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JOURNAL OF THE AMERICAN SCIENTIFIC AFFILIATION

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THE VALUES AND LIMITATIONS OF NATURAL THEOLOGY

G. DOUGLAS YOUNG

It is the purpose of this paper to focus on two areas of study, not just one, which we face continually in both the American Scientific Affiliation and in the Evangelical Theological Society. I do not expect to prove that either is without problems. In fact I would like to demonstrate that both societies must work together closely just because there are problems in both areas. We must be careful to endeavor to strike a balance. We must work cooperatively.

A paper delivered in Wilmore, Kentucky, at the joint meeting of the American Scientific Affiliation and the Evangelical Theological Society, on June 19, 1963.

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Charles Hodge once wrote: Theology is the analysis of our religious consciousness, together with the truths which that analysis evolves.

There are, however, two kinds of people who have religious consciousness: the non-Christian and the Christian. Christian theology is not the analysis of the religious consciousness of the non-Christian. It is not even the analysis of the religious consciousness of the non-Christian as he might modify it by the use of the Christian Scriptures. It is more than that for even the Moslem religious consciousness, for one example, has been modified by both our testaments—yet it is not Christian. The Christian consciousness has experienced a radical change, a change from non-Christian to Christian by a new life transmitted from Christ. Even after that total reorientation, the Christian consciousness is modified and determined further by the truths presented in the Scriptures.

Theology, Christian theology as a science, is the result of the analysis of this regenerated consciousness as modified by the Scriptures. It is the analysis of the facts of the Scriptures, of the facts of divine revelation, as they are experienced by the regenerated person. These facts relate to the nature of God, to sinful man, to redemption. Some of these facts, however, are revealed by the *works* of God. They are revealed in his handiwork — in the world and in the nature of his creatures including man. The analysis of *these* facts is called *natural theology* as distinct from the other.

That there is a natural theology is taught in Scripture. It has values. It teaches.

The heavens declare the glory of God; and the firmament sheweth His handywork. Day unto day uttereth speech, and night unto night sheweth knowledge. There is no speech nor language, where their voice is not heard. Their line (sound) is gone out through all the earth, and their words to the end of the world. In them hath he set a tabernacle for the sun. (They make no audible words but their voice has gone out to all the world.) Psalm 19:1-4

Understand, ye brutish among the people; and ye fools, when will ye be wise? He that planteth the ear, shall he not hear? He that formed the eye, shall he not see? He that chastiseth the heathen, shall not he correct? he that teacheth man knowledge, shall not he know? (He who made the eye—we argue backward from what the eye sees to Him who made it.)

Psalm 94:8-10

And saying, Sirs, why do ye these things? We also are men of like passions with you, and preach unto you that ye should turn from these vanities unto the living God, which made heaven, and earth, and the sea, and all things that are therein: Who in times past suffered all nations to walk in their own ways. Nevertheless he left not himself without witness, in that he did good, and gave us rain from heaven, and fruitful season, filling our hearts with food and gladness.

Acts 14:15-17

God that made the world and all things therein, seeing that he is Lord of heaven and earth, dwelleth not in temples made with hands; Neither is worshipped with men's hands, as though he needed anything, seeing he giveth to all life, and breath, and all things; And hath made of one blood all nations of men for to dwell on all the face of the earth, and hath determined the times before appointed, and the bounds of their habitation; That they should seek the Lord, if haply they might feel after him, and find him, though he be not far from everyone of us: For in him we live, and move, and have our being; as certain also of your own poets have said, For we are also his offspring. Forasmuch then as we are the offspring of God, we ought not to think that the Godhead is like unto gold, or silver, or stone, graven by art and man's device.

Acts 17:24-29

Because that which may be known of God is manifest in them; for God hath shewed it unto them. For the invisible things of him from the creation of the world are clearly seen, being understood by the things that are made, even his eternal power and Godhead; so that they are without excuse: Because that, when they knew God, they glorified him not as God, neither were thankful; but became vain in their imaginations, and their foolish heart was darkened.

Romans 1:19-21

It is important to recognize that it is not only God's being, his mere existence, that is revealed in natural theology — so are his eternal power and Godhead, at least. This *is* a trustworthy revelation, a trustworthy theology. But, it is incomplete. It is confirmatory, but it needs interpretation, and it may be inconclusive. It adds to the probability that our observations are true as revelation — and thus has value. I am thinking of such evidence as that of design in nature, or the argument from effect back to cause. These are the arguments usually called teleological and cosmological. Further, natural theology *does* illustrate Scripturally revealed truth.

Before the Fall, before sin entered the picture, Adam was able to think God's thoughts after Him. He was able to argue directly from nature to nature's God. He had the ability to name all the animals, for an example. This is only true when man can see the true relationship of all things in nature — and that includes man's relationship to God. When man had God's image in him marred by the Fall, his knowledge suffered. It could no longer be as fully true as before, or as it becomes after regeneration. Nor could man make the mental jump from nature to God's nature as triune, or to the way of redemption, or to the knowledge of God's saving destiny for man, etcetera. He needed a *supernatural* revelation. Man is blind at these points. His picture is blurred elsewhere.

Thus natural theology has a serious limitation at this point. It is uncertain. It has no *sure* validity. It tends to divorce "science" from religion or faith. It causes men to act as if there were between the regenerate and the unregenerate a completely "common consciousness." It leads men to confuse God, the incomprehensible, with the universe, as if the universe were ultimate.

Reason — natural theology — cannot be the ultimate source of knowledge. Man in his present condition as a sinner lacks that which renders him competent to reach certainty. Reason — natural theology — cannot lead a man to find salvation, for one example, just as every historical branch of the church through all the ages has insisted. This requires supernatural revelation. It is even clear from all experience that reason unassisted has never brought a man to this end.

A. A. Hodge once said that rationalism is strong only for attack and destruction. It has not produced a positive construction by which men can stand and live and die. Even regenerate man in his state of *posse pecare* (able to sin) cannot reach certainty or comprehensive knowledge by natural theology. Natural theology is good and scriptural, but it is limited as far as the knowledge of salvation, and many other pieces of information as well, are concerned. Natural theology is good and scriptural, but there is no way to double-check it, unless it be by the Scriptures, and the Scriptures are limited on scientific matters.

We could illustrate the manner in which natural theology might lead us to erroneous conclusions. *Natural theology* might lead us to the idea that man came into being as the result of evolution, for an example. Evolution seems to explain all. We see variation and we see progressive development through variation. Given enough time it *could* seem logical to believe that all life that exists might have come this way. Natural theolgoy might lead to such a conclusion. If it did, it would be wrong since supernatural revelation contradicts it at least in regards to man. In Genesis 2:7 God breathed into the nostrils of that which was formed of clay and it was or became *nephesh chayah — alive,* alive at that point but not before. This is contrary to the idea currently being espoused by some, that there were many thousands of years between the clay or dust stage and the time of the inbreathing of the soul. The dust-to-man sequence covers all the time from the first living thing coming from the inanimate to the culmination of the evolutionary process in man when God made the man-like brute into a man by in-breathing a living soul. This is consonant with the evolutionary principle, they say. Why should we assume, they ask therefore, that evolution, an item derived from observing variation in nature, and the Bible are in conflict? This item derived from "natural theology" *looks sound,* but it is not so when we compare it to the data of supernatural revelation.

The evidence for this is clear. In Genesis 1:20 God said "let the waters swarm with living *(nephesh chayyah)* swarms." The American Standard Version substitutes "that hath life" for "living." In 1:21 God created "great whales and every living creature (every *nephesh chayyah,* every soul of life) that moveth." In verses 24, 28 and 30 the words "living creatures," "life" are all *nephesh chayyah.* That is to say, before the creation of man there were many things that had life, *nephesh chayyah.* It was *life* that came to the clay in Genesis 2:7 when God created man. It was not that a brute became man at that point. The Bible and the deductions from natural theology, in this case, do not agree. The conclusion must be that while natural theology is good, it is limited.

The story is not a one-sided one, however. There are also limitations associated with supernatural revelation. Rather, this revelation has to be determined and interpreted, and that creates certain "limitations." Since human factors are involved at this level, there are problems. We must analyze the evidence to be sure that the sixty-six books of our Bible *are* the supernatural revelation of God, and all of it. We must study the variations in the manuscripts, versions and citations to be sure of the correct text at each place where a variant exists in the manuscripts, versions or citations. We face the problem of the translation of the Bible text from three languages into our own. All are aware that there are problems associated with rendering one language into another in exact, or even near-exact, equivalents. Added to these three, there is also the great problem of interpretation. Is this particular part prose or poetry? Is it a figure of speech or to be taken literally? Is it a parable or an historical event?

Inasmuch, therefore, as the understanding of God's supernatural revelation is subject to these limiting variables, and inasmuch as natural theology also has its limitations, can we conclude more than that both have values and both have limitations? The plea is, therefore, since this presentation is to the members of both societies (ASA and ETS), let not the scientist insist on ideas diametrically opposed to any part of God's supernatural revelation (the Bible) and let him not insist that the Biblical interpreter must find a way to make a given Scriptural text conform to his "scientific" conclusion at any particular point. But also, let not the theologian esteem too lightly that which is derived by the scientists from nature, natural theology. Let him, at the same time, always be willing to rethink the Scriptural data and interpretation in the light of information coming from scientific sources at an ever increasing pace.

Finally, let us not spend our major energies on debate and controversy. Nor let this be a continual thing with us. Let us debate. Let us argue. But may our major effort be constructive, a motion forward, an effort to use for the Glory of God and the good of man the information we are accumulating in both fields, looking ahead of developing events to the Christian solution to the problems that will arise and to the way we shall prepare for them, either to use them or to meet them.

FAITH AND WORKS

It is much easier to assume that orthodoxy of faith, which is so necessary, is enough. It is hard to put an orthodox faith to work where religion becomes vital and Christ-like, which is just as necessary. At least that is the repeated teaching of Jesus and the apostles. Who are we to change their emphasis to something we have decided is more important? It usually takes much more of God's grace to put faith to work than it does to feel proud of one's orthodoxy. But in the long run the results speak for themselves.

What we are trying to say is that *it is not enough for us to defend the faith.* Our primary task is to demonstrate to the world the fact that our faith will produce godliness of characer like that revealed in Jesus Christ. Such a faith does not have to be defended at every turn in the road. To argue that Army at West Point has a good football team when it is running up a string of victories is to argue the obvious. If Army loses a string of games, all the argument in the world will not convince many non-Army football fans that Army has a good team. When the Christian Church is marching as the army of the Lord, witnessing to its faith, putting its faith to work in every area of personal and social life, it will not require constant defense. B ut let it go dead on its feet and drift backwards, failing to accomplish its divinely appointed mission, and it will have to be defended on all sides. The trouble is that until it begins to march again, all the defenses of the faithful will not be very convincing to an unbelieving world. We are not decrying orthodoxy any more than Paul was, but we are trying to give a larger and deeper view of Christian orthodoxy in faith and conduct than some earnest and sincere Christians seem to hold.—*Joseph M. Gettys* (Prof. of Bible, Presbyterian College, Clinton, S. C.), *How to Teach I Corinthians* (Richmond, Va.: John Knox Pres,s 1951), pp. 50-51, italics added. Reprinted by permission.

CORRECTION:

On page 63 of the June 1964 issue, in line 17 of Professor Buswell's letter, the word should be "unbroken" instead of "broken."

SCIENCE THEOLOGY AND THE INTERPRETATION OF EVIDENCE

DONALD R. BURRILL

When a person says that he "knows" something to be true, what does he mean? It is not, as frequently assumed, a mere matter of describing commonly sensed experience. The development of knowledge is never the exclusive procedure of "ticking off" a series of denoted references. Rather it presupposes a set of theoretical constructs whereby certain experiences are "explained" in the light of a total schematic system. This essay traces some aspects of the knowing procedure in science and theology. It begins with some suggestions as to why communication between theology and science has always proved difficult. It then maintains that this divergence between science and theology should be expected, and that, rather than trying to eliminate the differences, we should accept them and recognize that they are the necessary result of different modal "sets." The final paragraphs consider some important values that pertain to both of these interpretations of experience.

In the last several years there has been happily a renewal of the dialogue between the theologian and the scientist. If, however, this dialogue is to prove fruitful, it is important that certain methodological precautions be exercised. The restoration of communication does not necessarily mean that some synthetic intellectual solution is imminent or will be in the near future. Two basic problems tend to make this dialogue difficult and any solution perhaps inaccessible.

The first is not unique to science and theology but is common to any inter-disciplinary communication. It is the psychological matrix within which each must operate. The second problem pertains specifically to the process of knowing. Speaking philosophically, we may say that a significant epistemological puzzle arises in discussions between theology and science. This paper discusses these two problems and offers a method whereby each discipline may continue to operate as it always has and still maintain "intellectual tolerance" for the other side. Let us consider each of these issues separately.

I. THE PSYCHOLOGICAL SEPARATION

The scientist and the theologian, of course, wear different hats; they use different words, have different meanings, and draw different conclusions—all of which makes communication with one another difficult. Our early scientific predecessors assumed that their rational-empirical inquiries (to the degree that they were motivated by such questions) demonstrated God's creative genius. They implicitly—and on some occasions explicitly—accepted the classical Platonic dictum that men think God's thoughts after Him. They were quite accustomed to sanctifying their discoveries by attaching them, however remotely, to the divine order. And yet composing religious "proofs" has never been, in any age, the scientist's primary concern. The

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relationship between scientific concepts and religious ones is often no more than a socio-cultural response; only infrequently is it a determined pious intention. The primary objective of science from Archimedes to Einstein has been a descriptive and explanatory analysis of phenomena, not a defense of religious beliefs.[1]

In contrast to the scientist's attitude, the Christian theologian never seeks analytic descriptions *per se;* his aim is to explain a previously established conception of the universe. The explication of the truth preciously acquired is his foremost concern. The Christian theologian does not solicit evidence in order to confirm the truth of Christian dogma. His commitment is complete and his conviction secure. It is hard for me to conceive of any evidence that the antagonist might offer which could dissuade the theologian from holding the convictions that he holds[4]. The theologian believes not just as a man gathering data in a disinterested fashion but as one who believes with his whole "self," with a passion. It is the theologian's intention to save the appearances religiously and only secondarily in a scientific sense; i.e., the theologian wishes to square his hypothesis with the "facts" religiously, not scientifically.

It is this passion of belief, from which the Christian theologian will not detach himself, that has fostered the constant and recurring conflict with science. The result has been that both theology and science have developed their own particular categories of understanding and developed them in separation from one another, in the rarefied monastic community requisite to any productive discipline. The French notion of the *deformation professionelle* underscores this constant estrangement between theology and science. And yet, while the psychological separation has made communication particularly difficult, there is an even more severe conflict.

