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Introduction

In the fourth quarter of the twentieth century we find ourselves at the end of a four-hundred-year-old tradition in which science has been regarded as a religiously neutral, completely objective quest for universal truth about the natural world.

Christians have traditionally objected to this supposed autonomy of science from religious foundations, but only recently has work by non-Christian philosophers and historians of science, such as Collingwood,[1] Hanson,[2] and Kuhn,[3] underscored these objections. To these scholars, scientific activity has indeed been carried out within a framework of beliefs or expectations which has supposedly played as great a role in the progress of scientific theories as have experience and reason. In fact, Kuhn concludes that the succession of two scientific theories is often characterized by a necessary "conversion" of scientists from one set of basic commitments to a new one, rather than by a set of new experimental results.

We shall try to show in this article that the Christian claim that the structure of science is determined by one's basic religious commitments in life has a clear echo in present day non-Christian philosophy of science. Christians have made, and can continue to make, a contribution to the discussions concerning the role played by religion in the structure of the sciences and the humanities.

Unfortunately, however valid the Christian objections to the hope of achieving objective, universal truth by means of an autonomous science may have been, Christians have often replaced this quest by their own search for "universally valid scientific truth."

We shall claim in this paper that to look to the Scriptures for a guarantee of the validity of a Christian scientific theory is also fruitless. Scientific activity belongs to the task given to man at the creation, and is a task that will forever remain incomplete, tentative, developing, and it is as much a creative, imaginative struggling with the secrets of nature for the Christian as it is for the non-Christian.

We shall, however, try to indicate the way we might expect our basic Christian commitment to influence our scientific "theorizing."

The Tradition of Neutrality

Briefly, the tradition of the objective neutrality of scientific activity is based on two initially separate streams of thought.

There was the earlier Cartesian tradition in which man, by applying pure reason alone, and divesting himself of all ideas of which he was doubtful, could arrive at a few central ideas concerning which there was absolutely no doubt. So Descartes arrived at his own most basic belief: Cogito ergo sum. On the basis established by radical doubt, man could, by reasoning carefully, develop in principle, all knowledge concerning the world about him, and, if his reasoning were carried out logically, he would arrive at universal truth. Even though such rationalistic attempts at scientific knowledge have without exception been notably unsuccessful (cf. Descartes' rules of impact and Leibniz' discussion of Descartes' rules[4]), the belief in the adequacy of man's reason has remained with us for a long time.

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The second tradition stemmed from Francis Bacon and others and is usually designated as British Empiricism. In this view, experimentation and observation of nature was the primary condition for arriving at objective truth. One of the best capsulations of this point of view was made by Thomas Huxley:

> "Science seems to me to teach in the highest degree the great truth which is embodied in the Christian conception of entire surrender to the will of God. Sit down before a fact like a little child, be prepared to give up every preconceived notion, follow humbly wherever and to whatever abysses nature leads, or you shall learn nothing."[5]

Both these traditions are obviously based on man's assumed autonomy in creation, on faith in man's ability to obtain true knowledge in one of these ways, or what in fact turns out to be a synthesis of these traditions. However, even when the emptiness of either of these ways of achieving true knowledge was pointed out

by Hume in England and later by Kant in Germany and a new method of philosophy was introduced which saw more clearly the interplay of man's reason and experience, this synthesis was still based on human autonomy, the professed independence of man's reasoning and scientific activity from any religious or philosophical preconceptions.

Of course, Christians have often criticized the claims of such an autonomous science:

a) First, Christians believe that man's commitment to God is a total commitment that must affect his task in all areas of life. Christ has not only truly restored our relationship to the Father but also our relationship toward our fellow man and to the creation. We believe that the work of man, in the absence of a positive relationship to God is tainted by sin in all his endeavors, and that man's place in creation and his understanding of creation are determined by his stand with respect to his Creator.

b) Second, Christians have claimed that a search for objective, universally valid truth independent of one's basic world and life view has led to a cheapening of truth. For example, in the psychological tradition of behaviorism, the view of man's behavior as determined by heredity and environment, the focusing of attention on that part of man linked with the animals, has led to a certain amount of insight into man's dependence on heredity and the influence of environment on his behavior, but represents a cheapening of the truth by denying man's responsibility before God despite these recognizable and existing limitations. (The philosophy of the cosmonomic idea of Dooyeweerd suggests that the belief in the autonomy of reason generally leads to the absolutizing of certain aspects in creation so that politically we get, for example, the isms: capitalism, socialism, communism, and scientifically we get the historical streams of empiricism, rationalism, determinism, etc., each of which represents a specific absolutization of an aspect of of creation.)

