclusion of faith from the realm of true science. This is an old view and can be seen to go as far back as Aristotle in various guises. Science, it was often said, proceeds from self-evident principles by way of deduction to new knowledge. In any science, i.e. a deductively organized set of statements, the first principles will be the most knowable of all.[1] They will be seen to be true by any appropriately rational human being. That person may need a little training, but he can be brought easily to see the truth of the principles involved. A person who is rationally deficient may, perhaps, fail of such insight. First principles are completely general and universal in nature. Indeed, in the Aristotelian epistemological tradition there is no true knowledge of individuals, but only of abstracted forms, essences, or natures. The Aristotelian tradition is also more hospitable to theology as a science than the contemporary tradition. In book Epsilon of the Metaphysics, Aristotle argues that theology is a science and the most general and universal of the sciences. But Aristotle's view of theology is not one that any evangelical Christian would or should endorse. Theology, on Aristotle's view, is the study of being itself, undifferentiated by genus or species. He also views the stars and planets as embodying some portion of the divine.

The methodological view of science that begins with Aristotle is continued with his most famous medieval interpreter, Thomas Aquinas. In his Summa Theologiae, the second article of question one, part one, Aquinas argues that sacred doctrine is indeed a science. He does this in his characteristic way of first posing objections to his view then rebutting them. Although the point of these objections is ultimately thought false by Aquinas, there is much in them that he endorses. Consider objection one in this first article:

> For every science proceeds from self-evident principles. But sacred doctrine proceeds from articles of faith which are not self-evident, since their truth is not admitted by all.

The basic Aristotelian methodology of science is endorsed here. Aquinas will go on to answer this objection by arguing that sacred doctrine proceeds--where "proceeds" means a deduction--from principles even more certain and evident than those of the natural sciences, known by the light of reason and the intellect. In other words, he will argue that sacred doctrine conforms to the scientific ideal of deduction from self-evident principles. And of course, the existence of God, for Aquinas, is one of the things demonstrable from principles known by the light of reason. Articles of faith are accomodated to the form and spirit of natural science and given the same status as principles of natural science that are self-

---

[1] See John Losee, A Historical Introduction to the Philosophy of Science, (Oxford: Oxford University Press, 1972) chapter one.

evident through the operation of the light of reason. Sacred doctrine presents a difference of degree with natural science not a difference in kind.

Notice something here that is important and to which I will return. When something is self-evident, its truth is admitted by all. This is where an ancient tradition touches base with a modern mythology. The objectivity of science lies, in part, in its self-evident principles, and the hallmark of self-evidency is universal agreement--no dispute. This is one condition that has been thought necessary to objectivity in the philosophical tradition. The reason for it goes in brief something like this. If something is "objective" then it is not mind dependent, it is there in the world independently of human will. Hence, there is no insurmountable obstacle to everyone's seeing it alike, through unbiased rational inquiry. In objection two, in this same article, Aquinas also endorses the Aristotelian doctrine that there is no science of individuals, only of universal essences or forms. On the Aristotelian view, the paradigmatic natural science is mathematics or mathematics and geometry. The basic principles of these sciences, or their axioms, were long thought the most evident and their methods of demonstration the most rigorous and truth preserving. There is one problem with this view (among many others) that I will mention only briefly, since my purpose here is not to give a history of the philosophy of science. It is a simple problem. Think of the things we take for granted today as sciences. Among them I am sure you will want to list geology, meteorology, oceanography, and geography. It cannot be avoided that each of these sciences is devoted to investigating and gaining knowledge about a single individual thing, although it is a different thing in each science. Geology is the science of the physical structure of the thing called the "earth." Meteorology investigates the earth's atmosphere, oceanography the individual oceans of the earth, and geography studies spatial location on the earth and is concerned with statements of individual fact, like 'The prime meridian runs through Greenwich, England'. Geology ponders statements like 'The earth is x number of years old'. Both of these count as statements about individuals and as such are not properly part of scientific knowledge on the Aristotelian view. So there is a prima facie problem here for the Aristotelian view. It cannot do justice to many things we would ordinarily think of as sciences. In fact, its canon entails that these things are not sciences at all. This goes to the heart of that fundamental, and most devasting problem of all Aristotelian epistemology--how to get knowledge of individuals.

In the medieval Jewish philosopher, Simon ben Gerson (alias 'Gersonides'), this problem goes so far as to deny that God Himself has any knowledge of individual human beings.

The Aristotelian view held sway throughout the 17th century, that great century of scientific and philosophical activity. Despite the attempt to distance themselves from Aritsotle's metaphysics and physics, most philosophers and scientists of this period embraced the idea that method is the key to scientific and philosophical success. For example, just think of Renes Descartes and his *more geometrico*. If one reads Descartes' Meditations and his Discourse on Method, one sees quite clearly that the model of scientific practice and the paradigm of knowledge for him is mathematics. Descartes was attempting to put all human knowledge on a footing of certainty by pouring it into the mathematical mold. This very same ideal permeates almost the entire century. Consider the book A Holy Commonwealth, written by the great Puritan divine, Richard Baxter. Baxter's purpose in the book is to place the foundations of juridical government on a secure Biblical footing. The book is written like a text in geometry. Baxter sets out to prove several hundred theses about the nature of government, each thesis becoming more complex and building on the one before it. He treats his theses as theorems in mathematics. He begins with the most basic and obvious to prove the more obscure, just like Euclid. The first thesis in the book is: 'There are men inhabiting the earth.' The argument for this goes as follows:

> He that denyeth this, denyeth himself to be a man, and therefore is not to be disputed with: yet proveth it to others, while he denyeth it.

It is hard to get more basic than this. Baxter then proceeds to demonstrate the existence of God, and from there certain basic truths about human nature then human polity. It is an attempt to make the science of jurisprudence mathematically rigorous after the fashion of the *more geometrico*. The mania for method found its way into all areas of endeavor.

Apart from the problems of Aristotelian epistemology, this attempt to see all true sciences after the *more geometrico*, has problems of its own. There is the obvious problem that not every science can be accomodated to the mathematical model. In fact very few can. In fact, just about the only ones that can be so accomodated are the namesakes of the model, logic, mathematics and geometry. Parts of physics as well could be included here, but then things come to a halt. In all honesty and in actual practice, no one knows how to give a mathematical axiomatization of psychology, economics, chemistry, and so on--although many have tried. There have been two responses to this problem. First, one could say that any endeavor that is not amenable to a mathematical methodological model is thereby not a science. Secondly, one could try one's darndest to fit the recalcitrant sciences to a model they simply do not fit. The latter approach is the one most widely and openly tried. The former is not openly tried, but secretly believed by many. I have an economist friend who, when he sees me visiting and talking with the people in psychology, calls me aside, secretly, to warn me that they are not real scientists. They do not employ real mathematics in their work. We can see the effect of this outlook in the structure and practice of contemporary social sciences, those sciences which are hardest hit by the charges of being "pseudo"- sciences. The effect is that in these sciences, in order to show that they are respectable and rigorous, there is an extreme emphasis placed upon statistical methodology. In some areas of psychology, it is hard to tell whether one is dealing with a psychologist or a statistician. Such sciences have identity crises as a result.

I, however, have never been able to see any good reason for this mathematical methodological mania. I don't think there ever has been good reason for it. Here is about the strongest reason I have ever found to justify this "imposition of method" (to quote the title of a book by Schouls). The mathematical sciences have a rigorous proof method that is satisfying and leads to certainty. We would like all sciences to have a satisfying method for justifying their claims and a good degree of certainty. Conclusion: All sciences must be accomodated to the model of the mathematical sciences. It is easy to see that this little syllogism is invalid. A corvette is a vehicle that is comfortable and has a satisfying rate of acceleration. It does not follow that all vehicles that are comfortable with satisfying rates of acceleration must conform to the model of a corvette. Certainly, we would not want this to be true of passenger aircraft. It may also turn out to be a disappointing fact of reality that not all sciences can have subject matter that is as nicely behaved and as simple, by comparison, as mathematical structures. The science of mathematics is the oldest and most well-developed we have. We cannot expect younger sciences to compete with a history like that. Furthermore there may be good reason that mathematics got off the ground first. I suspect that it consists in the fact that mathematics has, of all the sciences, the simplest and most well-behaved subject matter. Hence, it is the easiest to study rigorously. But there is more.