II. THE PROCESS OF KNOWING

This conflict I conceive to be substantially epistemological. That is to say, the procedure for knowing and what is considered knowable are vastly different because the methods for arriving at what are interpreted to be explanations or solutions are so dissimilar in religion and science. I cannot think of a better analysis of this methodological dissimilarity than the one Professor John Wisdom offers in his remarkable little article, "Gods" (3:187 ff.). Suppose, Wisdom suggests, two people return to their long-neglected garden surprised to find some of the plants amazingly vigorous. One of them concludes that there must have been a gardener who has concerned himself with the garden in their absence. The second decides that no gardener was present. "But look at the arrangement apparent here," the first man offers. The second shakes his head in disagreement. "What we see is an accident of nature," he replies. To confirm his opinion the second man inquires of the neighbors. Have they seen a gardener? None has seen one. "Ah, then," the first man counters, "he must have come at night or be invisible." With this strategic suggestion the first man has taken the argument beyond the legitimate canons of evidence acceptable to the second man. Nevertheless both remain desirous of establishing their position as the correct one, and each continues to amass evidence which he is convinced will substantiate his assertions. Finally, however, there comes a time when a vast amount of evidence has been collected, and each individual remains tenaciously committed to his original opinion. Little evidence can be added which will measurably affect the basic question—the existence of a gardner—but each feels his interpretation more honestly assesses the data. The evidence is the same, but the conclusions drawn differ greatly. However, now the difference is not in the least evidential—it is attitudinal and emotional.

Let us draw the strands of this analogical tale together and notice a significant point that is being made. When one asserts he knows something, he may not necessarily appeal to the same verifying roots as someone else. That is to say, there is a plural quality to the knowing process that frequently makes a difference. Sometimes the world and the phenomena of the world can be seen in a certain manner only when we have committed ourselves to interpreting the phenomena in such and such a way. When we say that we *know,* we are frequently at a loss to define just how we are using the word *know.* The word *know* is like the word *truth.* It is a difficult term to define, and it is often easier to define within a context of meaning or use than it is to separate out as a pure definition. To claim that we *know* something need not restrict us to a single methodological procedure, be it scientific or religious.

Consider, for example, the classical "proof" for God's existence drawn from the order and design in the world, customarily referred to as the teleological argument. One of the most elevated descriptions of this argument appears in David Hume's *Dialogues.* Hume puts in the mouth of Cleanthes the following assertion: "Anatomize the eye, survey its structure and contrivance; and tell me, from your own feeling, if the idea of a contriver does not immediately flow in upon you with a force like that of a sensation" (2:28). Twenty-three years later, William Paley popularized the same argument in his *Natural Theology*[5]. If we observe a timepiece, he writes, and give some care to its structure and use, we are eventually led to the conclusion that there must have been a watchmaker, that is to say, an intelligent mind responsible for this precisely constructed object. And so, reasoning analogically, if we perceive in a limited sense the intricacies of the universe, may we not conclude that there is a universe-maker? Or again, a variation on that theme—if we observe in the activities of minute organisms a meticulous order, are we not able to conclude that a guiding genius has so ordered them?

It is, I think, fair to say that this argument and its variations have exerted significant influence on the Christian community; and yet these same premises in the hands of the scientist have been quickly dismissed because the scientist has found it possible to describe the phenomena of design free from teleological entanglements.

It is my impression that the teleological proof is unconvincing because the notion of a designer who designs rests upon the Aristotelian conception of cosmology. The teleological argument is a conception that entails a certain interpretation of causality—a causal necessity which Aristotle defines as the prime mover —an argument based upon the rational claim that it is logically impossible to deduce an endless regress. In other words, it is just a variation on the cosmological argument theme. But science does not find it necessary to introduce a prime mover in order to explain the phenomena. No God, for example, need be introduced to explain the activity of organisms which swaddle the earth. The organisms which have most efficiently responded to the stimuli of the cosmic envelope in which they are immersed survive—the others do not. God does not need to place a "homing" instinct in certain birds, but rather any bird forced to utilize a homing instinct must have had that capacity or it would have long since perished. For the scientist, the teleological notion is an addendum. Occam's razor is relentlessly applied to such considerations without doing harm to scientific explanations. As Hume correctly noted, any universe must give the appearance of design, for there could not be a universe at all in which the parts were not adapted to one another to a considerable degree (2:52,53). To recognize the traits of order is one thing, but to draw from those traits a conscious orderer is quite another.

Observe, if you will, this same argument of design free from the teleological assumptions of Aristotelian metaphysics. I recall on one occasion seeing a machine specifically constructed for selecting and boxing oranges. It consisted of a series of vibrating perforated metal discs. These discs were placed in a descending order with the ones having the largest holes at the top. As the discs were set into motion the smaller oranges dropped onto the lower disc. When finally the oranges proved too large for the holes in any specific disc they remained on that disc until they were eventually jiggled off onto a ramp which rolled them into the appropriate boxes.

Now it would be possible to have seen all the oranges neatly sorted into specific boxes and yet, not having seen the sorting process, to conclude that some person had performed the operation, whereas anyone understanding the actual mechanical strategy involved would be aware of the wholly fortuitous nature of the selecting process. If, by chance, the selecting process had been contrived differently, perhaps by a rearrangement of discs, or if there had been a completely different type of sorting, then the end result would have produced a different phenomenon. In other words, we would observe another order.

Now the first reaction to this illustration is to exclaim, "Ah yes! But who created the sorting machine?" Yet this is just the reply that Hume contended one cannot make because to ask about the origin of the sorter is to beg the question. The question assumes that the sorter must have had a source (a designer in this case); but this is the very issue at stake. There is no reason why one could not envision the "designs of the universe" as constantly reproducing themselves in some type of kaleidoscopic infinity.

It is this disagreement on *interpretation* which is central to the entire problem. The scientist sees nothing in the nature of the evidence that necessitates the introduction of a teleological category; there is no need for a trans-sensuous explanation. And yet the scientist is constantly being pressed to answer the question of origins in a teleological manner. "How did the vibrating discs originally come to be as they are?" Or in other words, "What is the ultimate source of all that is?" However, there is no verifiable procedure which he can draw upon that will provide an answer to such a question.

It might be suggested that it is possible to assert that a conscious being (God) is the source of all ordered systems. But as Bertrand Russell has rightly observed, such an answer belongs outside of the scientific process of verification. To base the source of all phenomena in God is to force the next question, viz., What is the source or nature of God? This question assuredly lies beyond the perimeter of the scientist's criteria of meaning. Therefore it is not an act of impiousness on the part of the scientist but an act of scientific integrity which leads him to dismiss teleological—and eventually, in this case, religious— explanations of nature.

III. THE METHOD OF KNOWING

It now becomes the burden of the remainder of this thesis to argue that much of the conflict might be set aside if certain initial attitudinal differences are recognized and accepted. If the scientist is convinced that his procedure is the only conceivable method whereby one may obtain knowledge, no agreement is feasible for the obvious reason that such a method can never, in the final analysis, verify religious propositions. It must be conceded from the outset that the criteria of meaning whereby the scientist operates can never "discover" God. It would be utterly fruitless to imagine science as the intellectual instrument which would ultimately find God as though He were somehow the last empirical artifact yet to be exposed, or as though the operational procedures of the scientist offered statistical evidence which, when finally summed, would convince us all of God's existence. The primary assertions of theology, it seems to me, are beyond the empirical strictures within which the scientist is confined. It is not possible to verify the premise, "God created the earth *ex nihilo*," through the controlled empirical procedures of science. Every effort to apply the verification criterion to religious assertions of this type must fail, because the basic postulates of dogma are constantly reaching beyond the limits of the scientist's categories of meaningful and demonstrable evidence. It should be acknowledged also, that this estrangement is often perpetuated by the scientist's reluctance to see any significance in structures of meaning which do not conform to his formula of verification. He is inclined to dismiss out-of-hand all non-quantitative meaning, and in such a context religious explanations have, for him, no reference to reality.

Conversely, the theologian frequently gives his own case away by adopting, in a patently contrived manner, the restrictive demands of the scientist's tests of verification.[9] It is imperative that those who engage in religious utterances recognize forthrightly the intellectual risk in their conclusions. The Christian need not suffer embarrassment because his explanations differ from those of science. He must, of course, be aware that such explanations are alternates to scientific ones, but it is only necessary that he be convinced that his theistic constructs more adequately interpret his experience than do any contrasting explanations. The theologian errs when he superficially adopts the constructs of science and applies them to his religious categories of meaning. The critical word in that last sentence is *superficially.* Obviously many religious phenomena are supported by an appeal to empirical evidence, but the breadth of religious meaning extends the boundaries of the definition beyond the restrictive and limiting criteria of science in order to touch more adequately the depths of man's spiritual needs.

Nevertheless, the suggestion that religious knowledge is to be defined differently from scientific knowledge (by what I shall call a different modal structure), is usually disturbing to our monistic inclinations. But this is so, I believe, because we desire to reduce all explanation of experience to the simplest common denominator. We have a passion for orderliness even when it means that we must dismiss segments of our experience. An example of this homogeneous tendency is manifested in extreme behaviorism. This type of behaviorism denies the existence of consciousness on the ground that any description of the "mental" is eventually reducible to the terms of bodily behavior. Such a reduction is a fallacy of logical analysis. It is as though one should deny the existence of a Beethoven sonata as aesthetic phenomenon because, for purposes of precise scientific investigations, the sonata is to be defined as frequencies of vibratory motion. In logical terms, given an X (the sonata), and if X appears in a Y-Z complex (physiological description) then X can no longer exist as X. But the primary fact remains that many questions about life, e.g., man's poetic and artistic experience or his judgments of value, turn upon explanations whose criteria of classification and principles of interpretation are unrelated to those which scientific verification provides. No amassing of scientific data will resolve these issues.

Perhaps this multi-dimensional theory of knowing would hold significance for us if we could see more keenly the important place that the mind, as the knowing agent, fills in the knowing process. This primal aspect of epistemology is only now beginning to receive attention from scientists, and yet it is immensely crucial to all epistemological considerations. It endeavors to place the person back at the center of the understanding process, rather than relegate him to the role of a spectator before a passing and wholly indifferent universe.

We are constantly and erroneously inclined to talk of knowing the "facts" as though *knowing* were clearly and irrevocably established in a single method. Hence, *to know* is to subscribe to a certain cut-and-dried procedure. To *know* in this restrictive manner is to conceive of the mind—or better, the brain—as operating somewhat on the order of a camera, snapping pictures of the world around us and then storing each picture away on a microscopic index awaiting recall and future use. In *The Open Society and Its Enemies* Professor Karl Popper has referred to this particular interpretation as the "bucket theory of the mind"—the theory that facts drop into the mind as water into a bucket, and accumulated they become knowledge.[6] But such an interpretation oversimplifies the process. It does not recognize the significant role of the knower in the act of knowing. This was essentially Immanuel Kant's protest against earlier epistemological interpretations (Hume's). He explains that nothing can become an object of fact for us except through a complex process of mental structuring. Understanding entails the mental manipulation of empirical experience. But this claim is not merely the reflection of the nineteenth century metaphysician Kant. Contemporary scientists are now offering similar evidence. The noted physicist Erwin Schrödinger writes:

> The world is a construct of our sensations, perceptions, memories. It is convenient to regard it as existing objectively on its own. But it certainly does not become manifest by its mere existence. Its becoming manifest is conditional on very special goings-on in very special parts of this very world, namely on certain events that happen in the brain. (7:1)
>
> One might say, metaphorically, that consciousness is the tutor who supervises the education of the living substance, but leaves his pupil alone to deal with all those tasks for which he is already sufficiently trained. (7:6)

In a similar vein, the physiologist J. Z. Young writes:

> We cannot speak as if there were a world around us of which our senses give us true information. In trying to speak about what the world is like we must remember all the time that what we see and what we say depends on what we have learned; we ourselves come into the process . . . The brain of each one of us does literally create his or her own world. (8:61, 108)

It has been customary to describe this dramatic role which man himself plays in the knowing process as the intuitive agent in reason. The word *intuitive* is suspect in our scientific age, but it is still possible to use it if we do so with care. Science itself is certainly not devoid of such intuitional excursions, since they enter freely into its creative and speculative endeavors. The evolution of science would not have been possible without them.

The scientist, however, rightly insists that all such intuitional claims be fettered by empirical verification. The empirical process becomes the method for establishing the truth or falsity of scientific propositions. But the restrictive empirical qualifications of this method make many aspects of the individual's experience uncongenial to scientific verification.[9] Ostensibly, science provides a certain modal-structure, a logical schema, which produces a set of postulates applicable to observational data. Such a system is completely appropriate for dealing with mass and motion, so that under the aegis of scientific models the concept of God and man's desire to commune with God are superfluous and indefensible. Nevertheless, the austere demands which scientific methodology exacts are accessible to science only at the cost of removing from experience its personal character and its particular application to man as a moral, aesthetic, and religious being.

The Christian theologian, on the other hand, intentionally offers a trans-temporal epistemological method. He does not concern himself with particles moving through space at varying speeds, but he begins with man's eternal quest after ultimate meaning—after God. In such a case, man as a whole being is at stake—man as an existential being, not man in the restrictive scientific sense, that is, as thin protoplasmic slime stretched between two thick layers of cosmic indifference. When the theologian talks of God, he is talking of God as a reality drawn from the most personal and sensitive source of his experience, and this experience cannot be contained with the restrictive limits of scientific verification. For the Christian to *know*, it is necessary for him to extend his way of knowing into the depth of mystery that is life itself.

St. Augustine referred to theology as "fencing a mystery." The Christian finds that the pictorial symbols of the scientist do not sufficiently explain the mystery of one's confrontation with the divine. On many occasions confrontation is beyond rational explanation, and the only appropriate attitude for the Christian is silence; yet he finds himself unable to remain silent. But at these moments when he attempts to utter the sometimes unutterable, he should recognize that his theological constructs become strangely contrived if he attempts to squeeze them into the space-time picture of the scientist. The evidences for God as an object of knowledge are meaningful, but man's modal-structure for apprehending the divine must rest on a different set of postulates. As Ludwig Wittgenstein suggests, every assertion has its own logic. I shall not attempt to describe such a system here but only suggest that Christian confirmation, if free from certain institutional self-aggrandizement, can become the repository for expressions of love, mercy, and sensitivity that far excel the cold language of knowing of which philosophers and scientists speak.

Therefore, both modal spstems (as well as ethical, aesthetic, and whatever others there may be) rest ultimately on a set of postulates which cannot be a part of the "facts" of that set but are rather constructs which one imposes from the "outside." It is apparent that such postulate systems—scientific or religious—maintain their significance for us only to the degree that they are confirmable in us and not alien to the nature of the evidence as truth for us. And finally, the confirmability or verification of Christianity rests ultimately on its ability to provide salvation (healing) for man's spiritual estrangement, never on its ability to adapt itself to the structures of science's empirical verifications. Professor Wisdom has well said:

> Many have tried to find ways of salvation. The reports they bring back are always incomplete and apt to mislead even when they are not in words but music or paint. But they are by no means useless; and not the worst of them are those which speak of oneness with God. But in so far as we become one with Him He becomes one with us. St. John says He is in us as we love one another. (3:206).