This cheapening of the truth may have its effects also on the natural sciences, where scientists busy themselves exclusively with studying specific problem situations identified by the theory structure holding at the time rather than with investigating the foundations of the theories and the possible testing of the foundations.

c) Third, even if Christian students or scientists accepted the view that our faith commitment is meaningful in everyday scientific activity, it was not always clear how such a commitment should function, if at all, in the natural sciences. Although it appeared obvious that the humanities and perhaps even psychology and biology would be strongly influenced by the presence or absence of a Christian commitment, not much evidence was available before the last two decades that this may also be true in the physical sciences.

Textbooks have generally presented the physical sciences from only the "modern" perspectives, in which the various discoveries in science are portrayed as adding to that great cumulative body of knowledge. Older theories are, probably for pedagogical reasons, seen as limiting cases of the current theory; and the redefinition of basic concepts and the different picture of the natural world posed by successive theories are generally glossed over rather quickly.

Furthermore, scientists of many different religions, philosophical and political persuasions do appear to be working together harmoniously to develop the natural sciences, with considerable success. Consequently, the claim that scientific activity, at least in these areas, is objective and leads to universally valid truth has to be met by a study of these sciences themselves.

Out of many possible discoveries to analyze, to show how one's basic framework of beliefs or expectations concerning the natural world does influence scientific activity, we have chosen the discovery of the positron, and the current controversy concerning the basic nature of physical laws in quantum mechanics. We hope to show by these examples that we are indeed

as was claimed at the beginning of this article, "at the end of a four-hundred-year-old tradition in which science has been regarded as a religiously neutral, completely objective quest for universal truth." Many philosophers and historians of science have recognized this assumption as false, although much of the scientific community still labors under the weight of that tradition.

The Positron

"On August 2, 1932, Dr. Carl D. Anderson discovered the positron." With this quotation, N. R. Hanson points out that the discovery of the positive electron is often portrayed simply as the fourth elementary particle to be discovered by physicists, the fourth out of . . . what is now, hundreds.[6] When portrayed in this way, there appears to be nothing at all remarkable about this discovery. The positron is simply one more discovery to be classified in some elementary particle classification the way a specific plant or animal may be classified in some family.

Hanson then traces through the history preceding the discovery of the positron and notes that many physicists after 1932 remember seeing positron tracks on photographic plates as early as 1926. In fact, Hanson reproduces certain of these plates and records that certain physicists had drawn the attention of others to these peculiar tracks, which were often interpreted as tracks of electrons, emitted by chance simultaneously with the actual process studied, from the walls of the container and traveling in the opposite direction of the other particles studied.

When some physicists noted that these backward electrons were occurring too often to be attributed to mere chance, some physicists tried to interpret the tracks as proton tracks (thereby again reversing the direction of these tracks). Such interpretations led to the need to explain the "thinness" of the proton track (the width of the track in the photographic plate or the cloud chamber depends on the mass and the speed of the particle making up the track) and the length of the track.

On the theoretical side, P.A.M. Dirac in 1928 derived his first relativistic wave equation, which described the behavior of free particles and gave an accurate description of the spectrum of the hydrogen atom. Unfortunately, for every particle described successfully by the Dirac equation, there existed a corresponding particle in a "negative energy state," a particle which could be interpreted as a positive electron, if such existed.

> "[The Christian] will be more charitable toward others' views, will even admit the existence of alternative Christian scientific theories and Christian philosophies without proclaiming such theories to represent absolute truth but merely to be steps on the way toward that real truth which we can only approach."

However, Dirac and many others felt that such solutions were a drawback of his wave equation and tried either to reconstruct the equation in such a form that these spurious solutions did not exist, or to reinterpret the negative energy solutions corresponding to electrons, as protons, just as the experimentalists were doing and, admittedly, just as unsuccessfully. By 1931, Dirac was forced to admit that either one could ignore such solutions or admit that a positive electron might exist. As late as 1933, Pauli, one of the foremost theoretical physicists of the time, still felt that Dirac's equation was fatally flawed because of these negative energy solutions.

Hanson also relates that Rutherford and Bohr, when first told of Anderson's discovery, refused to believe in the existence of this "antiparticle."