C. Failures of the *More Geometrico*.

1. Mathematics.

Mathematics itself does not live up to the mathematical ideal, and this has become clear in the present century. At the turn of the century there arose the problem of proofs of completeness and soundness for formal systems. A proof of soundness is a proof that an axiom system will never deductively yield a contradiction. A proof of completeness is a proof that an axiom system will yield as theorems of the system everything it intuitively should. Then came Kurt Goedel with his famous incompleteness proof for arithmetic. Put simply, this is what Goedel showed. Take any mathematical system whose complexity is on the order of arithmetic, or greater. Let us axiomatize this system. Once we do so we will always be able to find theorems of the system, that are genuine theorems, but within the system there will be no formal deductive procedure that will yield these statements as conclusions of a formal proof. Suppose we decide to circumvent this problem by adding the recalcitrant theorem to the list of axioms and stipulating it to be an axiom, by fiat. In that case we can generate yet a new theorem which is not provable as a theorem in the new enhanced system. This process can be repeated indefinitely. Thus for any mathematical system rich enough to contain plain old arithmetic, there are no completeness proofs. There will always be a theorem which cannot be shown to be a theorem ***GIVEN THE METHODOLOGY OF THE FORMAL SYSTEM ITSELF***! So even if we take the axioms of arithmetic to be self-evident truths, there will always be statements of arithmetic that cannot be deductively grounded upon the self-evident truths of arithmetic. It has been realized that this result is most disturbing to the foundations of mathematics, but it has wider implications for the whole traditional methodology of sicence which takes mathematics as the paradigm of what-it-is-to-be-a-science. Nothing would fit the ideal case except some quite elementary formal logic, e.g. the first order predicate calculus and some simple modal logics. Of course, we could limit true science to these, but that acts as a

Reprinted from Contemporary Reflections on the Philosophy of Herman Dooyeweerd,
Strauss and Botting, eds., The Edwin Mellen Press, copyright © MM, pages 239-271.

reductio on the entire notion of the *more geometrico* as the mathematical paradigm.

The incompleteness proof emphasizes the breakdown of deductive methodology for sufficiently rich and interesting formal systems. On the other end of the spectrum, there was a breakdown in what truths were considered to be self-evident. For over two thousand years Euclid's axioms of plane geometry were considered paradigms of self-evident truths. This was so ingrained that in the 18th century the great German philosopher Immanuel Kant posited that these axioms were a priori ordering structures of our perceptive apparatus. But at the beginning of the 19th century, people began to wonder about the status of Euclid's parallel postulate, the axiom that says given a line and a point, one can draw at most one line through the point parallel to the first line. Another way to say this is that parallel lines are always equidistant at any segment of space. The parallel postulate was seen to be independent of Euclid's remaining axioms, i.e. the remaining axioms could all hold true while the parallel postulate was false. This was not the case with the remaining axioms, they were all logically interdependent. Given this, mathematicians began to wonder why the parallel postulate must be true. Granted, it looks true at the quite ordinary distances we have here on earth. But, given large enough distances, perhaps space bends in such a way that either 1) with enough distance parallel lines come to meet and space collapses on itself, or 2) parallel lines veer away from one another and spaces expands. What this would mean is that a rigid body would not keep the same size under transportation. In the first scenario, postulated by the geometer Riemann, the standard meter bar in Paris would actually shrink as one transported it to a far point in the galaxy while keeping all variables in its environment the same. In the second scenario, postulated by the geometer Lobachevsky, the same standard meter bar would expand in length. Whose case is the correct one, Euclid's, Riemann's, or Lobachevsky's? There did not seem to be any way to tell, and as a result people came to doubt the self-evidency of the parallel postulate. The ideal of the *more geometrico* was in real hot water.

This was not the death blow of the 17th century methodological ideal, however. Despite these problems the tradition continued and continues today. What has happened though, is that people have loosened the rigors of the ideal. It is no longer thought that the ideal method for science is a rigorous deductive one, nevertheless there is some method or other that keeps the basic insights of the ideal *more geometrico*. Among those who continue to hold some version of this view there is no universal agreement on what the true scientific method is, nevertheless, there is some method or other that provides a demarcation between science and non-science. This is often referred to as the "demarcation problem" in the literature of philosophy of science. The first person to use the term "demarcation problem" and one of the most famous proponents of this methodological approach to the demarcation problem in the 20th century was, and is Karl Popper. I want to talk about Popper a little later, but first I want to put forward some reasons as to why the methodological approach--no matter whether it takes the form of the 17th century *more geometrico*, or a weaker version--is bound to be unhelpful no matter what we mean by 'method'. I wish to argue that an appeal to method cannot support a dichotomy between knowledge and objectivity on the one hand and faith and subjectivity on the other.

2. The Merging of Self-Evidency and Objectivity with Faith.

I will take it for granted that we all have an idea of what a method is, and we all have some idea about what faith is. Let us think about what a method must involve, in science, at its most general. It must at least involve some quite basic laws of logic, laws I think we are all somewhat familiar with, laws like the law of identity, the law of excluded middle and the law of noncontradiction. Not only are we familiar with these laws, if we are of normal mental capacity, is quite impossible for us to escape a belief in their truth. Close your eyes and try to imagine the truth of a contradiction like 'my beach ball is blue all over and it is not blue all over, in the same sense at the same time'. For the life of me I cannot do it. That everything is identical with itself, strikes me as so "right" that I cannot conceive what it would be like for something to be non-identical with itself. Nor would I know what was meant if someone said there was a middle alternative to the having of a property in a given respect or not having it in a given respect. So why do we take these basic laws of logic to be true? It seems that we do this because they just "strike" us as true. They have a grip on us that serves as a reality check. We cannot shake off their truth, and if we try to do so our conscience bothers us in some way that can be described as the sound of chalk squeaking on a blackboard. Now, does any of this sound familiar? For those of us who are Christians, let us think about why we believe Holy Scripture and the Gospel. It is quite definitely not the case that most of us believe because we were exposed to the latest version of the ontological argument for the existence of God or read Aquinas' Five Ways. We believe because at some point we heard the Gospel explained, or read some portion of Scripture and it captured our hearts. Furthermore, there was nothing we could do to control it. It nagged at us and we had to pursue it further. The belief "came upon us" so to speak and we found ourselves with it, much like the names our parents gave us. At some point we realized we were believers and decided to do something about that fact, but we did not decide to have the belief itself. And now, even if we wanted to, we could not deny its truth. We could not blithely decide to go back and just ignore the Gospel, any more than you could decide that blue was not your favorite color, if, in fact, it was.

There are very close similarities between the way the laws of logic strike us, and the way the Gospel strikes the believer. In fact, I would suggest that the believer believes in the Gospel for the very same reasons that any one of us believes in the laws of logic -- One just "sees" that it is true. The truth strikes us and we cannot help but accept it. The epistemological situation of knowing the Gospel is the same as knowing the laws of logic. It is experiencing, directly and without inference, the truth of something. When experiencing the truth of the Gospel, or of Scripture, we speak of this as "faith." But it is not some mysterious other-wordly process. It is a process we have gone through dozens of times and do so every day. It is a process we went through when we first heard about the basic laws of logic. I said we go through it every day. What did you have for breakfast this morning, was it, perhaps, oat sticks? Then your remembering and believing that you had oat sticks for breakfast is the same sort of epistemological process. You don't infer that you had oat sticks, you know it directly to be true. It is taken on faith, especially if you have destroyed all the evidence of your breakfast by cleaning up the morning dishes. But that doesn't matter, you don't need that kind of evidence to know it is true that you had oat sticks for breakfast. You do have some evidence to be sure. It was your direct experience of having eaten oat sticks. And now you have your memory by means of which you directly remember the truth, or "see" it. I would suggest that this is strictly analogous to experiencing the truth of the Gospel through reading Scripture.

Already I can hear objections rising. One thing an objector may point out is that there appear to be some significant differences in the epistemological situation between believing the laws of logic on the one hand and believing the Gospel on the other. For example, one cannot conceive the falsity of the laws of logic without contradiction. But one can conceive of a world where God never sent his Son for our salvation, etc., etc. But this is, I think, a distinction without a difference. The former case looks like we are engaging in some epistemological test of the truth of the laws of logic, whereas in the latter there is no such test. Hence belief in the laws of logic is not a matter of faith. But the test is just deceptive. It already relies upon taking as true one of the very laws being tested, the law of noncontradiction. This is what philosophers refer to as "begging the question." Any attempt to establish a foundation for the laws of logic will have to presuppose them. After all, their basis will have to be rational will it not? So there is no test here and again knowledge of logic begins in faith.