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9. By restrictive demands, I do not wish to give the impression that I think that the scientist never reflects upon the broader questions of life—the questions which Crane Brinton has called the "Big Questions," such as Where did I come from? Where am I going? Does the Universe have a meaning? Furthermore, I do not assume that the scientist is ever free from emotional involvement. He is not. But to the degree that he engages in such questions or allows himself to make discussion on the basis of emotional involvement, he is not playing the scientific game, for he is straying from the canons of scientific verifiability.

MODERN SCIENTIFIC COSMOGONIES

THOMAS H. LEITH

This article is an analysis of the major ideas as to the origin of the universe found among 'scientific' cosmologists of this century. It discusses first the early applications of general relativity to the construction of models of the universe and the related questions each raised as to the origin and past history of the physical world. The remainder of the paper analyses later experimental and theoretical work either based upon these models or upon a conscious rejection of them, emphasis being placed upon the cosmogenic aspects of these labors. The views of Lemaitre, Gamow and his co-workers, the matter-antimatter theorists, and the Gödel-Heckmann-Omer school are discussed in some detail as examples of modern development of the earlier models. In contradistinction Milne's kinematic ideas, Eddington's fundamental theory, the views of Dirac and Jordan, and the positions of the steady-state cosmologists are explored. In all cases, fundamental assumptions and experimental difficulties are brought out fairly sharply.

It is our purpose in this paper to survey fairly comprehensively, but as briefly as possible, the major ideas as to the origin of the 'universe' to be found in recent cosmological speculation. To this end we will restrict our discussion to origins as they are conceived within schemes which one might call scientific rather than as they are seen in more philosophical systems. The distinction here is not as sharp as might be supposed but it cannot be explored in this paper; hence it will be retained for discussion only in a second comparison paper to follow. For the present, we shall base the difference upon whether scientists or philosophers, and their respective professional journals, have paid most attention to any given scheme. In our second paper we will also have something more to say about the somewhat vague term 'universe' mentioned above, because the writer feels sure that the vagaries of usage of this word will become apparent to anyone who thinks at all upon our remarks which follow below.

May we begin with some historical matter? After the development of the general theory of relativity, wherein the geometry of a spatial region was made dependent upon its relation to matter (or perhaps the very distinction of space and matter was reduced to the change in intensity of an energy field from place to place and thus to variations in space-time curvature), Einstein noticed that, on a very large scale and assuming the random distribution of galaxies and intergalactic matter and radiation, one could sensibly speak of the average curvature of an immense region.[1]

The eventual result of his thought here was the postulation of a model[2] in which matter and radiation were seen as smoothed out on a very large scale and in which there was no large-scale relative motion. The metric appropriate to this he took to be a Riemannian

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space of constant positive curvature, i.e. a closed space in which the curvature was the residue remaining after the smoothing out mentioned above. The radius of such a model depends upon the total matter-energy content assumed; the value for this latter figure being suggested by astrophysical analysis and observation.

To achieve the stability of his model Einstein believed that it was necessary to add a tensor containing the famous 'cosmic constant' λ to the tensor field equation of general relativity which was, of course, the basic theory behind the model.[3] This constant was then really descriptive of a sort of repulsion superimposed upon gravitational attraction so as to cancel it out on the large scale. It also served, he believed, to prevent there being any solutions for the field equations of the universe contained no matter. But therein lay at least one fatal flaw to the model — the field equations turn out to have a solution in the absence of mass even with the λ term.

This was shown in the same year by de Sitter.[4] Thus in turn, he suggested an alternative model, an empty one in which, were matter particles to be introduced, they would recede with increasing velocity with distance from any observer. Such motion is, of course, the consequence of retaining the cosmic repulsion without the presence of a balancing gravitational attraction. This and Einstein's model interest us here only because both are essentially static,[5] Einstein's in a true sense and de Sitter's because when it is empty repulsive motion is not apparent, and thus they suggest no beginning or end to the universe which they picture.

In the years following 1917, attention turned to increasing evidence that there was a recessional galactic motion not permitted by Einstein's model, to an increasing awareness that the average density of the visible universe, while quite small, was hardly de Sitterian, and to the λ term which, whatever the logical or esthetic grounds for introducing it as positive, might empirically turn out to be zero or even negative in magnitude. This combination of new empirical observation and varied mathematical possibilities led to the major work of Friedmann,[6] Robertson,[7] Lemaitre,[8] and others.[9] We will make no attempt to sort out the differences of analysis here (for example, Robertson used a kinematic approach which ignores the dynamical field equations of general relativity) nor the contribution of each, with the exception of Lemaitre who requires further mention later. Instead we will try to summarize briefly the net mathematical product of this work.

When we consider the case in which the cosmic constant is taken as zero in value, it turns out that we have three types of model dependent on whether the curvature is taken as positive (a closed model in analogy to a sphere or ellipse), zero, or negative (the model is open in analogy to a hyperboloid). The first of these has no unique beginning nor end, it pulsates endlessly from zero (or some finite) radius to some larger size and back again. The second has a singularity in time and size: it either contracts toward this from an infinite past or expands from it without end. The last model is not unlike the second, save that it contracts from or expands toward a de Sitter state far in the past or future. Consequently, the first can, at best, be given an age only as far as the time since the present pulse began is concerned; the second and third (if we ignore the contracting options in each, the universe to the best of our knowledge showing expansion) suggest a definite age since the model began expansion from near-zero radius and infinite density.

But there still remain the options wherein the cosmic constant is negative or positive. The negative cases, for any of the three possible curvatures, turns out to be fairly simple: all of them are pulsing models with a minimum radius of some size lying between zero and the radius of the Einstein universe. None then has a real beginning — the only meaningful age is given by the possibility of dating the beginning of the last pulsation, in which the regions of the universe which we see appear to be still on the expanding phase. The positive value for the cosmic constant eventuates, unlike the negative case, in quite a complex set of models. When the curvature is negative or zero the resulting schemes all involve a single expansion from zero radius to infinity with the passing of time, the models then ultimately becoming empty de Sitter universes.

Positive values for the curvature give, however, quite distinctive results depending upon the precise value chosen for λ. If we pick a value which is larger than that which Einstein chose for his static model the consequence is a scheme either contracting from a de Sitter state toward a small or zero radius or a scheme going the opposite way. The plot of expansion with time shows very rapid change in radius when the model is small; when it approaches the size of the Einstein model it slows down considerably; and then it speeds up again as it moves to larger size and closer approximation to the de Sitter empty state. If, however, we choose the value of λ so that it is the same as Einstein's value, we get either his scheme which maintains constant volume with time or two non-static models: one expanding from a very small radius toward the Einstein size asymptotically with time and another beginning asymptotic to the Einstein state infinitely long ago and expanding thereafter toward the empty de Sitter case. Finally, if we choose λ greater than zero, but less than the Einstein value, we get either models contracting toward the Einstein radius which slowly reverse direction and expand or models expanding and contracting from and to a singularity, with size somewhere between zero radius and the Einstein dimensions.[10]

One's first reaction might be to smile indulgently at the manifest fertility of the mathematical imagination as universe after universe falls from page after page of equations. Yet science often advances by putting to test just such suggestive ideas, and in the third and fourth decades of our century these cosmological models were behind a great deal of astronomical research. Certainly the general relativity theory on which they were usually based, the assumptions of homogeneity and isotropy of the universe on the large scale, and the more detailed physical theses of most of the models seemed to be, if nothing else, at least not improbable. On such a basis workers might well examine the theoretical and empirical consequences of the specific model types individually — and this they did. Three things only interest us here: which, if any, of these cosmological schemes have stood the test of time, whether the models in which a mathematical singularity occurs can explain what goes on around this point within the model, and whether pulsing models or those with an infinite past logically provide an escape from 'creation' ideas.

Let us turn first to the ideas of origin in models which, in the above outline, involve a single expansion, i.e. they do not pulse. In 1930 Lemaitre suggested a scrutiny of the case wherein the universe began close to the Einsteinian form but which has thereafter expanded, due to instabilities within this supposedly static model, toward a de Sitter state. As a result of this suggestion he incorporated a pre-Einsteinian stage, one in which matter was originally highly compressed in a very small space — a veritable primordial atom. This scheme he has fleshed out over the years and we may present his recent thought as indicative of the latest thinking on this sort of picture of how our universe began.[11]

The initial state of the universe he takes to be a 'quantum' or atom which explodes the instant it appears. This odd entity is postulated because he believes that entropy considerations teach us that the universe is moving toward maximizing the degradation of energy so that it must move from some state of minimum entropy, a state which can exist only for a moment but which is the simplest we know how to describe physically — a single undivided 'bit' of energy. Lemaitre suggests an analogy here to a lesson of quantum theory as he sees it: that a physical system may be described as an assemblage of potential states, the most probable distribution for which is to have all states occupied (maximizing entropy) and the least probable is that which has only one filled (thus minimizing entropy).

There is an ancillary idea involved in assuming this primeval 'quantum' which is of interest and may be noted briefly. This is that the properties of such an entity will always be only crudely describable; we can neither physically explain its origins nor can we predict deductively from its character the precise consequences of its disintegration. The first alternant implies that any philosophical view of its cause is permissible as far as science takes us, but that such ideas as the thesis that it must result from a prior contraction of the universe are impossible to prove — indeed one would expect on such a ground that the end of a contracting phase would be a state of maximum rather than minimum entropy. The second alternant requires that there be no way to predict just how it will split up or just what precise consequences will eventuate. Only when division has proceeded far enough to give a very large number of smaller 'bits' will laws based on statistical predictability enable us to describe the likely consequences of disintegration with some precision.

Lemaitre proceeds to this general statistical description. After the primeval disintegration the 'zero' space of the 'quantum' expands and fills with the pieces which lose kinetic energy in proportion to this expansion. As time passes these fragments disintegrate into protons, electrons, and gamma radiation though some still remain as uranium and thorium atoms, atoms of long half-life. After a few billion years of expansion most of the naturally-occurring atoms which we know had been formed and had settled down into a near statistical equilibrium in the form of a gas. This was a close approximation to an Einstein universe, a space-time equilibrium with space full of matter and radiation. After several billion years the gas condensed locally into proto-galaxies, and under the resultant repulsion, space resumed its expansion in these regions. Some regions, where the gas is not yet condensed, remain today as cosmic dust clouds and nebular clusters. At present, Lemaitre believes that the universe has expanded for some four billion years from the Einstein stage so that it is some one hundred times the Einstein volume and some 10^{17} times as big as the original atom.

We should not, however, leave this model without a brief critique, for it has several weaknesses. One such flaw lies in the highly speculative character of the primeval atom. It is argued that its nature may be generally described in analogy to radioactivity and quantum theory but to say the least this extrapolation is fraught with hazard, especially when his interpretation of quantum theory itself is rather debatable. It is also argued that it cannot have a prior physical history both because it explodes as soon as it appears and thus cannot have a stable history, and because a contracting universe prior to it should result in maximum rather than minimum entropy. However, Lemaitre seems to forget that if time direction is in some way connected with expansion and entropy increase in our present universe, a prior phase which contracted might well define a time of opposite sense leading to a minimizing in entropy. Whatever other difficulties this argument may have, it at least reveals the possibility that the primeval atom of minimum entropy, if there ever was such a thing, could logically have had an indefinitely long prior history.

But the major flaw in the model lies in discussing anything prior to or during the approximately Einsteinian stage. We noted earlier that such a state is presumably static; consequently, if our universe is now expanding, it must have only approximated such a condition, the closeness of the approximation determining how long it took for sufficient instability to develop so that we have had expansion ever since. The problem of stability has been studied extensively,[12] but it is safe to say that the closer our universe might have been at one time to an Einstein state, the longer it would have been close to stability, and thus the more unlikely is the value of any extrapolation from it to yet earlier processes. Whatever processes are suggested, and they are usually very *ad hoc,* for giving rise to instability and the processes and character of the presently observed universe, they will have occurred so slowly that it is simply fiction to presume that one can credibly explain these tiny changes in terms of physical entities and reactions all the way back to some primitive 'quantum.' It would seem far better either to presume our universe *began* in something like an Einstein state or to presume it has expanded *continuously* from some super-dense initial state along the lines of Lemaitre's 'quantum.'

The former option has received its most elaborate, and one might add mystifying, treatment in the hands of Arthur Eddington. Unfortunately the analysis of his ideas requires technicalities and criticism far beyond the possibilities of this paper, and the reader is therefore referred to other sources.[13] We may salve our conscience, however, because Eddington's *a priori* views as to the mass and size of the Einstein state are rather more suggestive to philosophy than they are as yet useful to science. If we can ignore Whitehead in this paper, we can presumably do much the same for this other great theorist and for the same reasons, but we will nonetheless have a few more words to say on Sir Arthur later.

The option for continual expansion from a small initial state has been given rather-better-known analysis. Here Gamow and his co-workers[14] have suggested a very condensed early universe in which neutrons are the stable constituent. As this expands and pressure is relieved, some neutrons decay to protons which, in the enormous flux of remaining neutrons, capture these successively and along with electron decay form the nuclei of the elements which we know. The entire process involves, presumably, only minutes. Later, in the highly supersonic turbulence of this expanding hot gas, denser areas are established. Stabilized by internal gravitation it is these which form the origins of the galaxies we know.

The thesis is based largely upon a theory of element formation now held suspect in most quarters. Gamow and his fellows had argued that the amazingly close relation between their figures for the abundance of any given elements in the universe and the target cross-sections of the various nuclei for neutron capture (when neutrons, with presumably the same energy distribution as these suggested for the early universe, were fired at them in the laboratory) could hardly be fortuitous. The cross-section determines the rate at which nuclei capture these neutrons; thus nuclei of small cross section would capture neutrons slowly and increase in relative abundance since they don't change quickly to the nuclei of the next highest atomic weight. The result would be the inverse relation between cross-sections and relative abundances of each element actually observed.

But there are difficulties. In the first case, it is very hard to feel confident in any available figures for relative abundance of the elements in the universe and this entire scheme depends on assuming we have good values. Indeed the iron group fits poorly even with the date available now. More important, however, are two theoretical problems. One of these lies in the fact that some nuclei which do exist should never exist at all on this picture since their stable isobars terminate the electron decay before the nuclei in question could be produced. The other difficulty is that there are no known stable atoms of mass 5 or 8, thus we cannot get past these to build more massive atoms. Finally, there is the practical question of how, since expansion *decreases* density and temperature in this model, the synthesis of elements with *increasing* charge and *increasing* electrical barriers, which require just the opposite situation, can occur as times goes on.

Most theoreticians have, as a consequence, felt that both the origin of the elements and the formation of stars and galaxies are better explained by alternative schemes. Stellar and galactic formation seems to be going on continually, as far as astrophysicists can tell, and do not appear to show the wide agreement in ages which one would expect on the Gamow model.[15] Similarly, the origin of the elements is now most commonly related to stellar interiors at different stages of development. But it should be noted, as Gamow has himself pointed out recently, that some sort of combination of these differing positions might be possible: perhaps, beyond those atoms with atomic number four, synthesis might occur within stars. The reasons for the apparently greatly varying ages of stars and galaxies is, however, still a mystery on the basis of Gamow's type of model.