The question quite naturally arises: Why was there such resistance to the discovery of the positron? Surely, if scientific activity is at all related to the "primacy of experimental findings" as on the photographic plates, or the "sufficiency of human reason," as depicted by Dirac's theoretical work, the positron should have been discovered much earlier.

It is not difficult to give a number of reasons why physicists were not at all predisposed to, or were in fact prejudiced against, finding new particles by 1926. The discovery of the nucleus containing positive particles (and possibly neutral particles) together with orbiting electrons explained a great many things in chemistry and physics. The periodic table of the elements, the complete field of chemistry, the theory of electromagnetism with its two identified types of electrical charge, and, in fact, almost all of the physics of the era could be explained on the basis of the existence of these three basic particles. Consequently, physicists still had a fairly simple, seemingly complete, picture of the structure of the material world and this clearly predisposed them to certain types of physical theories and to certian types of equations and concepts making up these theories. Moreover, this basic structural framework also helped to identify the important problems remaining to substantiate the theories; it helped to select the data required to solve the problems (and caused physicists to ignore other data, however relevant); and it suggested that the basic particles out of which explanations should be constructed were protons, electrons, and neutrons.

Similar analyses of historical episodes in the sciences have been carried out by many historians of science with the result that one could conclude that a Basic Framework of Beliefs or Expectations

1. Suggests the types of theory scientists might find acceptable at a certain time.
2. Suggests which elements of the theory should function as basic concepts of explanation.
3. Selects important problems to be solved.
4. Helps select the date required to solve the problems.

However, a Basic Framework also

1. Provides a conceptual box which forces scientists to ignore other, possibly more relevant data.
2. Causes a resistance to change which is often useful but sometimes harmful.
3. Leaves many other problems uninvestigated (by definition many problem situations exist only within a given framework).

It is, of course, extremely dangerous to base such general conclusions on one specific episode. Were it not for the many other historical studies carried out, with similar results, one might still have been able to conclude that the episodes related to the discovery of the positron were simply "bad science," examples of how human frailty also shows itself in science.

In the next example, we want to show more generally how basic commitments as to the structure of reality predisposes different communities of scientists toward different interpretations of quantum mechanics, and defines different sets of problems as crucial to further progress in

physics.

Quantum Mechanics and the Basic Laws of Nature

Quantum mechanics is basically a statistical theory which allows a scientist to give a set of probabilities for the position, energy, or momentum of a microscopic physical system, but does not allow him to predict exactly what the value of certain properties of a particle will be. This has prompted a group of physicists to conclude that, therefore, nature's laws are probabilistic, that the basic laws of nature no longer determine exactly what will happen in any situation, but merely give a range of possibilities for the future. A very small minority of physicists—including, however, Einstein and Planck—objected to this interpretation and, though they valued quantum mechanics as a major step forward in physics, suggested that quantum mechanics was merely a statistical theory and that the task of physicists was to seek for a deeper level of explanation which was more deterministic.

To give a specific example, quantum mechanics allows a scientist presently to predict to almost any desired degree of accuracy the time of disintegration of a given fraction of radioactive nuclei. But he cannot predict when a particular nucleus will decay. Scientists who feel that nature is basically probabilistic are not at all perturbed by this situation, whereas scientists who are more deterministically inclined, and feel that nature operates in a causal way, see the problem of the time of disintegration of a particular nucleus as a legitimate scientific problem.

In fact, among active physicists there appear to be basically three possible interpretations of quantum mechanics:

1. Quantum mechanics provides a complete description of natural processes: that is, natural laws are basically probabilistic (indeterministic).

2. Quantum mechanics is simply a statistical theory, but does provide a complete description of the knowledge we can have concerning microscopic natural processes. Nature may be deterministic, but we shall not be able to construct more deterministic theories.

3. Quantum mechanics is a statistical theory and does not provide a complete description of microscopic events. Scientists must search for a deeper level of explanation, one which will restore causality or determinism in physics.

In the western tradition, strongly influenced by logical positivism, most physicists have chosen the first interpretation. Only a few physicists—such as Einstein, Planck, and de Broglie—objected to this interpretation of quantum mechanics, and Einstein especially led the battle against indeterminism, for many years unsuccessfully. Only in the last few decades have a number of physicists tried to construct more basic deterministic theories (so-called hidden variable theories) which might, to them, be philosophically more satisfying.