Here is the first place where there is a breakdown in the dichotomy between science and non-science, especially between science and what is held to be prime examples of non-scientific enterprises such as religion and theology. Science must, in its methodology, involve a foundation rooted in some faith, if only a faith in the truth of some basic laws of logic. The traditional dichotomy between knowledge and faith will not serve to distinguish science from non-science and so should be abandoned.

There is another objection that can be raised to my position. It goes like this. Granted that there is no non-question begging way to establish an epistemological foundation for the laws of logic. Still there is a difference here and it has to do with "objectivity." The laws of logic are objective in the sense that everyone can and does come to see their truth. They cannot be doubted. They are publicly verifiable, i.e. anyone can verify them or "see" them for himself with the aid of the unbiased "light" of reason. None of this is the case with the Gospel. Only a small fraction of the world's population believes the Gospel. The Gospel itself even tells us that not everyone will come to see its truth. In this sense the Gospel is "subjective." There is no way to conclusively convince everyone of its truth. This is the benchmark test of "no dispute" for objectivity that I mentioned earlier. So we can rely upon the difference between "objectivity" and "subjectivity" to provide us with a difference between science and the non-scientific status of religious belief.

This is a serious point and relies upon a long tradition in epistemology called "foundationalism." Foundationalism is the attempt to discover a basis for knowledge and science that rests in direct experience of the truth of certain propositions that no one could doubt and which everyone can see to be true. Such propositions would be publicly verifiable as true and incorrigible. The laws of logic are taken to be such. They would certainly be part of the foundation of knowledge and science if anything is. Let me rehearse a few reasons why this distinction fails as well.

3. Failures in the Self-Evidency of the Laws Logic.

The first reason has to do with my own empirical experience. I have met people who do not believe in the basic laws of logic. At least they claim they don't. To all appearances these people are as normal as you and I and do not need shock therapy or lithium drugs. A man I knew in graduate school denied the truth of the law of noncontradiction. I did not know how to dispute him. You might say he was either confused about what the law of noncontradiction is, or perhaps he was lying to me. I do not think he was lying. To rule him out as a liar presuppses the truth of the very thing at issue, i.e. that all people see the truth of certain foundational propositions. Since I know people tried to dissuade him on this issue I do think he understood the law in question. I have also known people who seemed incapable of understanding basic laws of logic. Consider the elementary inference we call "modus ponens." The inference goes this way, if a statement, P, is true then a statement, Q, is true. P is true. Therefore, we conclude that Q is true. If P, then Q. P, therefore Q. I once worked long and hard with a young lady who could not master this inference. She could not see why Q followed in this instance. This is such a basic inference pattern that if someone does not understand it, I don't know what more to say. I would also suspect that if one failed to grasp modus ponens, one would also fail to grasp the law of noncontradiction and excluded middle. So here are some examples where the objectivity of logical laws has failed. Since only a very small portion of the general population are exposed to courses in logic, I suspect that there are many more such cases awaiting discovery.

The people I have mentioned above may be abnormal exceptions to the condition of most people. That is why philosophers often appeal to "normal" percipients or normal observers when discussing issues in epistemology. The standard reply to my cases is to claim that logical laws are incorrigible to normal percipients only. Now the big question becomes what is a normal percipient? And if we know what one is, how do we tell when we have found one? The normal percipient is the barometer of objective truth. But now, here is the crux. I know of no non-question begging way to describe and pick out the normal percipient. Who is the normal percipient? Well, obviously it is that person who picks out as true all and only the foundational, incorrigible truths. Thus we rule out the graduate student who does not believe in the law of noncontradiction and my student who was incapable of grasping modus ponens. But of course, this is not objective, it is question begging. We are identifying the normal percipient based on the very things we want him to identify for us. I do not know of a non-question begging way to describe the normal percipient. In fact, I will make a challenge. I don't believe that anyone does, so to show me wrong, produce for me please the non-question begging description of the epistemologically normal percipient. Without such, there is no standard of objectivity for the project we are engaged in here. But there is yet more. If there is no neutral, non-question begging way to designate the normal percipient, then the designation of a normal percipient is primarily a matter of faith as in our former discussion. Thus the attempt to designate a standard of objectivity has doubled back on the first problem. We can claim that an objective standard is thus-and-so only if we take the standard as a matter of faith and leave ourselves open to the possibility that there may be those who disagree with our standard and we have nothing that we can say to dissuade them, as in the case of a religious faith.

From an historical point of view there is even more and I will mention it only briefly. There have been grave upheavals in the history of the one objective logic. Logic is not one but many. For two thousand years Aristotle held sway. Kant even went so far as to claim that the categories of Aristotelian logic were also pure categories of our understanding. I have already mentioned how non-euclidean geometries undermined Kant's picture of the structure of perception. The same was about to happen with Kant's picture of logic. Along came George Boole and modern symbolic logic. Many traditional Aristotelian inferences were judged to be invalid.[2] And it got worse. There arose the intuitionist school of

[2] Case in point, the subaltern inferences.

logicians and mathematicans beginning, approximately, with a man named Kronecker. These logicians did not believe in the law of excluded middle, one of the traditional basic laws of logic. Furthermore, they had arguments as to why this law was false. The beginning of the 20th century saw a revolution in logic and mathematics that threw aside foundations that were over two thousand years old. A nice account of this revolution can be found in a book by Morris Kline, Mathematics, the Loss of Certainty. In this regard, I have already mentioned the effects of Goedel's incompleteness proof. There is thus, grave doubt that logic or mathematics can provide a foundation of objectivity for science in a way that will serve the traditional dichotomy between science and non-science along the lines of the objective versus the subjective, the undisputed and universally agreed upon versus the disputed and locally rejected.

4. A Simple Experiment to Demonstrate the Reliance of Science on Faith.

Let me drive this home with a small experiment, one I often do with my own students. Let us remember what is at issue, the so-called "objectivity" of science. Let me remind you that by that term we usually mean that scientific theories are in some sense factual, seen to be true by "neutral" and impartial observation, and established in a way that is publicly accessible to all fair minded, rational observers. The dimension of dispute can be reasonably limited, unlike the case with the non-scientific belief or practice. Let us see if this can hold up in the case of a relatively low-level scientific "fact" like the shape of the earth, which, as I understand it, is somewhat round. What does it take to establish that the earth is indeed round? Obviously, we cannot do it just by looking at the macro-level world around us. The Boston area is crowded with many tall buildings obstructing the view of the horizon. In Pennsylvania, where I am from, the horizon is broken and obstructed by the mountains of the Alleghenies, making the earth appear lumpy and not round. Perhaps we could go down to the sea and view the unobstructed horizon that lies eastward of us. Let us do so, in our imaginations. Stretching before us, is the clean line of the horizon at the edge of our vision. What prevents us from seeing further? Is this the limit imposed upon us by a radius of curvature, or is it the edge of a flat plane? There's an old story that logic books like to tell at this point. A ship sailing towards us from over the horizon can be observed to grow taller as it crosses the line of the horizon. It is observed to sink as it sails away. What is the explanation? We are standing on a large sphere and the ship is coming up over the radius of curvature, so the earth must be spheroid. Here is what has happened. If the earth were a spheroid, it would predict that the ship behaves as we see it to do. We see the ship give the predicted behavior, so we conclude the earth is a spheroid. But we must remember that the argument is of the form affirming the consequent, and as such strictly invalid. At best we have an inductive argument to the effect that positing a spheroidal shape for the earth can explain the observed behavior of the ship at sea. However, as logicians know, infinitely many hypotheses can explain exactly the same phenomena. Let me illustrate how that works.