When Gamow is mentioned most people do not think so much of our above remarks as of his thesis that the universe has, contrary to Lemaitre's position, a physical history prior to the present expansion. The Irish astronomer Öpik has argued in a similar manner, [17] and we might comment briefly on this idea. In essence, both theories are attempts to avoid any real temporal beginning to the universe, any 'age' we give the universe being that applicable to the present expanding phase only. To be sure Gamow and Öpik differ in detail: Gamow and his followers suggest either prior oscillations of increasing amplitude or a single contraction from extremely large size, with the present expansion probably having such velocity that it will never reverse, while Öpik postulates an endless series of pulsations of roughly equal amplitude.

One may say, however, that while such ideas are logically meaningful, they are in no way scientifically testable in the light of our best knowledge today. Indeed, it seems that such should remain the case, for if we may follow Lemaitre's suggestion that our knowledge of some hyperdense phase is hardly likely to be much use in *predicting* the future of the universe, may we not equally well say it is even less useful for *retrodiction* into some earlier phase?[18] If we really don't know what the properties of matter might be like in such a dense state, how can we hope to extrapolate with confidence to some prior phase or phases and above all how are we to test our beliefs? To be sure one might find evidence that our present universe is best described as a pulse, but there is really no basis other than mathematical symmetry, esthetic considerations, or some desire to avoid a beginning to the matter-energy of the universe for presuming that one pulse demands others before it. On the other hand, if Gamow is correct, and this present phase is unique in likely being open in topology and thus subject to endless expansion, might one not justifiably argue that economy of thought might suggest its equal uniqueness in origin?

Leaving this discussion we may, before turning to different considerations, remark on the application of anti-matter ideas to models which involve some very small volume at some time in the past, as do the Lemaitre-Gamow schemes. The literature here is fairly interesting but highly speculative.[19] It has been argued that the production of elementary particles should result in quantitative symmetry of matter and anti-matter particles but the quesion hen arises as o where all the anti-matter is. We see no firm recognizable evidence of their frequent violent union in observational astronomy, and there would be major difficulties in the entire general relativity theory were anti-matter present in anything like the amounts we see of matter, even if we assumed they repel one another. Perhaps parity considerations provide a segregation mechanism, but, if so, we then must have the apparently quite untestable thesis that there are really two types of cosmos of opposite handedness.

Kevane has suggested a model which rejects general relativity and utilizes anti-gravity possibilities. It originates as a plasma of both types of particles which, being unstable, expands continuously at an accelerating rate. The idea has some interest but is hardly testable at present. Kapp suggests relating anti-particles to the forming of space and particles to its disappearance. We will mention this theory later. Finally, Reiser suggests a model in which matter and anti-matter represent opposing vortices in a hyperdimensional and pantheistic cosmic field. This is pure speculation and presently quite uncorroborable. In sum, though we may expect to hear more from matter-antimatter considerations, it appears to this writer that, in direct proportion, we may expect an increase in the metaphysical or *ad hoc* content of cosmological theorizing, if present discussion is any indication, and a consequent decrease in scientific testability of much of the argument.

This exhausts our rapid over-view of the usual models growing from Einstein's work directly. Before turning for a brief look at rather different schemes reference should be made, however, to three rather far-out schemes which deny the homogeneity and/or isotropy of all the models previously considered. These are the work of Kurt Gödel, Omer, and Heckmann.[20] The result of their discussion is the avoidance either of any 'cosmic time' applicable to the entire universe, and thus of any unique beginning, or the avoidance of an extremely dense origin, approximating zero size, for the present expansion we observe. The latter eventuates instead in simply bringing the galactic material closely together at some early date, as de Sitter originally suggested in 1933.[21]

These models variously require such odd things as the idea of absolute rotation of the entire content of the universe (a thesis violating general relativity, as usually understood, and of the so-called Machian principle of inertia), and large scale anisotropic expansion. At present none seems testable but they are perhaps potentially corroborable or falsifiable by observation and thus of some little importance. In our present discussion their interest lies in their possibly providing in future some way out of the difficulties of getting back beyond some early compressed state of our universe to the description of some earlier phase. For if matter were never sufficiently condensed to lose the character it may have had earlier, an understanding of the laws of change in this state might enable us to extrapolate to this character. However, all this is presently only a hope and nothing more.

Not all cosmologists have felt that Einstein got cosmic model-making off on the right track. One of these was Milne whose kinematic relativity model had for a time a considerable vogue.[22] The approach here is unlike most of the method used in our earlier models: Milne believes that a correct understanding of the rational foundations of cosmology provides a means of deducing the necessity of the physical laws which careful experiment can only show to be probable. Milne begins by assuming, unlike general relativity, that not all frames of reference are equivalent for describing the universe but only the centers of the galaxies which we see receding from us. Consonant with this is the belief that the laws of nature are describable in the same way from all such centers. On these foundations, Milne proceeds to attempt to discover what the laws of nature would be in such a universe. To do this he assumes also that the galactic centers separate with uniform velocity, that a hypothetical observer at each center would be aware of the passage of time, that such observers could send light signals to one another, and that the space in which they move is Euclidean. The result is a model with an expanding spherical swarm of centers filling its space, its kinematics being that of special relativity. The background of centers provides what he calls a 'substratum', the necessary frame of reference for the subsequent construction of various theorems of dynamics. And on this dynamics he builds a gravitational theory and electrodynamic laws.

All of this is highly technical and approached variously in his different works, but certain aspects of it interest us here. One such facet is Milne's claim that, if the 'substratum' of the universe were not as he describes it, the structure of the world could never be known. This implies the deliberate creation of the universe, an event which he places at zero time in the kinematic equations when all the galactic centers now in uniform relative motion were in coincidence. Milne also believes that an infinity of such centers was involved at the creation in order that no preferential velocity frame be present immediately after the beginning. He believes too that such centers must have had initial velocities ranging from zero to infinity in a non-Maxwellian distribution. The detailed reasons for the last two beliefs are, I am afraid, too complex for a brief survey such as this.

A second facet arises from the fact that galactic centers form only a reference frame, a background for phenomena. Milne thus adds what he calls 'free' particles into this background and on this basis constructs his dynamics. An odd consequence arises: the motion of the 'free' particles is accelerated with respect to the 'substratum', but if observers appropriately regraduate the clocks they have set by signalling one another as mentioned above, this acceleration can be reduced to a uniform motion as in Newton's first law. When this is carried out, the two time scales differ in having $t=0$ on the kinematic scale equivalent to $T=-\infty$ on the dynamic scale. For *kinematics* there is a creation, but on the basis of the usual *dynamic* considerations of physics the same event disappears infinitely into the past!

All sorts of unusual consequences follow from reverting from the dynamic to the kinematic scale.[23] Constant length becomes steadily increasing length, relative rest becomes uniform translation, a stationary universe becomes an expanding one, decreasing frequencies of light emission with the past become redshifts interpreted as due to recession, and a hyperbolic space of constant density becomes a Euclidian space of decreasing density. I have discussed these at length elsewhere,[24] but it may suffice here if we say that there are a number of serious technical difficulties in various aspects of the thesis. Though the model is perhaps the most elaborate modern attempt at an argument to the existence of a creator from the design of nature, I am afraid these difficulties are in many ways sufficient to make the rationale as a whole quite suspect. This is not to say that the kinematic method of analysis in cosmology is to be ignored, for several notable figures at present use it widely, but it is to say that Milne's detailed attempt to show that a creation could be demanded on its basis and to describe the world at this time, together with the later consequences of its nature, must be considered unconvincing.

Our last models for discussion are quite different from anything considered heretofore: they all imply that the creation of the universe is a continuing affair. Possibly the earliest of the modern advocates of this position were Macmillan, Millikan, and Jeans,[25] but their views received only casual interest until the stimulating suggestions of the last fifteen years by the British workers Bondi, Gold, and Hoyle. However, before turning to them we might note several rather different schemes with a similar theme which are, perhaps, not as widely considered. One such model is that of Dirac.[26]

Working along similar lines to parts of Eddington's 'fundamental theory', wherein certain constants of nature (the 'fine structure constant', the ratio of proton to electron mass, the ratio of the gravitational to electrical attraction between an electron and proton, and so on) are related to one another, Dirac suggested that the age of the universe could be expressed, in terms of units given by atomic constants, as the large number 10^{39}. Noting that this was also very nearly the value, or the square root of the value, of certain of Eddington's constants, he theorized that such constants were really not constant at all but were related to the age of the universe in atomic units. Detailed differences he presumed would be resolved later when we attained a sufficiently comprehensive theory of cosmology and atomicity.

The consequence of this, of interest here, is that the number of protons and neutrons must increase in proportion to t^2, that is new matter must enter space, where t is the present age of the universe in the atomic units noted above. Of course, evidence of this increase directly would be unlikely since it is minute in any short time and likely takes place within stars in any case. But a check might be made based upon another consequence of his model: the gravitational constant should be proportional to $1/t$. He also predicted that, since the average mass of stars and galaxies cluster around $t^{1.5}$ and $t^{1.75}$ respectively, their masses should increase in that proportion and thus one might determine the resultant rate of increase of the average number of stars in a galaxy. A final consequence, too complex to outline here, is that space must have zero spatial curvature — a presumably testable deduction.

There are certain internal and empirical difficulties with this interesting thesis, but its importance lies in pointing out the odd relationship among the large physical constants which Eddington had also noted. It is safe to say that, whatever becomes of Dirac's peculiar model, this relationship will remain a challenge to future theorizing. One cosmologist who feels this way is Pascual Jordan.

In his scheme,[28] Jordan builds upon what he considers the six fundamental physical things in the universe: the velocity of light, the gravitational constant, the age of the oldest bodies (A), the mean density of mass in the universe, the Hubble constant, and the radius of the universe. Certain ratios between these turn out to be very near unity. Working on this base, and assuming that the negative potential energy of gravitation for the entire universe just cancels the rest energies of the masses of all the stars so that the universe has zero total energy, Jordan believes that the number of elementary particles is of the order of A^2.

This implies the continuous appearance of matter into our universe, a mass for stars proportional to the three-halves power of the age of the universe at the time they are formed, and a gravitational constant which varies with the age of the universe. The first of these requires that matter enter the universe with mass such that their negative gravitational energy just balances the energy of the matter within them so that the total energy of the universe is unaffected. Today this requires the mass be of the order of a star! New stars, appearing as a unit, are the signs of such new matter arriving on the scene.

Jordan suggests that the universe may be pictured as a four-dimensional manifold with a cone shape but with many subsidiary apices. At any given time, a cut across a cone may leave a large three-dimensional part and perhaps several smaller isolated parts, each unfolding in time. Eventually any smaller part coalesces with the larger universe, and we have ourselves a new star which Jordan believes is the source of the Type I Supernovae of observational astronomy.

Several features of this model, as with Dirac's, may be questioned, however. It implies that stars are not the product of condensation from diffuse matter, a thesis which disagrees with most observational theorizing today. It also seems to require a rate of supernova appearance several hundred times that observed. Finally, it and Dirac's model before it, require serious rethinking in the light of new estimates for the age of many old objects seen in astronomy which necessitate increasing the ages Jordan and Dirac use (and use fundamentally, it should be noted) by a sizeable factor.

As our last model before turning in conclusion to Bondi, Gold, and Hoyle, let us note that of Reginald Kapp.[29] Based upon the rejection of a single creation because this makes two moments of time unique — the moment creation began and the moment it ended — and on the rejection of an infinite age for matter, since entropy and other considerations empirically seem to deny it, and yet upon the thesis that past time is endless, Kapp constructs a scheme which is to say the least, different. Assuming an infinite time and the continual appearance of new matter, and because such a universe under all prior theories should have infinite density which it obviously has not, Kapp concludes that matter continually disappears as well!

In this model, matter arises at random in space and disappears in the same manner. But because, in the interval, much of it is attracted into neighboring existing stars, the disappearance occurs largely within them — stars therefore lose mass in proportion to their size. However, though stars, and the galaxies in which they are situated, gain and lose mass continually, there comes a time when a rough equilibrium is established so that stars and galaxies should eventually all attain a more or less uniform miximum size. Unfortunately, apart from numerous other problems in Kapp's type of theorizing, this point seems to falsify the model, for, if we calculate the rate at which his thesis requires that matter be created and if we assume it is lost in large stars and galaxies at roughly the same rate, the estimate turns out impossibly large in the face of observation. We need delay no longer then in moving to the famous 'steady-state' theories to follow.

In 1948 Bondi and Gold, and independently Hoyle, presented papers involving schemes of considerable current interest.[30] They, and others, have since refined these first suggestions and, in what we will say, we shall look at the composite result. Bondi and Gold built their thesis upon a rejection of all the models based on Einstein's early work for they believe that, if the universe changes in size with time it must also change in density, leaving the laws of physics altered in the past in an unknownable way. The result would be that observations of very distant galaxies, and thus of the universe as it was long ago, will not be interpretable in terms of the laws of nature as we know them today on earth and we must therefore be agnostic as to their real character.

To avoid this, which must remove cosmology from any serious scientific interest, they postulate a 'perfect cosmological principle' in which the universe and its laws remain unchanged on the large scale with time and place. At the same time they reject the theory of general relativity and utilize instead certain aspects of kinematic argument. As a result, since observation shows the recession of distant galaxies and since it is essential that the average density of any large region of the universe remain approximately constant, they postulate the continual 'creation' of new matter between the mutually separating galaxies.

From this matter, presumed to be hydrogen atoms or (in Bondi and Lyttleton's 1959 paper) protons and electrons with the former either in slight excess or with a slight excess of charge, new galaxies eventually condense. The result is that any large volume will show galaxies of greatly varying age, but with an average unchanging with any place or time one makes observation. Also, in time, galaxies will tend to cluster due to gravity, and this clustering is actually observed. But the point of greatest interest here is that the age of our galaxy may well be much greater than the age given by the Hubble constant in working back to the time when all the galaxies we observe might have had their world-lines (that is their extrapolated course back through space and time) coalesce. In other words, unlike most prior models the Hubble 'age' is of no real significance and certainly is not an age for the universe as a whole.

Hoyle's model is similar yet distinctive. It is constructed on the assumption that general relativity is valid and yet that the average density of matter in the universe remain steady. This requires certain revisions in Einstein's field equations wherein a C-vector appears in the place of the 'cosmic constant' mentioned earlier in the paper. The technical details are much too sophisticated to outline here, but they have resulted in some esoteric discourse between Hoyle and his friends, Bondi and Gold, which is noted in our references. We need only note that the net effect is quite similar to the Bondi-Gold scheme, with matter appearing continually in the model. The major differences lies in the fact that the 'perfect cosmological principle' here arises only as a consequence of Hoyle's axioms and is not fundamental as it is with the other men.

There can be little doubt that in assessing the consequences of these schemes, these three theoreticians and their followers have perhaps done more for theoretical astrophysics than has all the work predicated on the more Einsteinian constructs. The lite-rapture is permeated with the fruits of this beginning. However, this does not necessarily demonstrate the truth of their general thesis, since indeed it has a number of serious problems observationally and otherwise. Perhaps then, we should complete our survey by remarking rapidly upon the general status of the plethora of models we've discussed, for after all, any cosmological model must be judged on whether it is testable, whether it survives testing and whether among those which survive test it is most suggestive of future study.