In the Soviet Union, the dominant philosophy of dialectical materialism has predisposed a much greater fraction of scientists toward the second or third interpretation. Marxism is basically a more deterministic system, and only a small fraction of Soviet physicists, often attacked by Soviet philosophers of science prior to 1960, have adhered to the first interpretation, which is prevalent in the West. One can, of course, escape the controversy by simply applying quantum mechanics, very successfully, to a wide variety of specific physical problems without concerning oneself with the basic foundations of quantum mechanics. Students are often amazed, however, by the different picture of reality posed by quantum mechanics.

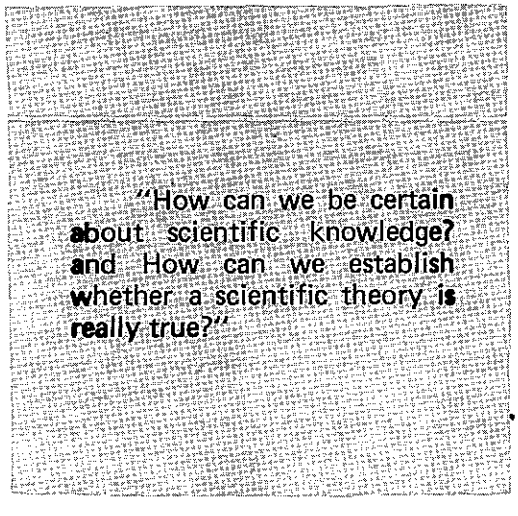
Christians have reacted to the choices posed by the above interpretations in different ways. The Roman Catholic historian of science Van Melsen[7] chooses for determinism; the physicist-turned-theologian Pollard[8] sees in chance the working of God's providence, and therefore favors the first interpretation; the physicist Stafleu,[9] in the tradition of the Philosophy of the Law Idea, sees in the first interpretation an

illustration of the ultimate individuality of all things created by God.

However, it is apparent, that if a scientist takes seriously his basic belief as to the structure and meaning of creation, this set of beliefs does dispose him towards

1. Acceptance of only certain kinds of theories as descriptive of reality.
2. Defining a certain research program as crucial to healthy progress in science.
3. Definition of basic concepts out of which explanations should be constructed.
4. Search for different sets of data in order to solve the problems defined above (hidden variables, for example).

The answer to the question whether a basic framework of beliefs, Christian or otherwise, affects one's scientific activity and results seems inescapably to be positive. The answer to the question as to how one's Christian commitment ought to influence one's scientific activity is also suggested above.



How Should a Basic Commitment Influence Scientific Activity

One of the important questions philosophers and scientists have traditionally asked is this: How can we be certain about scientific knowledge? and, How can we establish whether a scientific theory is really true?

Descartes sought to establish certain basic principles as true by means of his method of radical doubt. On the basis of these "evidently true principles," he then proposed to deduce logically all other truths concerning nature.

Francis Bacon placed the primacy in scientific activity upon experience, and suggested that from the basis of the facts of nature, "giving up all preconceived notions," man would be led to universal truth, primarily by induction.

Both traditions assumed the existence of a basic set of self-evident truths that established the universal validity and certainity of all scientific statements derived from them by deduction or induction (generalization).

The Roman Catholic Church replaced the basic set of self-evident truths of Descartes or of Bacon by the truth of the Bible (or sometimes Aristotle). On this basis the Roman Catholic Church could establish certain scientific truths and could, for example, make judgments concerning the scientific conclusions of Copernicus, Galileo, Bruno, and others concerning the motion of the earth around the sun.

All these methods of theorizing attempted to establish a criterion of certainty concerning scientific truth upon some indubitable and unshakable basis, and all of them proved to be inadequate.

The first two methods described attempted to establish certainty of scientific truth on the assumed autonomy of man's reason, and failed. The Roman Catholic view attempted to base the certainty of self-evident scientific truth on God's revelation in the Bible and failed, not only once, but again and again.

Wolterstorff, following Kuhn and others, notes that all attempts to establish scientific certainty, at least with respect to absolute truth, have failed, and that this is now recognized in the non-Christian world.[10] However, many Christian traditions even today have not given up the quest for establishing the absolute truth of

some scientific statements and theories.

If Christians are to take seriously the failure of all methods attempting to establish "scientific truth" in any absolute sense, the question of how our Christian commitment should function with respect to science must then be answered in a different way.