Our experiment had some hidden assumptions which may or may not be true. There are some simple assumptions. We assumed our ship was not a submarine that fooled us. More importantly, we assumed that light rays bounce off the ship and travel to our eyes in straight lines. Perhaps this assumption is false! If the earth were flat, and light rays travelled a path convex to the surface of the earth, we would see the ship exhibiting the same behavior. Why should we be so confident that light rays always travel in straight lines? Perhaps we could run a parallel experiment to confirm the results of the first. It might go like this. What if I travelled in a straight line, directly out to sea and beyond the point where I saw the ship. If I were to keep going and the earth is spheroid, I would end up right back where I started from. Suppose I accomplish this. Hasn't that proved my point? But again there are unspoken assumptions here which do not require universal agreement. How does one insure, in the experiment in question, that one has indeed travelled straight ahead without deviation left or right? Perhaps I could rely upon sophisticated radar sensing equipment that can pick up LORAN transmissions, or the transmissions of navigational satellites. But now we sink ever deeper in the mire. Aren't these radar transmitting devices built upon a quite sophisticated interplay of diverse physical theories? And once again they all assume that electromagnetic radiation travels in a straight line. It looks like before we can determine the shape of the earth we must determine that electromagnetic radiation, like light, travels in a straight line. Before we resort to such desperation let us try something else. Let us appeal to the much vaunted Coriolis effect.

Ever notice that the water in your bath tub turns in a clockwise direction as it runs down the drain? That's one manifestation of the Coriolis effect. In the Southern hemisphere, it would turn counter-clockwise. If you have ever watched the David Letterman Show, you may have become familiar with his attempts to verify the Coriolis effect by telephoning people all over the world and asking them to watch the water in their sinks and toilets.[3] The rotation of the earth, plus its spheroidal shape, are what is responsible for these manifestations of the Coriolis effect. Many introductory textbooks in astronomy go so far as to claim that this effect actually PROVES that the earth is a rotating spheroid. Here is how they go about it. An explanation of the effect is offered by asking you to imagine that you are standing at the North Pole (the South Pole would work just as well). You have a well built rocket with you, capable of traveling the entire circumference of the earth once it is launched. Your goal is to fire the rocket along a line of longitude southward and hit a spot on the equator. Since I'm unfamiliar with cities on the equator, let me name the point in question, perhaps it is in Peru, 'Punta Fortuna' for ease of reference. You point your rocket directly at Punta Fortuna, knowing its latitude west of Greenwich, and fire it off--away it goes. Your observer at Punta Fortuna patiently awaits its arrival, but it never gets there. However, reports come in that a rocket has crashed at the equator several hundred miles to the west of Punta Fortuna. What has gone wrong? Your rocket has exhibted behavior that seems to show there was a force on it causing it to veer to the west, to your right, and you did not correct for this force. While your rocket was in flight pointed directly at Punta Fortuna, Punta Fortuna did not stay still. The rotation of the earth carried it eastward while the rocket was in flight. The aim of the rocket was true, but Punta Fortuna did not behave itself, it moved. As a result, all objects moving freely over the surface of the Northren hemisphere have a westward "twist" applied to their motion. The larger the movement, and the less contact there is with the earth's surface, the more pronounced this "twist" becomes. What holds for the rocket holds for weather systems and the humble water in your bath tub. The movement of the rocket gets this clockwise rotation applied to it, as do high pressure systems and the water going down the drain.

But this textbook explanation of the Coriolis effect fails to "prove" anything. It explains these observed effects--the path of the rocket and the path

---

[3] These attempts always result in utter, incomprehensible, chaos.

of the water in a drain--by assuming that the earth is a rotating spheroid. In textbooks I have seen, one turns the page and there is a big picture of the spheroidal earth with a rocket launcher at the pole and a point marked on the equator, complete with motion arrows to suggest the direction of the earth's rotation--and that is supposed to prove that the earth is a rotating spheroid. The form of the argument here is the same as it was in the case of the experiment we did with the ship at sea. We have an hypothesis, that the earth is a rotating spheroid, whose job is to explain an observation, the westward drift of the rocket. We see the westward drift of the rocket, ergo we conclude the hypothesis is true. In other words we have reasoned: If H then O, O, therefore H. But there are other explanations for the westward drift of the rocket. Perhaps lines of gravitational force cause space to bend slightly to the west and as a result the rocket follows the bend in space, and so on.

We could go on, but I'm going to bring our thought experiments to a close here, since my point has been made. Trying to establish even a simple scientific hypothesis is a process fraught with difficulty. There are dozens of background assumptions involved that must be taken on faith, unless the task is to proceed to infinity. Any one of these assumptions could be called into question. The fact that we don't call them into question only aids my point. We take them on faith nevertheless. And since it is not possible to provide a foundation of certainty for all the assumptions involved, we have a failure of the methodological ideal to live up to itself at the heart of scientific experimentation. This being so, we have no clear cut demarcation between the objective and the subjective, universal agreement and the disputable, deliverable by an appeal to method.

II. Popper and Falsificationism.

A. The Abandonment of Verification and the *More Geometrico.*

Let me now turn attention to one of the premier defenders of the methodological approach to the demarcation problem, Austrian philosopher Karl Popper. Popper is quite well known for the view that what makes a theory "scientific" is the ability of the theory to be falsified by adverse or disconfirming empirical evidence. In our previous thought experiments, we were attempting to confirm an hypothesis about the shape of the earth. We found it quite hard if not impossible to rule out competing hypotheses that explained the same observations. Popper agrees that this task is fruitless and that the process of confirmation cannot yield methodological objectivity or complete universal agreement on the confirmation of an hypothesis. However there is a method that will produce a solid objective result, and anything cranked out by this method can be relied upon to be scientific as a result, that is the method of "falsification." Although scientific theories cannot be confirmed they can, on Popper's view, be definitively falsified. And this process is objective. The form of the method is that of the inference structure called 'modus tollens' by logicians. It has this form: If P then Q, not Q, therefore not P. To put it in Popper's words:

> ... the criterion of the scientific status of a theory is its falsifiability, or refutability, or testability. [Popper, 1965: 37]
>
> Every 'good' scientific theory is a prohibition: it forbids certain things to happen. The more a theory forbids, the better it is.[Popper, 1965: 36]
>
> A theory which is not refutable by any conceivable event is nonscientific. Irrefutability is not a virtue of a theory ... but a vice.[Popper, 1965: 36]
>
> Every genuine test of a theory is an attempt to falsify it, or to refute it. Testability is falsifiability; but there are degrees of testability: some theories are more testable, more exposed to refutation, than others; they take, as it were greater risks. [Popper, 1965: 36]

But, to be fair to Popper, it is not just this form alone which does the demarcating. The things we plug in for P and for Q must be certain kinds of statements. This is especially crucial in the case of the values for 'not Q'. These values must all come from what Popper calls the class of "basic" statements. This class includes:

> ...all self-consistent singular statements of a certain logical form--all conceivable singular statements of fact, as it were. [Popper, 1959: 84]

Furthermore, Popper fleshes out the characterization as follows:

> ...basic statements have the form of singular existential statements ... In addition...a basic statement must also satisfy a material requirement--a requirement concerning the event which, as the basic statement tells us, is occurring at the place k. This event must be an 'observable' event; that is to say,

> basic statements must be testable, inter-subjectively, by 'observation'.[Popper, 1959: 102]

An observable event is an event that involves position and movement of macroscopic physical bodies. [Popper, 1959: 103]. Here we see the traditional standards of objectivity emerging. Inter-subjective testability is just another way of saying that any two randomly picked "normal" observers will agree in their observations of the event. The syntactic form of all such basic statements is then given by:

$$(\exists x) \Phi x$$

As a result, and this is an important point to keep in mind, the conjunction of a basic statement with any other basic statement is also a basic statement. So you see, the class of basic statements provides the empirical grounding for scientific theories. Scientific theories will entail statements that conflict, potentially, with some member of the class of basic statements.

As far as candidates for 'P', in the schema, go, virtually any statement is a potential hypothesis of science as long as (a) a deduction can be made from the statement, and (b) the statement is empirically testable in light of some statement deduced from it. In other words, the potential hypothesis yields at some point a statement that is potentially falsifiable by some basic statement [Popper, 1959: 75-77]. I now wish to point out one rather basic criticism of Popper, before turning to a much subtler problem with his whole approach.

1. Mathematics: Problematic for Popper.

The first problem, is that Popper's demarcation criterion seems, in one sense, just too broad. A statement like, 'all the cranberries in my refrigerator are red' yields the statement, 'It is false that some cranberry in my refrigerator is not red' which is potentially falsified by the basic statement 'some cranberry in my refrigerator is not red' and so the universal claim about cranberries becomes an hypothesis of science. It now becomes part of science to investigate the color of the fruit in my kitchen. This has struck many people as counterintuitive. Furthermore, in another sense, the criterion is just too narrow. Pure mathematics, and logic, are denied the status of sciences because they do not yield statements that are potentially inconsistent with some basic statement. If we remember, a basic statement itself must be testable by inter-subjective observation of macroscopic physical objects. In Popper's sense of an empirical test, pure mathematics and pure logic are not empirically testable.