Yet here we find a phenomenon not unknown to the history of science: the theory has outrun available test data, or even any testing potentially available in the near future. While I have given this problem in currently cosmology several hundred pages of discussion in my work noted in the references we must make a few comments of interest to our present theme.

Obviously one way to falsify any specific interpretation of a cosmogony is to disconfirm the model from which it is deduced. At times this may be done by spotting certain incoherences within the construct, as we have noted on occasion earlier, but usually it is a question of observational data providing the test as should be the case in science. Several such potential tests are the famous red shift-distance law and the density counts of galaxies at increasing distance from us. We can only report certain tentative conclusions here, because the data is not without question. The result is that presently the steady-state models of Bondi, Gold, and Hoyle are in some difficulty and the specific Einstein-de Sitter, Lemaitre, Dirac, and Milne models likewise seem rather untenable. However, we as yet cannot settle the value of the 'cosmic constant' nor the curvature permitted to the models, except that there is some possible preference for small negative values for both λ and the curvature. This leaves a number of our models permissible on these grounds.

Another test is the ability of any model to explain stellar and galactic theories of age and evolution which seem to fit observation rather well. One problem with some of the schemes such as Eddington's, Jordan's, Dirac's, and the earlier expanding and pulsing models, has been that they inadequately handled such theories of stellar and galactic origin and also that they gave ages for the present expanding universe which were too small to fit the ages of the things they contain. However, while this is quite serious in the case of Eddington, Jordan, Dirac, Lemaitre, and Milne it is not so important, perhaps, in many of these other models. The reason is that it is not at all beyond possibility that, while all matter might have a finite age (that is, the universe had a beginning), much of the matter may have appeared subsequent to this origin as suggested by the various continuous 'creation' theses. This is not to say that Jordan's, Kapp's, or the Bondi-Lyttleton suggestions are therefore acceptable, for all have other major problems, but it is to say that a combination of certain facets of the Bondi-Gold-Hoyle cosmogony with some of the earlier general relativity models is a tenable option at present.

Of course future work is going to have to consider the suggestions of the Gödel-Heckmann-Omer theses as well as the odd large dimension-less constants of Eddington, Dirac, and Jordan and the results may well be exciting. Nonetheless, we presently face the interesting tenability of a fairly broad spectrum of models, however we may refine these, and it looks as if this leaves us with even the maximum age and origin of our universe rather undecidable at the moment. In such a case, some hard thinking is going to have to be put into which models of this spectrum may be most quickly put to new tests (for only in this way can cosmology advance as a science) and which best fit broader esthetic, philosophical, and logical requirements. In our paper to follow, we shall assay the last of these points, insofar as it directly involves the question of origin and age. We have surveyed the landscape; it may be well now to do something which we might call a geological analysis of some of the structure beneath it.

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governing astrophysical processes as a whole and the character of future observation which should be possible if the laws are true.

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GEOLOGY AND THE DAYS OF GENESIS

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The two chief problems in attempting to match geological and Biblical creation accounts are (a) durations of the time units, and (b) sequences of events. Both of these difficulties can be overcome, in good measure, if we adopt two basic ideas: (1) the "days" of Genesis are not necessarily mutually exclusive and purely consecutive; and (2) the "eras" of geology are not pertinent time divisions for the student of creation.

The first of these ideas can be clarified by considering the "day" of printing, the "day" of electricity, and the "day" of space exploration. These are meaningful time units in the history of civilization, but they are neither mutually exclusive nor purely consecutive. The second can be clarified by pointing out that geologists have been shifting the basis of their calendar from orogeny (mountain-making) to paleontology and radiochronology. This shift makes it clear that the eras are largely arbitrary.

In order to compare the geological record with the Biblical account, we need specific landmark events, of a geological nature, pertinent to the Genesis story. The most important such events are: (1) creation of the solar system, (2) transition from a primitive, hot, translucent CO_2 atmosphere to our present oxygen-rich air, (3) appearance of animals, and (4) appearance of man. The Bible records three distinct creations: the "world," animal life, and man. The fourth landmark event (termination of the early atmosphere) is given in Genesis in terms of the "appearance" of the sun, moon, and stars—in the middle, rather than at the beginning, of the creation "week."

The creation story given in the first chapter of Genesis was written in terms of six "days." A great deal of discussion has arisen around the possible meaning of the Hebrew word (yom) which is here translated as "day" (5).

Some people have held to the idea that "day" must mean 24 hours, neither more nor less, a concept which does not hold in English, much less in the original Hebrew which had a very sparse vocabulary, and therefore had to use each word for many different meanings. Despite the wealth of our own language, which has more than one million words (compared with a few thousand for the Hebrew), we use "day" to mean (1) 24 hours, (2) 12 hours, (3) daylight, (4) an indefinite period of time, plus many more. (Number 4 can be illustrated in the following sentence: "There were no airplanes in George Washington's day.")

Some people have held that "day" means "1,000 years," taking their cue from statements in both the Old and New Testaments that "a day with the Lord is as a thousand years."

Some have attempted to equate the six days of Genesis with six geological eras. This approach does not appear to offer much prospect of success, because the geological eras as now shown on a calendar of earth history are quite arbitrary, rather than having been dictated by God. It is standard practice to identify three eras in the last half-billion years: Paleozoic, Mesozoic, and Cenozoic. However, there is no reason to believe that a three-era sub-division of all of pre-Paleozoic time has any particular meaning; or even that the three named eras have any special significance. They were named when geologists still thought that orogeny — the dividing mechanism which is usually invoked — was both periodic and world-wide. Now that it is fairly clear that neither of these premises is true, our present arrangement of eras is only a matter of convenience rather than of significance (11).

The "geological era" theory also has had difficulty in accounting for the fact that the Genesis story indicates the separation of night and day before the appearance of the sun, and likewise the development of plants (which require sunlight for photosynthesis) before the appearance of the sun. Appeals to the miraculous power of God — which admittedly can produce light without a source — haven't helped to satisfy those Christians who still believe that He operated in a systematic and methodical fashion.

And many people, unable to accept any of these three ideas, all of which have large, obvious flaws in them, have turned to other, less simple, explanations. Some have thought that the "days" are divisions of a poem which Moses wrote to describe creation. Others have speculated that they refer to the separate days on which Moses was given six visions, all of which (when taken together) record creation activity. Still others have wandered even further from the Genesis story, which appears to be an itemized account and therefore *should* be fairly easy to understand. The only trouble has been, each explanation has failed to be satisfactory.

Research in geology, over the last couple of decades, has provided new evidences which may enable us to return to a modified version of the "day equals era" suggestion. However, we shall have to proceed with great caution, inasmuch as the recognized eras can not be used for this purpose, and many uncertainties still remain unresolved. Before considering how the geological history of the earth and the Genesis account can be matched, let's review, briefly, the developments which lead to this reconsideration.

It is now clear that orogeny, or mountain-making, is *not* world-wide, at any one time (it is going on in California today, but not in Arkansas), and can be more-or-less continuous at any given place (11). The folding and faulting which are associated with deformation may, therefore, introduce "markers" which are extremely helpful to the field geologist, but they cannot be taken as "landmark" events which are to be used as basis for a geological calendar if we wish the latter to have ultimate significance.

Instead, what occurrences can we expect to find, recorded in the rocks, which will be important to both the Genesis story and also to a geological history of the earth? For an answer to this, we must look beyond the usual calendar, and we must push back into the dimly-lighted events of Precambrian time (i.e., more than about 6 x 10^8 years ago). There we have no calendar, in the ordinary geological sense; we have only a few field facts, and the inferences which can be drawn from these.

The evidence points to one basic idea: the primitive earth had a carbon dioxide atmosphere (7). Venus and Mars ehave such atmospheres today (9, 10); the other two interior planets (Mercury; the Moon) are too small to retain any appreciable gaseous envelopes. We have no reason to think that the earth's early air was any different from that of her closest neighbors. Furthermore, the rocks (primarily limestone and secondarily coal) contain approximately 20,00 times as much originally-atmospheric carbon as the air still retains (6). If we return this large volume of carbon to the air, in combination with the equally large volume of oxygen locked up in limestone, we produce a thick CO_2 shroud essentially like the one which surrounds Venus today (9).

Our air has apparently gone through at least three stages: I. A primitive CO_2 blanket, having a pronounced greenhouse effect (3), hence higher temperatures (perhaps between 500°F and 1000°F; much like those on Venus; 1, 2, 9) and a chemical reducing effect; II. A transition atmosphere; and III. The modern, cool, oxygen-rich (i.e., close to 20%) air which we now breathe. The first of these would be translucent, to some small degree, but not transparent; the third would be cool enough for water vapor to condense to form the oceans.

Radioactivity dates indicate that the initial event which started the change from I to III must have occurred about 2 or 3 x 10^9 years ago (4, 8). There is even less assurance about the completion of the change, but it probably took place before Precambrian time ended (because seas were well-developed then), and perhaps was completed much sooner (8). For purposes of discussion, we can adopt two rough figures: about 2 x 10^9, as a fairly reliable estimate of the first shift (from I to II), and perhaps 1 x 10^9, as an approximation to the second change (from II to III).

Precambrian rocks younger than 2 or 3 x 10^9 years old contain tremendous quantities of carbon which, in view of the C^{13}/C^{12} ratios, had an organic origin (4, p. 205). The best evidence, including a few well-preserved Precambrian fossils, suggests that algae may have been responsible for dissociating the primitive CO_2 blanket to form carbon (which they incorporated in their body structures) and oxygen (which they gave off as a waste product) (4, 8).

The nature of the primitive atmosphere, the early appearance of algae, the change in atmospheric conditions, the large volume of carbon, and the development of the seas are all reasonably well supported by geological data. From this basic information we can draw several conclusions which are pertinent to our topic:

1. Prior to the end of Atmosphere I, no sun, moon, or star would have been visible from the earth, but it would have been possible to distinguish between night (complete darkness) and day (not quite completely dark).

2. Tiny, simple plants may have appeared before the sun and moon became visible as distinct entities (4, p. 215).

3. Animals did not develop until after plants had already engineered a cool atmosphere (III) overlying oceans in which ample oxygen was dissolved.

With this background in geological evidence and inference, we can consider a most important facet of the revelation given to Moses. It does not seem reasonable to believe that he was given a vision of creation from the standpoint of inter-planetary or inter-stellar space. The planets are so small, relatively, and so far apart, that they are not visible from each other, with a few exceptions, without a telescope. For God to have taken Moses on a trip — even in his mind — out into space to view the work of creation would have meant that the geometry of sun, earth and moon would have been distorted hideously.

Instead, let's suppose that the insight which God gave to Moses was presented in the form of a vision of the earth itself, as seen from its own surface — the only truly logical point for Moses to take as he observed what God revealed. Under these conditions, the story would be quite different. From the vantage point of Pluto or Jupiter or Mars, the sun was formed at the same time day and night were separated; but from the vantage point of the earth's surface, the distinction between day and night came long before sun or moon could be seen. It should be realized that Moses did not write that sun and moon were *created* on the fourth day; they were merely "made," or rearranged, or made manifest, at that time.

The six days of Genesis can be characterized as follows:

First: Separation of night and day.

Second: Establishment of the "firmament."

Third: Plants; oceans.

Fourth: Sun, moon, stars.

Fifth: Animals of all kinds.

Sixth: Man.

These items fall into a chronological sequence — when viewed from the earth's surface — but the sequence is of an overlapping kind. For example, if plants first appeared about 2 x 3 x 10^9 years ago, in the form of algae, then the history of the development of the plant kingdom must have been spread way past the first appearance of animals. The latter date from some unknown time in the Precambrian, whereas many types of plants show up for the first time in the fossil record hundreds of millions of years later. That is, some plants appeared before the first animals, and some plants after the first animals. It seems that we have an overlapping chronological order.

To avoid the use of standard geological terms, such as era, and their non-overlapping implications, let's adopt the word "span" for each of the "days" of Genesis. The six "spans" described by Moses can be summarized in geological terms as follows:

First: Night and day; the translucent but dark CO_2 atmosphere; from very early in the earth's history until about 2 x 10^9 years ago.

Second: Inasmuch as "firmament" has been used to translate a Hebrew word which means "beaten out" "stamped out," we are unable to make an unequivocal geological interpretation. During the interval of the hot, translucent, but dark, CO_2 atmosphere, the "waters" of Gen. 1:6 would apparently include (a) water vapor above the ground surface, and (b) liquid water below the ground surface; hence the latter may be meant, in some way. A reference to meteorite impact, common in early geological history, may have been intended.

Third: Dissociation of Atmosphere I, by plant activity, to produce oxygen in the air, much carbon in sediments, a general cooling, and the early seas. Perhaps 2 x 10^9 years ago, to the present.

Fourth: Coinciding in part with, or overlapping, the third span; the first visible appearance of sun, moon and stars, as the atmosphere became transparent. About 1.5 x 10^9 years ago.

Fifth: The development of animals, a process which has continued into the Cenozoic; from perhaps 1 x 10^9 years ago, to the present.

Sixth: The creation of man as a spiritual entity; quite late; possibly Pleistocene.

None of the standard geological dates show up in this chronology. Moses wasn't writing a geological history; he was reviewing the important events in God's three-step creation (matter; cognition; soul).

The organization of earth history into six "spans" is pertinent to an understanding of both the Genesis account and geological history. It would be quite correct to use the English word "day" in the sense which has been adopted here; the "day" of the CO_2 atmosphere, the "day" of plants, the "day" of animals, and the "day" of man. These days are not to be combined to form a calendar week of 168 hours, inasmuch as the advent of any given "day" doesn't necessarily terminate those which went before.

The Bible phraseology, ". . . and evening and morning were one day," can be interpreted to mean that a chronological order is intended, without requiring a purely sequential order of mutually exclusive events.

The important actions in this account — identified by the colorful verb, "to create" — are described against a setting which is barely detailed enough to show us that a meaningful history was being recorded. Moses may not have understood it all (as we still do not today) but he was able to reproduce his revelation faithfully.

Geologically, the background in the Genesis story (night-and-day, plants, seas, sun and moon, animals) is also significant. It provides a landmark event — at 2 or 3 x 10^9 years ago — in what would otherwise be the monotonous expanse of Precambrian time. It also offers Biblical support for the only geological theory which has yet appeared which makes anything like a systematic approach to understanding early earth history.

If the present synthesis proves to be in error, a similar combination of Bible and scientific information will have to be substituted. God's revelation, whether recorded in His word or in His world, cannot have a split personality. Both methods of investigation must, ultimately, yield the same results. The "span" theory is at least a good step in this direction.

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COMMENTS

by Mr. James Murk, M.A., Instructor in Anthropology and Sociology, Wheaton College, Wheaton, Illinois

It seems quite probable that the "days" of Genesis do not refer to measurable periods of time but to a sequence of creative events. There is certainly no comparison of the length of time involved in each of the first five days, according to Mr. Tanner's paper, and the 6th day. I am personally most interested in his suggestion that the 6th day of creation begins sometime in the "late Pleistocene."