In analogy with the two historical episodes studied above, one can propose that

1. A Christian commitment should help us to select which types of theories are acceptable at a given time.

For example, two of the major variables influencing human behavior in the psychological tradition of behaviorism are heredity and environment. Behaviorism has shown that man's behavior is indeed limited to a high degree by his heredity and the effect of his environment. However, as a theory, behaviorism is totally unacceptable to a Christian, because man's responsibility before God, despite these limitations, is clearly part of the central message of the Gospel.

Quantum mechanics is also recognized by physicists all over the world as an extremely valuable theory in describing atomic and subatomic processes. Yet many physicists are not really happy with the probabilistic structure of quantum mechanics, and would like to see it superseded by a more deterministic theory.

Clearly, the Christian framework can tell us some of the elements that must be contained in a scientific theory, but it does not allow us, on a purely Biblical basis, to construct such a theory. That is clearly the work of Christian scientists, and although it can be a developing task, it will be an always-unfinished task.

2. A Christian framework, like any other framework, also helps to identify a research program.

Just as in quantum mechanics, the different philosophical traditions identify different sets of problems as crucial, so also a Christian commitment would, in psychology, biology, and even physics, identify certain problems as being especially important in helping to build valid scientific theories.

3. A Christian commitment helps us to define the basic elements out of which scientific explanations should be constructed.

For example, in a science of behavior, besides heredity and environment, clearly the concepts of sin and human freedom must play a role.

In some proposed "hidden variable" theories, certain, as yet undetected, variables are suggested as allowing one to predict exactly, rather than statistically, the results of certain experiments. Experimentally, such theories have had little or no success up to the present, but the search for such theories illustrates the "need" for different basic elements in microscopic physics and a more causal method of explanation.

4. A Christian commitment should also help us to identify the types of data that are needed to solve outstanding problems and weigh the methods used to obtain such data.

Perhaps, in identifying data required to solve outstanding problems and to substantiate theories, our Christian commitment can help us to select valid methods by which such data can be obtained.

It is perhaps trite to say that statistical methods in psychology, despite their supposed objectivity, do not lend themselves well to the study of individual human behavior, which is however, a necessary part of a complete psychology. Obviously, methods other than the statistical, perhaps intuitive rather than analytical, are needed in the social sciences to establish complete sciences.

A number of implications of the above way of using our Christian commitment to shape scientific theorizing have been outlined by Wolterstorff, some of which are the following:

1. Christians must, like non-Christians, give up the idea of scientific certainity, or absolute scientific truth. With all Christians, we believe that this universe does have a lawful structure, but

that our scientific knowledge of this structure is forever tentative and subject to change.

2. More than one scientific theory may at a certain time be consistent with our Christian beliefs.

During certain stages in history, Christian scientists may well have held quite justifiably that the particle theory of light was more correct, whereas other Christians might again justifiably have held the wave theory to be correct.

3. One's basic commitment ought not to be the source of one's data.

Duane Gish of the Creation Research Institute holds, for example, as part of his unquestioned commitment: "that the earth has suffered at least one great world-wide catastrophic event or flood which would account for the mass death, destruction, and extinction found on such a monumental scale in geological deposits."[12]

Despite the great need for a Christian biology, Christians will have to reject the type of foundationalism espoused by Gish's attempt to obtain certain scientific truth on the basis of Biblical propositions. The data available in God's creation must be accepted and analyzed, certainly according to our Christian commitment, but not ordered in a preconceived conceptual structure which does not do justice to the lawfulness of the creation.

4. Scientific freedom should have a deep-going Christian meaning.

Scientific activity is a creative, imaginative task given to man by his Creator. A non-Christian scientist when confronted by the question of his existence has little freedom of explanation available. He can conceive of no other mode of explanation than an evolutionary theory. He is placed in a conceptual box from which there is no escape. He wears the blinders of evolutionism, selects the data required, and explains his findings using the basic concepts of chance mutations, survival of the fittest, adaptation, etc. A Christian scientist can put himself into just as tight a conceptual box in which his interpretation of the Bible describes the development of creation in such detail as to make a science of biology unnecessary. Then two warring systems, neither of which is correct, will oppose each other, and each will suffer occasional losses in the skirmishes, but progress toward a Christian biology can hardly be made.

Within the framework of theorizing outlined above, a Christian can have much more freedom in his investigation of God's creation. He will also be somewhat more skeptical of his own theories, for, after all, future generations will probably develop far better theories. He will be more charitable toward others' views, will even admit the existence of alternative Christian scientific theories and Christian philosophies without proclaiming such theories to represent absolute truth but merely to be steps on the way toward that real truth which we can only approach.

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