The problem with mathematics is a quite obvious and even disatrous one for Popper's position. Yet, in all the Popper literature, I know of no attempt on Popper's part to address the problem (although people other than myself have raised it against Popper; a source for this eludes me at present). One would think this a glaring oversight, and, indeed, it is. To be fair, or, rather, just, we must consider whay Popper might have said in reply to this problem, and in doing this I can only make conjectures that risk being a caricature of what Popper might actually have said. In the interest of a just consideration of his position, we must take that risk. One obvious reply to the problem, which seems like it should be rejected out of hand, is to accept the result that, on Popper's criterion, mathematics is not a science--*Quod erat demonstrandum*. But these seems a gross miscarrage of justice. Rather it impugns Popper's criterion. Is mathematics, as a result of being deemed not science, therefore a pseudo-science? Well, no, that seems plainly wrong. Mathematicians are not charlatans and mountebanks pretending to be something they're not, and afraid of being found out. Is mathematics useful? Well, of course it is. Does mathematics tell us important things about the world? Well, of course it does. If you answered 'No' to the previous question, try getting along without mathematics. In fact, we all know that nothing known colloquially as "science" could, in that event, survive. So, now we must ask ourselves, "What good has Popper's demarcation criterion done, in this case?" Well, in this case, it has sorted "sciences" into one bin and mathematics into another. But it's a distinction that's been made without a difference. In short, it's a sorting procedure without value, full of sound and fury, signifying--nothing.

In the interests of charity, let's make another proposal. Let us suggest that among true sciences there are two varieties, natural sciences and those that are sciences, but not natural sciences. (I hesitate to dub them 'non-natural' or 'un-natural' sciences for obvious reasons.) Because we need a name, let us call the latter 'scientiae'. Now it may be suggested that Popper's demarcation was meant to distinguish between natural sciences and pseudo-sciences, only. About the scientiae, it has nothing to say; it leaves that for another day, and, perhaps, yet another demarcation criterion. Mathematics is just one of the scientiae. Now there's no problem. Mathematics is still respectable, has it's own niche, and is not a pseudo-science. But now, as you would expect, there's another problem. Popper's demarcation criterion cannot distinguish between the scientiae and the pseudo-sciences. Of course, on this gambit, it would not be meant to do so. So what's the problem? Well any so-called "science" that failed the criterion has an easy defense. Its defenders simply say, "Well, here's another of the scientiae! We're not really confronted with a pseudo-science, this discipline is on the order of mathematics--a scientiae." Honor is preserved. Astrology, Marxism, psychology (or, at least Freudian and Adlerian psycho-analysis) and the entire gallery of Popper's bug-a-boos can now save face. All they need do is claim that they are no worse off than mathematics and until more is said, they can lay claim to classification as just more of the scientiae--things that are sciences, just not natural sciences. This tactic is, therefore, not tenable, at least not until we have a criterion that can tell us when a discipline is one of the scientiae. Of course, Popper offers us no such criterion, not even a hint of one nor a hint that he is aware of this gambit or the problem that brought it on. Mathematics still leaves us with a crisis in Popper's demarcation criterion.

There are other standard criticisms of Popper, such as the problem of auxiliary hypotheses, but I wish to leave these aside for a criticism that is much more problematic (Popper has a plausible response to the problem of auxiliary hypotheses) and as far as I'm aware, not previously discussed in the literature.

B. Problem: How do We Read the '-able' in 'Falsifi*able*'? All Theories Become Falsifiable.

The problem is this: Just how do we interpret the criterion of falsifiability? Does it mean falsification in fact or only *in potentia*? Must a theory be actually falsified or only potentially falsifiable? It could not be the former, or else only false theories would count as scientific. It must, therefore, be the latter. When we talk about falsifiability, we must mean 'potentially falsifiable'. The way philosophers usually express this is to say that there is some *conceivable* event that would falsify the hypothesis--not an actual event but a *conceivable* one. Another slightly more technical way to put this is to say there is a "possible world" in which the theory *is* false. Hence, we need only appeal to a possible, or *conceivable* situation to adjudge a theory scientific. This is also Popper's view of the situation.

> A theory which is not refutable by any conceivable event is nonscientific. [Popper, 1965: 36; emphasis added].
>
> ...we may distinguish three requirements which our empirical theoretical system will have to satisfy. First, it must be synthetic, so that it may represent a noncontradictory, a possible world. ...it must not be metaphysical but must represent a world of possible experience. [Popper, 1959: 39; emphasis added]
>
> ...all the statements of empirical science...must be such that to verify them and to falsify them must both be logically possible. [Popper, 1959: 40; emphasis added]
>
> For I do not demand that every scientific statement must have in fact been tested before it is accepted. I only demand that every such statement must be capable of being tested; [Popper, 1959: 48]

Conceivablility is the achilles heel of falsificationism. Let us remember that the grounds for testing a theory lie in the set of what Popper calls basic statements. This set includes "*all conceivable singular statements of fact*" [Popper, 1959: 84]. Some implication of a proposed scientific theory will be tested by conflicting with a member of this set. But let us remember, the set contains not statements of actual fact, but *conceivable* fact, facts that are logically possible, facts from every possible world. Now it is my contention that every claim of the Bible--the foundation of the Christian faith--is strictly scientific in Popper's sense. Let us gather together all the declarative statements of Scripture and form their conjunction. I will designate this conjunction as 'B' (for 'Biblical') and call this the 'Biblical theory'. Now Popper has stated that all scientific laws or theories must have a universal syntactic form. We can take care of this cosmetically by prefixing to 'B' a vacuous universal quantifier, thus forming '$(\forall x)(B)$'. One of the things derivable from our Biblical Theory will be 1 Thessalonians 4:17:

> Then we which are alive and remain shall be caught up together with them in the clouds, to meet the Lord in the air: and so shall we ever be with the Lord. -- 1 Thessalonians 4:17

This is tantamount to a universal statement that says 'All believers shall meet the Lord in the air'. This is derivable from the Biblical theory. Now consider the class of all basic statements. Certainly the statement 'There is a believer who does not meet the Lord in the air' is a conceivable statement of existential form and so is a member of the class of basic statements. Furthermore it conflicts with the statement 'All believers shall meet the Lord in the air'. But, Popper would remind us, the basic statement must be about something that is "observable" and so testable, inter-subjectively, by observation. Well, if we can "observe" sub-atomic particles, as Popper quite clearly thinks we can, certainly the existence of a believer who does not meet the Lord in the air is inter-subjectively test***able*** by observation, if indeed anything is. Therefore, the Biblical Theory meets the test of counting as a true scientific theory with positive empirical content, since in Popper's words:

> ...it divides the class of all possible basic statements unambiguously into the following two non-empty subclasses. First, the class of all those basic statements with which it is inconsistent (or which it rules out, or prohibits): we call this the class of the potential falsifiers of the theory; and secondly, the class of those basic statements which it does not contradict (or which it 'permits'). [Popper, 1959: 86]

The Biblical Theory has potential falsifiers that can be intersubjectively tested by observation. Hence, it is a full-fledged scientific theory. But let's drive the point home even more. I can now directly test for the existence of God. I do it with my *THEO-METER*. The description and functioning of my theometer is given by the following formal statement, that I will call 'T':

T: $(\forall x)(\forall y)$(x is a working theometer & y is God & x is in the presence of y $\supset$ x glows red)

This description is true. It is *vacuously* true because, as far as I know, there are no working theometers. We can add this sentence to our theory B and still have a true theory. Let us do so. Let us call the enhanced theory B+. In the class of basic statements there is also found the statement:

T': $(\exists x)(\exists y)$(x is a working theometer & y is God & x is in the presence of y & x does not glow red)

B+ is also testable, falsifiable, and scientific with empirical content since it deductively yields a true description of a theometer which conflicts with a conceivable, intersubjectively testable-by-observation-existentially- quantified basic statement, T'[4]. We can now test, empirically, for the existence of God. Let

[4]Being in the presence of God is observable if anything is. See Acts 7:55-56. Is the statement 'I am now at Redeemer College' testable by observation? How many of you actually "see" Redeemer College? Or Ancaster? Or electrons? I only see a bunch of buildings. As for electrons, well, golly...

us conjoin T with the statement 'God exists', add a vacuous quantifier and produce the following theory:

$$(\forall x)(T \ \& \ \text{God exists})$$

This theory counts as scientific for the very same reasons that B+ did, it deductively yields a conflict with the basic statement T'. But what's more, my description of a theometer now turns ***ANY GROUP OF STATEMENTS INTO A BONA FIDE EMPIRICALLY CONTENTFUL SCIENTIFIC THEORY, AND WILL DO SO WITHOUT MAKING THE THEORY ACTUALLY FALSE*** because statement T is vacuously true. Let us take astrology and formulate it as a theory by conjoining all the statements of astrology and calling that formulation 'A'. Let us enhance theory A by adding T to it to, plus a vacuous quantifier, and form 'A+'. A+ deductively yields a conflict with T' as did B+ and so for the same reasons counts as a scientific, empirically grounded theory.