What does "late Pleistocene" mean? (Also, does the indication of "the creation of man as a spiritual entity" imply his physical creation or evolution earlier?) The so-called "Upper Pleistocene" includes the interglacial period before the last glaciation beginning maybe 175,000 years ago. "Late Pleistocene" might also mean 25,000 years ago. The problem of correlating the fossil and prehistoric cultural evidence for early man with the Biblical account of the creation of man is far from being settled. Most Christian anthropologists, however, would suggest a middle, even an early Pleistocene date for the creation of Adam. I personally am a dissenter from this view and have a paper concerning it.*

I do take exception to an incidental argument in the paper which contrasts the English and Hebrew vocabularies. Mr. Tanner is selling the Hebrew short when he implies a small vocabulary. Probably no living language of any primitive people has less than 20,000 words, and spoken Hebrew doubtless had many more. Also the great bulk of the million words claimed for English, (and this in itself is an exaggeration) are terms related to our technology and science. Few speakers of English have a working vocabulary of more than 40,000 words.

* Mr. Murk's paper developing his views on a late Pleistocene Adam was presented at the A.S.A. convention in August, 1964.

EDITORIAL

YOU ARE THE EDITORS

To you, who have cooperated with David Moberg in bringing the Journal to its high level, are due the thanks of all the members of the American Scientific Affiliation. Especially does Dr. Moberg deserve credit for careful planning, mastery of detail, and wise judgment. Accept our gratitude, Professor, for an arduous task completed in masterful fashion.

Your following of the suggestions in the editorial in the June issue will keep our Journal both interesting and profitable. The Journal is yours, not the present editor's, and he wishes all of you to be represented within the confines of the policies mentioned by the former editor. So you are editors: you may write editorials, letters to the Journal, and the extended writings that make up the body of the magazine. No Journal is completed until you have edited it and expressed your approval and disapproval. But we know what you think when you write it to the editor.

The September 1964 issue has benefited from accumulated articles as well as two from a science symposium. The December Journal begins the reporting of the August Convention at John Brown University. To the University for its cordiality and to all of you for your cooperation, a hearty "thank you."

EXPLANATION IN THE BEHAVIORAL SCIENCES

LARS I. GRANBERG

Several weeks ago Senator Margaret Chase Smith of Maine stood before the National Women's Press Club and gave an impressive set of reasons why she should not be a candidate for the office of president of the United States. Among her handicaps, she said, were lack of money, no time to campaign, and no organization. Whereupon she announced she was going to run anyway. I think I understand this a bit. When the invitation came to participate in this symposium, devoted to an inquiry into the nature of scientific explanation, a number of reasons why I should decline came to mind. First, the niceties of this topic are the province of the philosopher of science, and philosopher I am not. (As a matter of fact, my old philosophy professor, Dr. Gordon Haddon Clark, would be more than a little bemused to find me in this role.) To compound the felony, the science of psychology is practiced with fierce intensity by those persons usually designated experimental psychologists, a group who scoff at the scientific pretensions of clinical psychologists. Clinicians in turn tend to divide themselves into those oriented toward experimentation and scientific verification and those tenderminded (soft-headed?) apostles of clinical intuition who feel more at home with the products of poets, philosophers, and theologians than with logic, statistics, and experimental design. This is the bottom of the barrel. So, like Margaret Chase Smith, I considered why I should decline; then, from my couch on the bottom of the barrel, I accepted. This represents a rare opportunity to have to become involved with important issues which I ordinarily ignore, to my detriment.

What I have to say will have to do with explanation in psychology. Some of it may be applicable to anthropology and sociology, but their special problems of explanation I have set aside as outside my sphere of competence.

THE CONTEXT OF EXPLANATION

It is now four score and five years ago since Wilhelm Wundt declared psychology's independency of philosophy and established in Leipzig, Germany, the first laboratory given over to psychological experimentation. Since then psychology has succeeded neither in living without philosophy nor in living with it. E. G. Boring points out that "often the men who cry out most loudly against philosophy in psychology are the men who regard psychology as a system and who write of epistemological matters."[1] He continues,

> Ever since their foundation, the journals of psychology in all countries have been weighted down with "theoretical" papers that are really the expositions of psychologists, untrained to philosophy but writing on philosophical matters. 2

The psychologist thus sketched consciously eschews philosophizing but indulges freely in the pastime by giving it another name. If the psychologist really

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1. E. G. Boring, *History, Psychology and Science*, p .27.
2. E. G. Boring, *ibid.*, p. 28.

wants to avoid philosophizing, why doesn't he? This uneasy relationship to philosophy is but one of the sizable difficulties psychology faces in seeking satisfactory explanation; for we find ourselves still trying to clear away the underbrush of certain persisting problems that complicate the development of scientific explanation in psychology.

The basic problem is of course the complexity of personality, especially the private aspects of personality. It is a truism that what people say does not necessarily reflect what they do, and what they do does not necessarily show how they feel about either what they say or what they do. Man is also the creature who can watch himself while he is proposing marriage to his beloved and mentally compliment himself on a neat turn of phrase even as he continues to press his case. Self consciousness, the capacity for the kind of divided consciousness which enables one to be actor and spectator simultaneously, along with the rich realm of private experience vastly complicate the application of scientific modes of study to the human person. But it seems that these inherent difficulties have been seriously complicated by psychology's legacy from the eighteenth and nineteenth century; a legacy which has resulted in three conflicting explanatory approaches.

To understand this legacy it is necessary to recall that before Wundt, psychology was usually called "mental philosophy" and taught by philosophers. One such, the influential Immanuel Kant, laid down a set of criteria for a natural science which called for an *a priori* mathematical foundation and the possibility of experimentation. In view of these Kant regarded the possibility of psychology's becoming a natural science as dim. Herbart, Kant's successor, was ready to go along with the idea that mental facts could be quantified, but reiterated Kant's doubts about the possibility of experimentation. This moved Gustav Fechner, who already had a well established reputation in physics, to prove him wrong. Building upon Weber's experiments on the sensitivity of the touch and visual senses, he claimed to have succeeded in measuring sensations, albeit indirectly, through a careful measure of the stimuli that aroused them. Fechner's work helped provide impetus to the establishment of Wundt's laboratory.

Wundt's laboratory, then, was founded in a climate of reaction against philosophizing ("arm-chair speculation"); and in a spirit of determination to prove that a psychologist could be fully the scientist which the physicist had become, his students proceeded to study the phenomena of consciousness through introspection.

Barely a generation later, John B. Watson and his followers founded the school known as Behaviorism. In a mood of radical reaction they cast off the introspectionist techniques of Wundt and his followers and asserted that the only proper study for a scientific philosophy is observable behavior, which must be submitted to strict experimental procedures — in particular control of critical variables and verification of results.

The conflict between Wundt's structuralists and Watson's Behaviorists expressed a basic tension between competing philosophical roots which continues to complicate (and enrich) experimental psychology to this day.

Behaviorism finds its origins in the British associationism of Locke and his associates. It sees man as a *tabula rasa* (blank slate) in need of stimulation from the external world to activate him ("There is nothing in the intellect which was not first in the senses" — Locke[3]). He is thus *reactive* rather than active; almost infinitely plastic, and acquires his characteristics through the process of developing conditioned responses. The position is epitomized by Watson's much quoted boast: "Give me any healthy infant, let me control his conditioning during the first seven years of his life, and I will make of him anything you want me to: richman, poorman, beggarman . . ."[4]

The image (scientific model) of man employed here is the machine. The aim of scientific activity is seen as the discovery of regularities of behavior ("laws") through careful observation and measurement. This movement, which comprises the main stream of scientific psychology in America, is *reductivistic*. It has severely limited its curiosity about man to the observable (public), the regular, that which men have in common (the general) and the quantifiable. These are sought through the analysis of small segments of behavior.

The consequences of this reductivist approach to the person may be seen in the answers which follow in response to the same question:

"What is a kiss? asks the coed of the Reductivist:
"Two moderately contracted orbicularis oris muscles in juxtaposition," he replies.
"Oh," she replies in a disappointed tone, "there seemed to be more to it than that!"

Now hear the sublime spokeman for all true lovers as he muses on the same question:

And what is a kiss when all is done?
A promise given under seal — A vow
taken before the shrine of memory —
A signature acknowledged — a rosy dot
Over the i of living — a secret whispered
To listening lips apart — a moment made
Immortal, with a rush of wings unseen —
A sacrament of blossoms, a new song
Sung by two hearts to an old simple tune —
The ring of one horizon around two souls
Together, all alone! 5

One would hesitate to claim that a kiss invariably means all these things. Is it not nevertheless indica-

3. G. W. Allport, *Becoming:* Basic Considerations for a theory of Personality, New Haven, Yale University Press, 1955, p. 7.

4. John B. Watson, *Behaviorism.*

5. Edmond Rostand, *Cyrano de Bergerac,* Act III

tive of something that, as Cyrano's rhapsody comes to an end, audiences customarily respond with prolonged, enthusiastic applause while the characteristic response I have observed to the reductionist definition, if any, is a brief, hearty guffaw (mainly from the male section of the audience)? What this indicates admits no simple explanation. My illustration admittedly tends toward caricature. But it does underscore the presence of complex, nevertheless real and important experiential elements in human behavior which have been largely ignored by the dominant tradition in scientific psychology. Valuable as are its emphases on caution, accuracy, careful checking and rechecking, and conservative generalization, this tradition seldom takes into account that in Gordon Allport's words "it is a prisoner of a specific period of culture, and of a narrow definition of science."[6]

Few, if any, even of the most conservative behaviorists would deny the existence of a private world within the individual. Their ground rules for science, however, tend to write these off as not suitable for scientific inquiry. One need not, however, minimize the necessity for scientific precision, nor need one look back nostalgically to pre-Wundtian speculation, to be uneasy at the recollection of Aristotle's remark, "It is the mark of an educated man to look for precision in each class of things just so far as the nature of the subject permits."[7]

Many psychologists feel that the associationist tradition has sought scientific precision at the expense of an adequate conception of man, i.e., it has done violence to the nature of their subject. Characteristically those who think this way turn toward the alternate philosophical root of experimental psychology, German idealism, which, for convenience, Allport calls the Leibnitzian tradition. Leibnitz' response to the Lockian observation that there is nothing in the intellect which was not first in the senses, was "except the intellect itself". This was intended to portray man as an active agent, one who initiates behavior, exercises a selective approach to his environment, and who is modifiable only within limitations. This image of man underlies such diverse psychologies as Gestaltists, Organismic (Holistic), Personalistic, and Existentialist. Representatives of these viewpoints study behavior at the molar rather than segmented level. That is, the whole human in action, or some large portion of behavior as compared with conditioned responses.

Approximately at the same time that the structuralists and the behaviorists were struggling for ascendancy over American academic psychology, Sigmund Freud and his associates were setting the foundations for modern clinical psychology. Freud's early theories were the culmination of a century of attempt's to understand a spectacular and comparatively common form of behavior disorder known as hysteria. This is a disorder, now relatively infrequent, which gives rise to spectacular physical symptoms (blindness, deafness, paralysis).

6. G. W. Allport, *Pattern and Growth in Personality*, p. 551

7. cited in Allport, *op. cit.*, p. 457.

Freud based his system of explanation on *the centrality of striving*. He saw men pushed from within by blind, pleasure-seeking impulses and threatened from without by an unconcerned, prohibitive society. Men needed to find defenses against the ensuing anxiety which would allow a modicum of pleasure while avoiding society's wrath. Most attempts at clinical explanation have accepted Freud's paradigm of anxiety and unconscious defenses as the key to understanding behavior. Contemporary clinicians prefer explanations grounded in unconscious dynamics.

We see, then, that contemporary psychology's efforts at explanation of behavior is complicated by three major perspectives. These are by no means totally antithetical. They do, however, represent different moods toward explanation. Each has some tendency to paint the others in the role of villain. Yesterday we heard Dr. Giles observe that what is regarded as good explanation is ultimately grounded in the fact that a community of scientists (e.g., physicists) like it. This suggests that a workable system of explanation within a science presupposes that there is within that science a well developed sense of community. Here the existence of these three moods within psychology, which generate more than a little mutual hostility, appears to be retarding the formation of the needed sense of community.

It appears to me that a constructively eclectic spirit around which this sense of psychology as a scientific community can develop, is needed in order to further good explanation. There are encouraging signs that this attitude is on the increase.

SPECIFIC COMPLICATIONS OF PSYCHOLOGICAL EXPLANATION

Scientific explanation, then, says Scriven, "Requires *selecting* from among the variables that are involved; those whose activities are *unknown* to the inquirer and *crucial* for the phenomena; . . . The explanation won't be an explanation unless the variables are crucial,"[8] (e.g., to explain soil erosion without giving due consideration to wind direction and velocity and mean annual rainfall is to fail to explain. Proper selection of variables presupposes some reasonably well established general theories (laws) to use as a guide. Explanation becomes a way of showing whether or to what degree new facts fit into accepted patterns.[9] And at present there is a distressing paucity of general laws.

If a small parenthetical indulgence in self pity may be permitted, explanations are bound to be a good deal more difficult to come by in psychology than in the older sciences. Scriven observes that "we already have common-sensical and well supported explanations

8. M. Scriven, "Explanations, Predictions and Laws," in Feigl and Maxwell (Eds.) *Scientific Explanation, Space and Time*, Minnesota Studies in the Philosophy of Science, Vol. III., p. 211, (italics author's)

9. J. G. Kemeny, *op. cit.*, p. 164 italics mine.

of nearly all the easy cases, and we are therefore left with the problems we have not been able to solve exactly by common sense."[10]

Unrealistic expectations make trouble too. We tend to measure our success against physics operating under laboratory conditions and in consequence expect exact predictions. However, in the realm of *practical problems,* which make up a major portion of the psychologist's province, Scriven maintains that exact predictions or faultless explanations are probably not possible inasmuch as these are rarely achieved by any sciences today. In physics, where practical problems are represented by engineering problems, meteorological problems, and problems in aerodynamics, solutions to problems are frequently compromises and approximations. He cites as an example the problem of determining how far a given missile of a particular shape will travel with a given propellant. This cannot be learned exactly from scale models since neither air molecules nor the critical mass of the propellant can be scaled down. The physicist can, to be sure, give good answers to such questions. He can even develop radio controls (as he has) which get him around the problem of prediction. Generally speaking, however, we in psychology must work with a larger number of critical variables, and are more unlikely to be able to run valid, full scale, repeatable tests. It hardly surprises that psychological prediction or explanation is currently less successful than the engineer, the aerodynamicist and even the meteorologist (!), and probably will continue to be for a long time.

Explanation is further complicated by the tendency in psychological research for the data-gathering process itself to bring about or to change particular characteristics. People often change their behavior in the process of being studied (e.g., polling on attitudes toward public issues). And the publication of studies of behavior has been known to change conditions sufficiently to significantly modify or even invalidate the original study. To what degree, for example, did the early Kinsey publications modify the trends they published by 1) providing the predatory with statistics to prove to the reluctant that "Everybody's doing it!" and 2) by promoting the thesis that *what is not should be?*

This is a problem, but more readily surmountable than others discussed. Possibly the limits of variation may be measurable. One can also moderate this effect at least in some contexts, by the use of indirect measuring devices such as projective techniques. It should also be borne in mind, Nagel observes, that all scientific "laws" are conditional.[11] They obtain if such and such conditions exist. If, then, one of the conditions of the law is that actions be based upon ignorance of it, we cannot consider the law in error when actions based on knowledge of it do not conform to it.

10. Scriven, "A Possible distinction between Traditional Scientific Disciplines and the study of Human Behavior, in Minnesota Studies in Phil. of Sci., I, p. 334.

11. Nagel, *op. cit.* p. 467.

Possibly the most plaguing of all is the problem of individuality. Our present techniques are normative. They measure the ways in which people are like one another. Individual uniqueness is missed, and to degree this is crucial our explanation misses the point. A person is more than a nexus of profile percentiles. These leave out much and tell us little about how a particular position on a scale fits into the total pattern of behavior. Finally, the psychologist whose presuppositions concerning man are Christian is disturbed by an approach to the study of behavior that seems to confine man within the realm of nature. How can one adequately explain regeneration, worship, prayer, and fellowship with God as natural phenomena? Moreover, the individual's *experience* of God, salvation and spiritual fellowship cannot be directly dealt with. Nevertheless his *reports* of these things and the influence of his beliefs on his behavior can be placed, at least to a significant degree, in the realm of psychological explanation.

CONDITIONS FOR GOOD EXPLANATION IN PSYCHOLOGY

Few things bring such chagrin to the dedicated experimental psychologist as the difficulty of gaining adequate experimental controls. Nagel suggests that this concern is exaggerated. In response to the question whether controlled experimentation is a *sine qua non* for the achievement of warranted factual knowledge and the establishment of general laws he points out that astronomy and astrophysics did not arrive at its theory through experimental manipulation of the celestial bodies, yet have arrived at well grounded general laws. He goes on to suggest that *controlled investigation,* which does not involve manipulation of variables, can serve a function similar to experimentation in psychological inquiry. Controlled investigation consists of a deliberate search for contrasting occasions when a phenomenon is either uniformly present or present in some cases and not in others. This is followed by an examination of certain factors discriminated in those occasions to see whether variations in these factors are related to differences in the phenomena. (Goldfarb's studies on the effect of psychological mothering or its absence seems to illustrate this approach.) Nagel regards it as immaterial whether observed variations are introduced by the scientist or are produced "naturally' and observed (discovered?) by him.[12]

Concerning the view of controlled experimentation which requires variation in just one relevant factor, Nagel considers this idealistic and difficult to achieve even in the natural sciences. Desirable as it may be, it can hardly be regarded indispensable. Temperature change and rainfall, for example cannot be varied independently, but statistical analysis allows the investigator to cope with many situations in which he cannot systematically control all but one variable at a time.[13]

12. E. Nagel, *The Structure of Science,* p. 452.

13. Nagel, *op. cit.* p. 453 ff. ,

Comforting as this may be to the experimental psychologist, his troubles are by no means ended. Statistical analysis of psychological data, Kemeny notes, has been retarded by the lack of development of a mathematics for intermediate range numbers (of the order of 5,000 to 50,000). Small numbers (of the order of 5) can be solved by elementary arithmetic. Large numbers (of the order of 5 million or even billion) are amenable to treatment by calculus. There is at present no equally effective mathematics for intermediate range numbers, so that progress in the behavioral sciences in some measure awaits mathematical progress at this point.[14]

The subjective nature of much psychological data creates further problems for scientific explanation. Men think, wish, desire, intend, suffer pain, heat, and cold. They experience joy at the presence of a friend and heartache over personal rejection. They believe or doubt, feel guilty, seke meaning, and erect value-hierarchies. For the most part, these activities are not open to the direct observation of the scientist, but it hardly seems that one can afford to exclude them and still make claims about adequate explanation.

In their zeal to eliminate the excesses of introspectionism the early behaviorists tended to take the position that psychology should be based solely upon public data which could be observed and confirmed by two or more observers. Today's more sophisticated behaviorists recognize the need to deal with introspective reports. They do not, to be sure, treat these as the expression of private inner states. Reports purporting to represent the inner life are classed with other observable activity in which a person engages under certain conditions. As such they form part of the basis for psychological generalizations. This, Zener comments, "shifts the burden of scientific responsibility from the report of the subject to the report of the experimenter."[15] Percy Bridgman presses the behaviorist at this point too: "Once the behaviorist has admitted that introspectional report is a proper subject for psychological study he must also admit, I believe, that in particular the report of his own introspectionings is a proper topic . . .[16] Bridgman insists that private (inner) activity not only can, but must be made public. He considers the phenomenon of *projection* an effective means for unlocking the private world of the person. This gives pause to the clinical psychologist, as we shall see. Bridgman argues, however, that the inevitable result of living in society is that one learns how to interpret words referring to private experience. "When we project", he says, "we understand the action of our fellows by imagining ourselves in his place. This involves the assumption that we and our fellows are . . . sufficiently alike for practical purposes."[17]

14. Kemeny, *op. cit.* p. 247 ff.

15. K. Zener, "The Significance of the Experience of the Individual for the Science of Psychology," *Minn. Studies in Philos. of Sci.*, II, p. 367.

16. Bridgman, *The Way Things Are*, p. 242 ff.

17. Bridgman, *op. cit.*, p. 243.

In support of Bridgman's contention it is well to recall that the process of projection has a stout ally in the individual's need to communicate himself to others. John Donne is right. No man *is* an island — even the badly regressed schizophrenic patient. And if the pathological effects of psychological isolation are well known, so also is the promised bliss of "dialogue", a phenomenon regarded by a troop of contemporary psychologists, philosophers and theologians as the key to self-discovery. I come to know myself, they say, in the struggle to make myself clearly known to another. (cf. Sidney Jourard, *The Transparent Self).*

The perturbed clinician's response is likely to be that men have not lost their need for "fig leaves" (psychological defenses). Neither do they possess the capacity fully to report their experiences. How does one adequately report all he sees as he watches a sun set in the Rocky Mountain area? Much less describe the total effect of what he is seeing upon himself? These are valid concerns, but for all of them subjective experience is considered to be so essential for an adequate view of man — hence for adequate psychological explanation — that the effort to counter these limitations must continue. Significant recent developments in methodology (Q-technique; projective technique; analysis of verbalization of therapy clients) stand to further effectiveness in ascertaining and properly assessing inner factors.

It would not do to leave this line of discussion without illustrating one of the chronic pitfalls of clinically derived explanation. I refer to the tendency to incomplete explanation so blithely indulged in by more than a few clinicians (to the despair of the science makers among us). An explanation is *incomplete* when it fails to explain what it purports to because the connection between a given effect and the phenomenon that is supposed to have produced it is inadequately established.[18] Consider one of Freud's explanations. In *The Psychopathology of Everyday Life* he explains a slip of the pen he had made. On September 20th, shortly after his return from a holiday, he found that he had written "Thursday, October 20th" just below the correct date. This he interpreted as the expression of a wish not to have the next month fly by as quickly as it was going to. Freud's apparent hypothesis here is that when a person has a strong, but perhaps unconscious wish, any slip (tongue, pen, memory, etc.) will represent an expression and perhaps fulfillment of the wish. This is no model of hypothesis-making, but at that it is probably more explicit than Freud would have liked. What makes this an incomplete explanation? Let us for a moment assume that the above hypothesis is true and that Freud had the wish he reports. One can imagine a goodly number of things Freud could have done to express his unconscious wish, any of which should have been equally effective. Why then the slip of the pen? There is nothing in the specific conditions that seems to make it either

18. Scriven, "Explanations, Predictions and Laws," Minn. Studies in Philos. of Science, III, P. 200.

necessary or inevitable. Nevertheless it cannot be rejected for it is not only plausible, it has elements of probability. Hence this is called an incomplete explanation.[19]

What constitutes a complete answer, then? There are those who feel that a complete explanation cannot be given in science. Certainly, as Scriven comments, "there is the possibility of indefinitely challenging the successive grounds of an explanation."[20] However, within the context of science the word "complete" has acquired a standard use which applies to some explanations and not to others.

> A *complete* answer has been given when the particular object has been comprehensively related to the directions that are understood . . . the request for an explanation presupposes that *something* is understood, and a complete answer is one that relates the object of inquiry to the realm of understanding in some comprehensive and appropriate way. What this way is varies from subject matter to subject matter . . . and what counts as complete will vary from context to context in a field . . .21

At the present time, particularly in clinical psychology, *explanation sketches*, such as the Freudian example given above, are the rule rather than complete explanations. An explanation sketch is "a suggestion of general outlines of what, it is hoped, can eventually be supplemented so as to yield a more closely reasoned argument based on more explicit and more testable explanatory hypotheses.[22] To move in this direction, we need to learn how to get beyond the obstacles discussed above.

WHAT OF THE FUTURE?

Kemeny, taking the historical approach is cautiously optimistic. He reminds us that in the history of science many avenues of research turn out blind alleys during the early stages of a science, and suggests that for a long time to come the really fruitful results in the behavioral sciences are likely to come in areas offering no immediate benefit to mankind. Then he makes the interesting comment that some mathematicians believe that the inspiration from the physical sciences which has for so long given impetus to progress in mathematics has about run its course, but that the next great development in mathematics is likely to be sparked by the behavioral sciences. So much the better for the latter, for, as indicated above, the behavioral sciences are handicapped by deficiencies in mathematical knowledge.[23]

Scriven is more sanguine. He observes:

> a set of refinements and extensions of the idea of scientific . . . the last few decades of work in psychology have produced method without parallel in the history of its potential contribution to human welfare. The sophistication and efficiency of modern experimental design and analysis in psychology is comparable with anything physics has to offer, and comparable not only in difficulty but in fertility. I only hope that we are able to utilize the magnificent tools that have been created for us in psychology. If we do we shall have no need to regret the fact that humans are both complicated and self-conscious and its attendant consequence that psychology will never be lige Newtonian astronomy.

19. Colodny, *op. cit.*, p. 15
20. Scriven, *op. cit.* ,p. 201.
21. Scriven, *op. cit.*, p .202
22. Colodny, *loc. cit.*
23. Kemeny, *op. cit.*, p.256 ff.

CONCLUSION

Scientific explanation in psychology is presently at a low level of completeness, tending toward explanation sketches, which are rich in experimental potential, but incomplete as stated.

Greater scientific completeness of explanation in psychology seems to require a more adequate conception of man, a broader view of science; a sense of community among psychologists; a large assist from the mathematicians; data-gathering techniques which will not alter the situation in unexpected ways; and a better approach to individuality. Good progress has been made, and there is good reason for optimism.

AN EPILOGUE FOR CHRISTIANS

I should like to beg the indulgence of the Christian public. One of the persistent pressures it places on the Christian psychologist is that he should keep jumping from his empirical data to theological ends. That is, there is a tendency to try to make a given postulate or conclusion in the realm of the person or behavior fit a theological statement far too soon, and to opine darkly concerning the psychologist's orthodoxy if he does not do this. This makes it difficult to build from sparse, moderately validated data to ultimate frames of reference in the solid, step-by-step way that makes for genuine growth in knowledge. It also leaves little margin for the trial and error and the inevitable fits and starts that accompany progress. We do see through a glass darkly. We do know in part. All of us. My plea, therefore, is that God's revelation of himself in the Scriptures not be reduced to a Procrustean bed into which data must fit on demand.

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BOOK REVIEWS

AUTHOR'S REPLY TO ARTHUR KUSCHKE'S REVIEW OF "THE GENESIS FLOOD"

In the June 1964 issue of the Journal

In his rather lengthy review of THE GENESIS FLOOD, Mr. Kuschke begins by pointing out his agreement with the authors' aim of placing Scripture first rather than placing Scriptural and scientific evidence on an equality. He is happy to find that the authors hold to the integrity of the early chapters of Genesis, the reality of the created 'kinds,' and the direct creation of Adam's soul and body. "Their unwavering testimony to such things is wholesome and refreshing."

Such statements might lead the reader to expect a fair and careful investigation of the validity of the seven Biblical arguments for a geographically universal Flood as set forth in the first chapter of the book: (1) it mountain-covering depth, Gen. 7:19-20; (2) its duration of 371 days; (3) the breaking up of all the fountains of the great deep (tehom rabbah) for five consecutive months, Gen. 7:11, 8:2; (4) the huge dimensions of the ark, Gen. 6:15; (5) the pointlessness of building an ark if the Flood was limited in extent; (6) the strong testimony of II Peter 3:3-7; and (7) the main purpose of the Flood, which was the total destruction of a widely-distributed human race. Each of these arguments is carefully developed in the book, and much of the superstructure rests upon the validity of this Biblical foundation.

In rejecting the doctrine of a geographically universal Flood, however, Kuschke practically ignores these Biblical arguments! While admitting that Gen. 7:11 "describes a physical event, which caused waters to flood the land," Kuschke feels that "we simply cannot describe the character or degree or extent of this physical event; the Bible does not tell us." Similarly, he states: "Except for Noah and his family, the flood destroyed the human race; but we do not know whether it covered the entire globe." But if the seven Biblical arguments listed above are valid, then we do know whether the Flood covered the globe! Such statements simply beg the question at issue, and leave the reader with the impression that the reviewer has conveniently ignored rather than honestly faced the Biblical evidences for a universal Flood.

Kuschke unfortunately reveals a similar superficiality in dealing with the chronological problem. He quotes with approval Warfield's astonishing statement that "the Scriptural data leave us wholly without guidance in estimating the time which elapsed between the creation of the world and the deluge, and between the deluge and the call of Abraham," and on this basis assures the reader that "we may properly turn to the data of natural revelation in our inquiries respecting that chronology." He has apparently not read the arguments of Appendix II which show why Genesis 11 cannot be stretched beyond certain limits.

The authors were surprised to learn that "stratigraphy is a major difficulty for flood geology" and that "such orderly structures seem to have been laid down slowly under non-violent conditions and not in a great flood," for the major thrust of Chapter Five is that stratigraphy is an embarrassment to uniformitarianism, not to catastrophism, and that such "orderly" structures in many cases had to to be deposited by a gigantic flood, and in all cases could have been deposited by the Flood and its associated events.

In spite of the fact that the authors sought to demonstrate that fossilization is a clear evidence of catastrophism and that such processes are rarely occurring today, Kuschke states: "Fossilization also compounds the problem, for countless fossils are found in rich variety in these sedimentary strata, and in formations very deep in the earth. Coal seams occur 4,000 feet below the surface, intercalated with layers of limestone, shale, or sandstone. Many fossil materials thus appear to have been deposited over much longer periods of time than the authors allow.' This *nonsequitur* seriously raises the question as to whether the reviewer has carefully read the book he attempted to review, for these very facts are untilized by the authors against the standard geological interpretations!