For Popper, the prime example of a non-scientific theory is Marxism [Miller, 1985: 127 ff.]. Ah, poor Marxists, if you are but willing to make one small concession, this poor befuddled, Christian can really save your bacon. Let's call your theory 'M'. Now, if you but add T to your theory, and perhaps a vacuous quantifier, a small price to pay, we will enhance it and produce M+, fully falsifiable and scientific as was A+ and B+. But now my strategy so exemplified can be applied in the same manner to any theory and so *everything* is an empirically testable, or falsifiable, scientific theory. And notice that this comes about because the class of basic statements must contain all *conceivable* existentially quantified statements whose truth can be directly observed, if they were true. I think this is sufficient to reduce the criterion of falsifiability to absurdity, if not complete lunacy.

C. Lakatos and Sophisticated Falsificationism.

The successor theory to Popper's falsification is generally taken to be something on the order of Imre Lakatos' *sophisticated* falsificationism. Popper's view, although praised by Lakatos, is referred to by him as "naive." It does not accurately represent what happens in the history of actual scientific research. Lakatos wishes to capture the idea that falsification occurs only after a successor to a theory is proposed and corroborated. But he also wishes to do justice to what he considers an essential insight of Popper's, the ability of a truly scientific theory to be subject to experimental test. Lakatos proposes that:

> ...a scientific theory T is falsified if and only if another theory T' has been proposed with the following characteristics: (1) T' has excess empirical content over T: that is it predicts novel facts, that is, facts improbable in the light of, or even forbidden, by T; (2) T' explains the previous success of T, that is, all the unrefuted content of T is included (within the limits of observational error) in the content of T'; and (3) some of the excess content of T' is corroborated. [Lakatos: 32]

A theory is scientific if it is part of such a chain of theories, each one falsifying its predecessor. The status of being scientific is actually conferred upon the chain of succeeding theories. The prime example of such a chain, in Lakatos' view, is the replacement of Newtonian physics by Einstein's [Lakatos: 39]. "...it [Einstein's theory] explained everything that Newton's theory had successfully explained,..." [Lakatos: 39]. First, I want to challenge this historical picture. Einstein's theory does not explain everything that Newton's theory did. The unrefuted content of Newton's theory is not contained in Einstein's and cannot be. The reason is that Newton believed in action at a distance through gravitational forces. Einstein's theory dispenses with gravitational forces, and so with action at a distance between bodies having mass alone. Einstein makes use of space-time curvatures. Space and time are totally "flat" and Euclidean on Newton's view. So, there is no way that one can explain or deduce Newton's laws of motion from Einstein's theory. There is no common content between the two theories. There is no way to derive something like 'force = mass x acceleration' from Einstein because Einstein does not mean, by words like 'force', 'mass', or 'acceleration' what Newton meant by them. My point is one about logic and the nature of deductions. If axiom system A does not have the same content as system B, then no amount of fiddling will enable one to derive B from A. This point has been made in print and in public by University of Syracuse physicist Fritz Rohrlich.

Secondly, there is the "tacking paradox." Any scientific theory can be replaced or modified by a successor theory of a trivial nature. Hence, we can falsify scientific theories and create scientific progress with utterly trivial modifications, all of which are allowed by the Lakatos definition. Let us formulate Newtonian physics as "N". Now let us take a sentence like 'All copper conducts electricity' and add it to N to form a new theory, N'. N' will now count as having falsified N on Lakatos' definition of sophisticated falsificationism. First of all, N' has excess empirical content over just N. It will predict novel facts not predicted by N. In fact, N says nothing about copper or electricity. So, if I discover that the penny in my pocket is copper, N' will predict that the penny will conduct electricity, something that N alone will not. Clause 1 of sophisticated falsificationism is met. Clause 2 is also met since N' is a conjunction of N and 'all copper conducts electricity'. N', therefore, deductively yields N. Anything N explains N' also explains through the addition of one extra step of conjunction simplification to the explanation. Clause 3 is also met since we can corroborate some of the excess empirical content of N'. We can test copper items to see if indeed they conduct electricity. N', therefore, counts as having falsified N and in so doing represents scientific progress. As an account of scientific progress and the falsification of scientific theories, sophisticated falsificationism is thus too broad. To avoid this paradox, Lakatos has said that sophisticated falsificationism must demand "...that the additional assertions must be connected with the original assertion *more intimately* than by mere conjunction" [Lakatos: 46]. However, he does not say what 'more intimately' means, nor how we are to keep from thereby ruling out legitimate scientific progress that does come about through conjoining new laws to older theories. But even if he did, none of what he says would prevent even astrology from becoming a science as long as it incorporated some trivial research program (perhaps just handing out surveys to clients) in the light of which astrological practice was slightly revised or modified. Thus I have my doubts that the methodological approach to the demarcation problem will ever bear fruit.

III. A Biblical Alternative to the Question of 'What is a science?'.

A. A Radically New, Content Oriented, Demarcation Criterion.

Let me now turn to my own proposal for defining a science. It's a proposal that I call "content oriented" since it focuses on what the science studies rather than the methods it employs. In this regard I wish to adopt the procedure used by Roy Clouser in his fascinating book, The Myth of Religious Neutrality, for defining 'religion'. I wish to draw up a short list of things we can agree are sciences and see if we can extract some common characteristics therefrom. Notice that neither Popper nor Lakatos do this. They begin by legislating for the sciences what they should all be like. Here is my short list: Mathematics, physics, biology, chemistry, psychology, linguistics. If we agree on this list, there is something we can notice immediately. Each science investigates a more or less homogeneous group of properties and laws that are all of the same kind. Mathematics investigates a group of properties and laws that are distinctly different in kind from that investigated by physics, whose concerns, in turn are with a group of laws and properties that are distinctly different in kind from those of biology, or psychology, or chemistry or linguistics. Each science focuses on a unique sphere of laws and properties, all of the same kind. I must reveal at this point, something about the metaphysical theory I am presupposing here. One's general theory of reality cannot help but influence how one sees the relationship between the various sciences. I admit to being a "Clouserian", someone who follows the philosophical position of Roy Clouser as outlined in the book I just mentioned. But Clouser's work is designed to bring to American philosophers, the work of a Dutch philosopher, Herman Doyeweerd. Here we both are following the christian/calvinist philosophy of the Netherlands, whose primary proponent in this century was Herman Dooyeweerd, and whose foremost expositor in the United States is now Roy Clouser. In what follows I will rely heavily on chapter 4 of Clouser's book, especially his account of aspects of reality and abstraction in thought, and I am much indebted thereto.