The authors do not claim to have answered all the possible objections that could be raised against their position, for "the scope of these problems is vast, bearing really upon the whole spectrum of the sciences" (Intro., xxi). But they are confident that the Scriptures provide the basic frame of reference within which the history of the earth must be understood, and in the light of which our scientific investigations must be carried on. And they are fully confident that a universal Flood is part of that frame of reference. Unless it can be shown by sound principles of exegesis, hermeneutics, and logic that the Scriptures do not depict such a catastrophe in the days of Noah, it appears to the authors that Christian men of science and theologians must challenge the uniformitarian assumptions which underlie many of the theories of modern historical geologists.

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Henry M. Morris, Virginia Polytechnic Institute
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A STRESS ANALYSIS OF A STRAPLESS EVENING GOWN AND OTHER ESSAYS FOR A SCIENTIFIC AGE

edited by Robert A. Baker. Prentice-Hall, Inc., Englewood Cliffs, N. J., 1963. xvi, 192 pp., $3.95.

This "amalgam of satiric science and scientific satire" by scientists and literary men lampoons the fads and foibles of our day. The 32 essays and poems demonstrate that "as a group, scientists have a fresh, sensitive and highly developed sense of humor." Four criteria governed their selection: they have entertainment value, expose inanities of our age from a future perspective, make masterful use of parody, and/or expose pitfalls and frustrations of scientific research. In so doing they strike a blow against the cult of scientism and against dehumanized, power-drunk scientists who "forget that science is public property" and that it has a mission which, though mighty, is not almighty.

The reader will find among the contents an exposure of the neurotic conflicts of missiles, a firm scientific basis for the ladies' garment industry (the title essay), proof that the Abominable Snowman is a Chinese Communist, Parkinson's Law for Medical Research, archaeological findings during the excavation of the Weans (the land of the We, or Us) 5,000 to 6,000 years hence with interpretations of the institutions and people of such places as n. Yok, Cha'ago, O'leens, and Boxton, a description of "body ritual among the Nacirema" (spell the word backwards!), and even a scientific calculation demonstrating that the average net working time of a scientist during his entire lifetime totals 0.25 years or about 90 days.

If you enjoy humor, you will enjoy this book. But like me you may have mixed feelings about certain details. Among them are two modern versions of the Twenty-Third Psalm. They begin, "The Lord is my external-internal integrative mechanism," and "The AEC is my shepherd; I shall not live." When does "religious" humor become an irreverent, blasphemous form of casting pearls before swine?

"Today, thank God, it is still not unscientific to laugh!" —*Reviewed by David O. Moberg, Chairman and Professor of Sociology, Dept. of Social Sciences, Bethel College, St. Paul, Minnesota.*

LETTERS TO THE EDITORS

THEISTIC EVOLUTION AND BIBLICAL INERRANCY

I wonder if Mr. Hearn would give his explanation concerning several points that seem to me to be obstacles to harmonizing theistic evolution with Biblical inerrancy (revelational inerrancy or arbitrary inerrancy):

1. Could he comment on John Klotz's three paragraphs beginning "But there is an even more striking reason for interpreting Genesis 1 to 3 literally." (Journal of A.S.A. 15:84-85, Sept. 1963).

2. The Bible gives genealogies from Adam to Jesus Christ (admittedly gaps exist). Where do they cease being parabolical or symbolical and begin listing actual people? And what are these early names symbolical of? (Note Klotz's two paragraphs on p. 84 beginning "Is it possible that this is saga or myth?")

3. Are the Hiddekel and Euphrates rivers actually rivers? If only symbolical, why did the author choose to use the names of existing rivers?

As far as I can remember these most crucial points have never been discussed by those ASA members who are inclined toward some form of theistic evolution. Bernard Ramm's article in the same issue cannot be meaningful until it also deals with these matters.

Frank Cole
Royal Oak, Michigan

REPLY BY WALTER R. HEARN, ASSOC. PROFESSOR OF BIOCHEMISTRY, IOWA STATE UNIVERSITY

1. I certainly agree with Dr. Klotz on the importance of letting the whole of Scripture (and indeed, the whole of our knowledge) throw light on particular parts of Scripture. As a theist, I regard evolutionary processes as God's way of creating what exists today; I worship God as my Creator, believing that He has brought all of me into existence and not merely the tiny part of my DNA linking me to a single act of "special" creation long ago. I do not think my view is radically discordant with the New Testament view of the Creator and Sustainer of the world, of life, and of man in particular, in spite of the fact that the scientific outlook which influences my view was not in existence in New Testament times.

In Matt. 19:3ff or Mark 10:2ff, Jesus refers to the Genesis creation account to insist that human sex has a divine purpose, since "He who made them from the beginning made them male and female." Personally, I do not see that the impact of our Lord's statement depends on a strictly literal interpretation of Genesis 1, but I imagine his hearers did so interpret it, having no compelling reason to interpret it otherwise. Similarly, in the passages in Romans, I Corinthians, and I Timothy referring to Adam, Paul's interpretation of Genesis and that of his readers was very likely a literal one; however, the significance of his relating Christ to Adam does not seem to me to depend on that particular interpreation. Paul brings out the great contrast between the first Adam as earthy, physical man, who invented sin and discovered death as a result—and Christ as another kind of man, heavenly, spiritual, who through His righteousness atones for sin and provides life for the descendants of the first Adam. Personally, I think neither this contrast nor the religious imperative based upon it is weakened if Adam refers to "the kind of creature who first appeared on earth as man, and whose descendant I am" rather than to a specific individual. I worship God as the Creator of Adam as well as of myself; I know that processes have been involved in my own creation and I suspect they were involved in Adam's creation also.

The references in I Cor. 11:12 and I Tim. 2:13 to the creation of Eve make it clear to me that the writer and his immediate readers took Genesis 1-2 literally, so that the details of the creation narrative were important to them. The writer could use details familiar to his readers to make a religious point about how Christian women should behave. It is interesting that in this case a wide range of interpretation exists among evangelicals concerning the religious significance of the passage, some groups insisting that women should always wear "coverings" and others saying that the passages mean only in church or referred merely to some local custom at the time of writing. Is it necessary that we agree on their biological significance? The spiritual message of Matt. 6:26 is not lost on those who have looked at the birds of the air and watched their feeding habits just because they do not picture God literally putting seeds or insects into their beaks.

2. I divide what seems primarily parabolic from what seems primarily historical in Genesis at chapter 11 simply because of the wealth of detail beginning with the story of Abraham. That is, the first eleven chapters compress many hundreds of years (to a literalist —many thousands, perhaps, to others); yet fourteen chapters are then devoted to Abraham alone, eleven to Isaac and Jacob, and fourteen primarily to Joseph. I do not generally use the terms "saga," "myth," or "allegory" to describe my concept of the nature of Genesis 1-11: I prefer the term "parable."

3. It seems reasonable to me that a parable told to put across a spiritual point might use specific names (as in Luke 16:19ff), especially if the names had some particular significance to the immediate hearers or if the parable did involve historical or traditionally accepted events.

My acceptance of a parabolic interpretation of Genesis 1-11 is a tentative and personal solution to problems arising from taking both the Bible and biology seriously. There may be a great variety of Biblical interpretation among theists who accept evolution as a valid and valuable scientific generalization. Dr. Klotz's characterization of theistic evolution at the end of his article does not fit my position particularly well. If God does work through natural laws (such as that of natural selection), then He is not "more or less out of touch with the world in which we live"; on the contrary, He is so thoroughly involved in our world, in the world of Darwin's finches, in the world of amino acids—that the operation of the world becomes wholly contingent on His creative power. My own theological definitions of "natural" and "supernatural" are perhaps not very satisfactory at the present stage of my thinking; however, I think a God who works "exclusively through natural laws" and a God who works exclusively apart from natural laws are not the only alternatives open to us on the basis of Scripture.

LOBBYING

Nebraska law for years has prohibited interracial marriage . . . I discourage such marriages unless they, in individual cases, are clearly within the will of God, as reverently and prayerfully determined. However, to force others by law, to my point of view, does not seem to me to be consistent with an ideal of maximum personal liberty and minimum governmental restrictions . . .

A legislative committee was hearing testimony on a proposed bill which would legalize interracial marriages in Nebraska. The Rev. Harold E. Garland, pastor of Temple Baptist Church in Lincoln, took his turn after those testifying in favor of the new bill had been heard. His statement appeared in The Lincoln Star as follows: He said "proponents of the bill had failed to answer the question in his mind that 'if God didn't want a difference, why did He make a difference?' "

. . . I tip my hat to Brother Garland for taking time to spend an afternoon at a legislative committee hearing, for putting the gist of his Christian thinking into a brief quotable sentence, for clearly indicating that God was involved in making people as they are, which is certainly remote or non-existent in widespread evolutionary thought . . .

I believe more Bible-adhering pastors and laymen ought to speak to . . . lawmakers and testify at public hearings . . . After a bill becomes law is not the time to complain about it. Jesus said, "Ye are the salt of the earth, but if the salt have lost his savor, wherewith shall it be salted?" (Matt. 5:13a).

Rev. A. R. Paashaus
Firth, Nebraska

CHEMISTRY

Author: Russell Maatman

MACTLAC is the abbreviated organizational name which has meaning for many ASA members as well as a few hundred of their midwestern teaching colleagues. The Midwest Association of Chemistry Teachers in Liberal Arts Colleges, founded in 1952, meets annually to exchange ideas on questions which interest ASA members in colleges which are not state-supported.

One of the highlights of last fall's meeting at Wabash College in Crawfordsville, Indiana, was the distribution and discussion of the report by Harry F. Lewis on chemical research in MACTLAC schools. Following are some of the data for fifty-seven liberal arts colleges in eight states. In the 1962-3 school year 69% of the chemistry department staff members (there was an average of 3.5 staff members per school) engaged in research. There was an average of 8.1 senior chemistry majors per school and an average of 5.7 students (not necessarily all seniors) engaged in research. The average school received $6,750 in research grants for this work (only nine of the fifty-seven received nothing), with the National Science Foundation, the National Institutes of Health, and the Research Corporation the most frequent granting agencies.

For the three-year period ending with the 1962-3 academic year, there was on the average 0.61 research publication per college per year and 0.75 presentation at a scientific meeting per college per year. Five of the fifty-seven colleges were responsible for 53% of the publications, while nineteen published nothing in that period.

The data in the report show further that a larger fraction of faculty members and students participate in chemical research each year, and that this activity is significantly larger than it was a dozen years ago. There is therefore now a substantial interest in chemical research (and presumably in other scientific research as well) in just the type of college at which many ASA members are carrying out their calling to serve Christ by guiding students.

What does this growing interest in research mean for the Christian faculty member? If the trend towards more and more research continues, will it harm or hurt our work? The data given above seem to indicate that in spite of the fact that there is now appreciable research activity, this activity does not approach the point of dominating the professional lfie of the average faculty member in these colleges. Whatever problems arise from "too much research" seem to be far off. But the expenditure of $6,750 per year per college, on projects involving almost six students and two-thirds of the chemistry staff, means something radically new is being added to our chemistry curriculum.

"Curriculum" is hardly the correct word: the varied, unpredictable, and uneven activity associated with a research project, fraught with intellectual hazards, has little resemblance to the relative regularity and safety (since someone else has worked out the problems) of conventional courses in the curriculum. One reason research can be valuable for the undergraduate is that he thereby has the experience of finding his way in uncharted territory. In a talk at the recent meeting of the Iowa Academy of Science Dr. M. Dresden, a physicist at the State University of Iowa, even argued for introducing the uncharted-territory learning situation into the terminal, general education physical science course. He contended that the science student at any level must have the lost, where-do-I-go-from-here feeling that the research scientist experiences-always provided, of course, the student is confronted with a problem appropriate to his level of development.

One may claim that research activity merely develops students into chemists earlier than would otherwise be the case. If this were the only consequence of the newer approach research activity would hardly seem to be worth the considerable effort usually attending introducing it into and maintaining it in the chemistry department program. It seems there are at least two good reasons for us to be pleased with these latest developments.

First, God does give us specific commands on what we are to do with our talents. Those who have the talents enabling them to use music to praise the Lord should do so. Those who can use science to praise him should also do so. In Genesis 1 we are told to subdue the earth; in our day subduing the earth must include scientific investigation. Almost all science faculty members have been trained at some time to carry out research. The basic or fundamental research implied in "subduing the earth" by scientific investigation is just the kind of research best adapted to the academic environment, even though mundane matters associated with condensation reactions and electromotive force measurements may superficially seem far from the divine command.

Second, faculty-student cooperative research improves the entire scientific environment in a school. Research is not merely something added, leaving the rest of the curriculum alone. In research the student learns much about a very small area of science, but because of this method of learning, he appreciates more the kind of struggling someone experienced in order that each fact he learns in any of his courses is developed to the point that it appears in the student's textbook. Both student and faculy member acquire a really lively interest in the advancing scientific front. Research brings the faculty member and the student together in a relationship enabling the faculty member to transmit his Christian faith much as he would to his own child. Finally, we must admit that encouraging research in a chemistry department makes it easier to obtain new staff members. There are very many chemists who are Christians and who can help improve the scientific environment in a school who cannot be recruited if they are not encouraged to develop their students by the research method.

The question most frequently asked about undergraduate participation in research is, "Can they do it?" There certainly was a feeling on the part of some at the MACTLAC meeting that the research approach has been unsatisfactory. It is objected that the student's efforts in research replace effort he should be making in learning more chemistry. Some feel that helping the student takes too much of the faculty member's time from the project. Others think good projects are by their nature too difficult for the inexperienced. These are not necessarily "sour grapes" comments: the objectors have seen undergraduate research in action. A refutation of these objections should not be attempted. Rather, the problems raised are the very ones which are pitfalls for those who are over-enthusiastic. The writer feels that the student's problem should be small and of such a nature that he can really understand what he is doing. He should not, at least after the first few months, be merely a pair of hands. We ought to admit there are very many problems that are simply too advanced for this group. Time spent on the project should be time he would ordinarily not spend in study; this implies some kind of fellowship or assistantship.

Perhaps it is not unreasonable to expect that if there are undergraduates with dramatic, athletic, or musical talents exceptional enough to warrant public exhibition, that there are also undergraduates with original-thinking skills which can be developed enough to make it possible for these students to present original papers at some of the smaller scientific meetings. Recently the writer attended the South Dakota Academy of Science where, in the collegiate section, twenty-six undergradute papers were given. Here was proof of the major point of this essay. Some first-class original-thinking abilities were displayed. Small schools, without unusual facilities or support, and with average incoming students, evidently were successful in using this approach to teaching in chemistry, physics, biology, and mathematics.

One of these twenty-six students knew absolutely nothing of research at the beginning of the academic year, and yet this student accomplished a creditable piece of work. This student remarked privately that the research experience meant more than any course laboratory work. A revealing additional comment was, "One difference is that in the research lab the experiment *must* be repeated until you're sure you're right." Each reader will want to draw from that remark his own conclusion.

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