This philosophy is anti-reductionist. Unlike the majority of Anglo-American philosophers who are physicalists, or materialists, and view reality as consisting of just one basic kind of law and properties--physical laws and properties, this christian school sees objects as exhibiting a plurality of different kinds of aspects. Each aspect of an object consitutes a collection of laws and properties of a given kind, like the kinds investigated by each science on our short list above. Although intimately related to each other, the various aspects of reality are not reducible to each other, even though no aspect could exist independently on its own. For example, spatial properties seem to characterize things in terms of their position and extension, while linguistic properties seem to concern the idea that one thing can point to and *signify* another, symbolically. So linguistic properties seem to concern themselves with an aspect of objects which is not at the forefront of our interests when we are concerned with an object's spatial orientations. Similarly, biological properties seem to concern themselves primarily with life, its growth and development in those organisms we consider to be living. But when our concerns turn to physical properties, we are no longer concerned with life, but with notions of energy which is a concern that is separable from that associated with biological properties. (Although this is not to deny the obvious fact that life requires energy.) Different sciences are distinct from one another only in so far as they each are primarily concerned with investigating the kinds of laws and properties in a given aspect. Thus my short list of the sciences presupposes that there is a plurality of different kinds of laws and properties as part of the basic nature of reality. One must, of course, do more than just set out to investigate a given aspect of reality. Every science advances theories of some sort about laws and properties in a given aspect and then attempts to justify those theories in some sense. But theory making is not limited to the sciences. We make theories and offer explanations on an everyday basis about a host of things. Theory making in the sciences differs from that in ordinary everyday life in that it is more abstract than ordinary everday theories or explanations. This again is a content oriented notion. I wish to suggest that what makes the kind of thought-activity one finds in the sciences more abstract is the attitude that is taken towards the subject matter. The word 'abstract' is of latin origin, from the word 'abstrahere' which means 'to drag out'. When a scientist investigates his aspect he "drags it out" and separates it from all the rest. This separation is only one of thought activity. The scientist isolates the properties and laws that interest him through the activity of thought alone. Let me briefly illustrate this. We use arithmetic on an everday basis to count our change, our books, or what-have-you. We are worried about mathematical properties as they exhibit themselves in close connection with the objects of experience. Our worries are with numbers as numbers-of-objects-of-a-certain-sort. But a mathematician will raise questions like, 'Are systems of arithmetic obtainable from finite axiom systems?' 'Are there finitely or infinitely many prime numbers?', 'Is every even number the sum of two prime numbers?' and so on. His questions presuppose that mathematical properties themselves, and the entire mathematical aspect has been "abstracted" in thought, dragged out from the context in which ordinary experience first encounters mathematical properties. Rather than worry about the number of a group of objects, a mathematician worries about number itself, and numerical properties as they exist in isolation from the objects of ordinary experience. Physicists isolate and abstract the physical aspect, and worry about the laws and properties associated with energy itself. Biologists isolate and abstract the biotic aspect, investigating laws and properties that are concerned with the production and maintenance of organic life. Chemists are concerned in the abstract with compositionality, and how this notion affects homogeneity or heterogeneity of materials. Psychology investigates the sensory aspect of reality, and tries to discover how laws of sensory feeling and perception guide and direct life. Linguistics abstracts and isolates the symbolic functioning of objects in an attempt to discover how meaning itself operates and is conveyed, symbolically, in language. So, in all the sciences on our short list, the isolation in thought of one specific kind of properties and laws is presupposed before that science can ever begin to make theories. I will now make bold to propose my content oriented definition of a science:

D1. A given discipline is a ***specialized science*** IFF: 1) Its investigation of reality is delimited by one aspect (modal sphere) of reality, and 2) in proposing and justifying theories, it presupposes this same aspect of reality has been isolated in thought, through abstraction, from the ordinary objects of experience, and 3) the explanations it offers have the same presupposition as 2).

This definition immediately avoids some problems inherent in the methodological approach. It does not include the simple investigation of fruit in my refrigerator as a science, nor astrology, since neither of these are investigations into the laws of a single aspect. It avoids being overly broad. But as it stands it is too narrow. Anthropology and geology, for example, would not count as a science and this is counterintuitive. I will therefore treat the above as a definition of a basic, or specialized science. There are other sciences that are not basic or specialized, yet are indeed sciences in some legitimate sense. I will call these *inter-aspectual* sciences. Sciences like anthropology, geology, astronomy, meterology and others investigate laws across aspectual boundaries. But they must make use of and build upon the insights of a specialized science. This is not to belittle these sciences, but to make a factual comment on the structure of their subject matter. These sciences must use abstract thinking every bit as much as a specialized science. But they use it with regard to more than one aspect. Their subject matter cuts across aspectual boundaries. I will therefore propose the following definition of an "inter-aspectual science":

D2. A given discipline is an ***inter-aspectual science*** IFF: 1) Its investigation of reality is delimited by two or more aspects, and 2) in proposing and justifying theories, it presupposes that two or more aspects of reality have been isolated in thought, through abstraction, from the ordinary objects of experience, and 3) the explanations it offers make the same presupposition as 2), and 4) It will make use of work in one or more specialized sciences.

Geology, anthropology, meterology, oceanography and a host of other cross-disciplines now count as sciences. Finally I will say that a discipline is a science IFF it counts as either a specialized science (D1) or an inter-aspectual science (D2). Pending further discussion, I will claim that the strongest justification for my view is that it does justice to our ordinary intuitions about what disciplines are sciences and it supports those decisions as they already exist in various social institutions, especially academic institutions.

B. Consequences of the Content Oriented Proposal.

Let's explore some interesting consequences of "my" definitions. For one thing, on D1 and D2 the traditional distinction between natural and social sciences collapses as utterly null and void. This is as it should be. Let us ask ourselves the question, "Do social sciences like sociology, economics, history, (and perhaps psychology) investigate distinct kinds of properties and laws that really exist in the world?" I'm inclined to say that they surely do. They investigate aspects of reality that are just as much a part of the world as those aspects that are investigated by the misnomered "natural" sciences. If sociological, economic and other properties are a part of reality then they are just as natural as the aspects associated with physics, chemistry, mathematics and biology. In which case the division between natural and social sciences is born of clear metaphysical bias, a reductionistic bias that regards the world as containing only or primarily physico-chemical and mathematical properties. The social sciences are just as much "natural" sciences as physics and chemistry. Literary criticism is also a bona fide science. Its field of investigation is a subdivision of the aesthetic aspect. Here I'm presupposing a familiarity with the fifteen distinct aspects of reality as they have been identified by both Dooyeweerd and Clouser. 'Aspect' is Clouser's word, Dooyeweerd uses the term 'modal sphere'. Thus, there are 15 specialized sciences, one for each aspect (See Fig. 1).

In the sense of D1 and D2, philosophy is truly a science. It is the grandest of all inter-aspectual sciences, and for those of us who have studied it we can certainly attest to its highly abstract nature. Furthermore, you cannot hope to do philosophy well without some rather detailed knowledge of one or more specialized sciences. Theology as well counts as a science.[5] We must remember that in both Clouser's and Dooyeweerd's listing of aspects there is a pistical aspect in which all objects function. Everything has properties or relations that involve faith. The field of investigation in theology is a subdivision of the pistical aspect. It is those pistical relations found in

[5]After conversations with H. Geertsema, R. Clouser, and D.F.M. Strauss, I realize that this is not quite right. Theology bears more the characteristic of an interdisciplinary science and is not primarily devoted to making theories about the functioning of our faith-lives. The specialized science proper to the pistical aspect should be called 'pistology' and unlike theology it does not have a primary concern for explicating Scriptural doctrine. Rather it is devoted to making theories about the functioning of faith. Without a doubt, more investigation is required on this subject.

religious belief, and in Christian theology -- which is Reformed theology -- we try to make clear those foundations and relationships involved in peculiarly Christian faith.

Now here is something else about my proposal. It does not rule out the possibility that people do science and do it badly. The mad rush on the part of methodologists into methodological demarcations is born in part by their paranoically apopleptic dread of a spectre called "pseudo-science." They live in terror of poly-water scandals, cold fusion, gadgets that take tap water and turn it into hydrogen for affordable home energy, astrology, etc. They fear that such things will reflect badly upon science and so they wish to disassociate themselves from it through the myth of a methodological approach to science. But this ignores the fact the people do make mistakes in all fields of study, even science, and that this is to be expected given our limitations as sinful human beings. So, through the recognition of noetic sin, one motivation for a methodological approach to science is eliminated. I admit that while doing science we can do it badly, nevertheless, it is still science. The rush to escape pseudo-science through methodology either causes us to rule out as science genuine sciences or includes as sciences things that clearly are not. Paul Feyerabend has agrued persuasively that if one looks at methodology alone one is often hard pressed to find any difference between practicioners of astrology and bona fide scientists.

Most importantly, here's why I think my approach is one that can be called a Christian outlook on what a science is. It has to do with its metaphysical assumptions. You have heard me use the words 'reductionist' and 'anti-reductionst'. Let me explain those. A metaphysical reductionist is someone who believes that reality contains only a very limited number of kinds of properties, usually just one or two. Materialism or physicalism is a popular reductionistic view. Materialists believe that the world contains only physical laws or properties. The subject matter of all other sciences and disciplines is ultimately reducible to the subject matter of physics. The basic kinds of laws and properties that the world contains are physical laws and properties exclusively. This has been the dominant view in philosophy of science during most of the present century. Roy Clouser has argued persuasively that such reductionist viewpoints are religious because they treat one aspect of reality as an ontological absolute which explains the existence of all else while that aspect itself is just there, depending upon nothing but itself for its existence. The aspect of reality to which everything else is reduced is treated as a divinity would be treated in things we ordinarily understand as religious belief. In keeping with Clouser's position I, as an evangelical Christian, would want to avoid reductionist metaphysical viewpoints because they conflict with the Biblical position that everything about created reality depends upon God for its existence, and not something God has created. Reductionistic viewpoints are equivalent to idolatry. The methodological approaches to the demarcation problem all strike me as reductionistic. First of all, remember my earlier comment about a colleague who did not think psychology was a science because it was not mathematical enough. This betrays a metaphysical bias that sees mathematical laws and properties as somehow more real than those studied by psychologists. So, to be scientific, one must accomodate one's methodology to that of those sciences that study what is real--mathematics for instance. In fact, the entire attempt to accomodate scientific thinking to the *more geometrico*, as that tradition existed from Aristotle down through the 18th century, betrays the same reductionistic bias. The bias still exists in a much reduced form in Popper and Lakatos. Remember, the criterion of demarcation they are looking for is primarily a formal and logical account of the methodology of a science. They are motivated to find a logical methodology for science and a formal, logical relationship by means of which theories succeed each other in research programs.

A stronger bias in Popper and Lakatos is their physicalism. It is my hypothesis that both have taken the methodological approach that they have because they see physics as the paradigmatic science. The formal methodologies they propose to demarcate science from non-science are best suited for the supposed structure and history of physics. It is always physics to which they appeal for their test cases. Theirs is an attempt to accomodate all sciences to the methodology and history of physics. As such, it sees the physical aspect of reality as that which is most "real" [Popper, 1965: 35-36]. The attempt to see all sciences as possessing the same method, irrespective of subject matter, would have be hard to motivate, if it was recognized that sciences differ in their subject matter. Why should one thnk that one method fits all, unless there was only one real subject matter to begin with, namely, that of physics? Thinking in terms of a physicalistic reducton makes it easier to impose the method of physics on all sciences. It is a motivation for avoiding a content oriented approach that sees a metaphysical plurality of aspects behind a plurality of sciences, and if there is a plurality of sciences there is likely to be a plurality of scientific methods, too. There is one real scientific method for Popper because there is ultimately, only one real science and subject matter--that of physics.

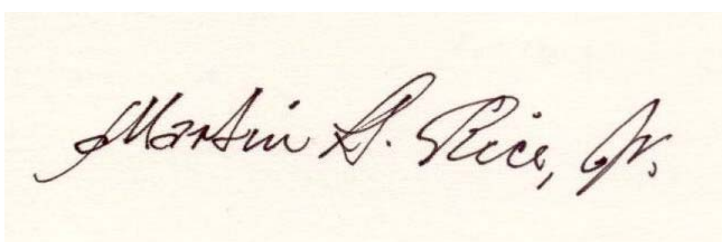
I find a similar bias motivating the distinction between natural and social sciences, which often fits together with a distinction between facts and values, the "fact/value" distinction. Natural sciences are supposed to be more in tune with "facts," and "value" free; social sciences have more to do with "values." As value content increases we shade off from science into non-science. The motivation for such a distinction could only be that what is studied by the social sciences is somehow not a part of the natural world. In short, their subject matter is not real. But of course this would be plausible only if one held to a reductionistic viewpoint that saw only the subject matter of physics and chemistry, and perhaps biology, as real. If those aspects studied by the social sciences are indeed parts of reality, then the social sciences are just as "natural" as physics and chemistry. Moreover, there is then no reason for the social sciences to accomodate their methodologies to those of physics, chemistry, or mathematics. There is also no reason not to see values as facts about the world every bit as much as the facts of chemistry and physics. There is a fact/value distinction concomittant with the natural/social science distinction only if "values" are less real than facts are. But this again betrays a reduction that says the norms that are inherently a part of the ethical, political, social and economic aspects are not as real, or not a real part of the world in the way that the laws of physics and chemistry are. But again this is a reductionistic bias that does not comport with a Biblical world-view. On the view I am advocating, values and norms are every bit as much "facts" about the world as is the shape of the earth. If we are tempted to think that disagreements over values and norms somehow places them in a different ontological realm from the "facts" of physical sciences, let us remember that there has been just as much disagrement over the so-called "facts" of astronomy, physics, and even chemistry. There has only been general agreement on the molecular nature of matter since shortly before the First World War, to take one example. Without a reductionistic, anti-Biblical bias, the fact/value and social/natural sciences dichotomies are groundless mythologies.

My view, on the other hand, is anti-reductionist. It does not treat any aspect of reality as more real than any other. To that extent, it admits to being motivated by a Biblical world-view, in so far as an anti-reductionistic metaphysics is compatible with a Biblical world-view in which only God functions as an ontological absolute upon which everything depends for its existence. So there is no ground for rating the sciences hierarchically in terms of importance. It does not denigrate the social sciences in favor of the physical sciences. Nor is there any reason to think some one methodology will best capture what all sciences do that makes them distinctly sciences. Furthermore, this view does not rely upon what cannot be relied upon, namely the piece of popular mythology that sees true science as devoid of a faith component and somehow more

Reprinted from Contemporary Reflections on the Philosophy of Herman Dooyeweerd, Strauss and Botting, eds., The Edwin Mellen Press, copyright © MM, pages 239-271.

objective than any other discipline. It also allows us to classify the various sciences in a way that seems intuitive, into specialized and inter-aspectual, nonspecialized sciences. The methodological approach bears no fruit in this direction. Indeed, I would go so far as to say that the methodological approach is highly non-empirical in its philosophical approach. Rather than let the scientific community and actual practice inform one's philosophy of science, the methodological approach strikes me as an attempt to legislate for scientific practice after an a priori manner that is ill-grounded at its best.[6] These are some of the advantages that a content oriented approach to the demarcation problem offers the Christian world-view. I admit that mine may not be the only approach that is distinctly Christian in terms of its metaphysical assumptions. I do think it is a place where Christian philosophy of science can start and do justice to the empirical diversity of scientific life and practice.

- FINIS -



[6]This accusation against Popper in particular is not new. It has been emphasized by Paul Feyerabend.

Reprinted from Contemporary Reflections on the Philosophy of Herman Dooyeweerd,
Strauss and Botting, eds., The Edwin Mellen Press, copyright © MM, pages 239-271.

The Clouser/Dooyeweerd Listing of Aspects

Aspect	Corresponding Specialized Science
Fiduciary/Pistical	Theology
Ethical	Normative & Meta-ethics, Casuistry
Juridical	Political Science, Jurisprudence
Aesthetic	Literary & artistic criticism
Economic	Economics (micro, macro, etc.)
Social	Sociology
Linguistic	Linguistics
Historical	History, Historiography
Logical	Logic & Cognitive Sciences
Sensory/Psychical	Psychology
Biotic	Biology
Physical	Physics, chemistry
Motional	Kinematics
Spatial	Geometry, topology
Quantitative	Mathematics

Figure 1
Adapted from R.A. Clouser (1991: 56-57).

Bibliography

Clouser, Roy. The Myth of Religious Neutrality. Notre Dame, University of Notre Dame Press, 1991.

Lakatos, Imre. The Methodology of Scientific Research Programmes. John Worrall and Gregory Currie, Eds. Cambridge, Cambridge University Press, 1980. Volume I.

Losee, John. A Historical Introduction to the Philosophy of Science. Oxford, Oxford University Press, 1972.

Miller, David, Ed. Popper Selections. Princeton, Princeton University Press, 1985.

Popper, Karl. The Logic of Scientific Discovery. New York, Harper and Row, 1959.

Popper, Karl. Conjectures and Refutations: The Growth of Scientific Knowledge. New York, Harper and Row, 1965.