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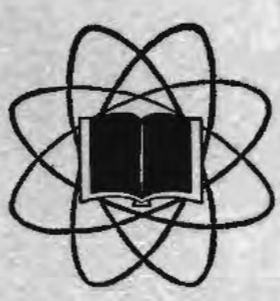

The fear of the Lord is the beginning of wisdom. Psalm 111:10.

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The American Scientific Affiliation was organized in 1941 by a group of Christian men of science. The purpose of the organization is to study those topics germane to the conviction that the frameworks of scientific knowledge and a conservative Christian faith are compatible. Since open discussion is encouraged, opinions and conclusions are to be considered those of the authors and not necessarily held by others in the organization.

PUBLICATIONS

The Journal of the American Scientific Affiliation is issued quarterly. Its contents include primarily subjects both directly and indirectly related to the purpose of the organization, news of current trends in science (including sociology and anthropology), and book reviews.

Modern Science and Christian Faith, is a 316-page book containing ten chapters on nine fields of science, each written by a person or persons versed in that field.

Evolution and Christian Thought Today, is a 221-page symposium by thirteen authors, expressing the attitudes of Christians on this subject a century after Darwin's writings.

EXECUTIVE COUNCIL

The Journal of the

American Scientific Affiliation

Table of Contents

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Introduction

Last year the American Scientific Affiliation sponsored the book, *Evolution and Christian Thought Today*, edited by Dr. Russell Mixter. This volume has been read by many thoughtful Christians and has received the recognition of *Eternity* magazine as the outstanding evangelical book published in 1960.

On February 17, 1961, several of the authors of this volume participated in a symposium entitled, "Origins and Christian Thought Today," sponsored by the Division of Science of Wheaton College (Illinois). It was the purpose of this meeting to consider the scientific evidence on the subject of origins as well as to discuss the various views of the interpretation of this evidence held by evangelical Christians. The divergence of opinion among attending scientists, as well as philosophers and theologians, was expressed in lively question and answer periods following the prepared papers and the panel discussion.

The members of the Division of Science of Wheaton College constantly assert their faith in the authority of the Lord Jesus Christ and the validity of the Scriptures. A belief that God's truth as it is found in the written Word must be consistent with His truth as it is revealed in the natural world stimulates their examination of scientific data and discussion of its relationship to Scripture. They appreciated the opportunity to consider these issues with the speakers in the symposium, even though the views expressed by the speakers were not necessarily those held by Wheaton College faculty members. They also appreciate the willingness of this Journal to publish the four main papers of the meeting. Reprints of these articles are available from Wheaton College, Wheaton, Illinois.

Stanley M. Parmerter
Chairman, Division of Science
Wheaton College

Origin of the Universe*

J. R. HUIZENGA**

In a scientific discussion of the subject, "The Origin of the Universe," one attempts to systematically reconstruct past cosmic events in terms of our present scientific knowledge. Any such discussion is launched from a philosophical or theological starting point which embraces certain presuppositions about the laws of nature and primordial matter, the so-called ylem.

Given the fundamental building blocks, it is of great scientific interest to attempt to explain the origin of the elements. It is this particular aspect of the "origin problem" which I shall emphasize. At present more than one hundred elements are known and on the average each element has about ten isotopes. This means that approximately one thousand different nuclear species have been identified. The present cosmic abundance of the elements is related to both the way the elements were formed and their age. In attacking the problem of the synthesis or formation of the elements, therefore, one must study the relative cosmic abundance of the elements in the universe. From a knowledge of the present abundances of the elements one can obtain clues to the history of the galaxies, stars, and our solar system, for the elemental abundances are a product of cosmic events.

Before embarking on a discussion of the cosmic abundances, formation and age of the elements I would like to outline briefly the magnitude of the known universe and our relative position in it. Only a few hundred years ago man thought he was living in the center of the universe. The earth in the Ptolemaic theory was stationary and the sun and other heavenly bodies were thought to be rotating about it. Copernicus dethroned the earth and gave the sun the central position in the universe. Digges and others made slight alterations in the Copernican theory, which at the time were thought to be rather minor. These new ideas, however, have led to important changes in man's view of the universe. The solar system does not occupy a central position in our galaxy, the Milky Way, but instead is located out on the edge of our galaxy which has a disklike shape. The Milky Way is 80,000 light years in diameter and about 800 light years thick. A light year, which is the distance light travels in one year, is equivalent to approximately

*Presented at Wheaton College Science Symposium on "Origins and Christian Thought Today," February 17, 1961.

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six trillion miles. A typical galaxy has a radius of 15,000 light years and contains about one hundred million stars which are approximately the size of our sun. In the average region of space the average distance between galaxies is about three million light years, and one considers two galaxies in collision when their centers are no more than 30,000 light years apart. Approximately one hundred million galaxies lie within the range of present telescopes.

One is interested in the abundances of the elements in various regions of the universe, although the determination of such abundances in faraway regions of the universe is a very difficult task. It is, therefore, only natural that our earliest information on abundance came from analyses of the crust of the earth, the ocean, and the atmosphere. Already in 1889 Frank W. Clarke read a paper at the Philosophical Society in Washington entitled "The Relative Abundance of the Chemical Elements." In this classical work an attempt was made to determine the abundances of the elements primarily from the earth's crust. Certain elements have preferentially diffused to the surface layer of the earth and the interior composition of the earth is undoubtedly much different than that of the surface.

As time passed it became more and more evident that meteorites were better objects than terrestrial rocks for the study of the average abundance of the chemical elements in nature. The paper by Goldschmidt on this subject is classical and still referred to in present literature. Meteorites are objects from outer space which strike the earth. Their origin, however, is thought to be from within the solar system. They are remnants of larger bodies in our solar system which have suffered collision. The advantage of analyzing meteorites lies in the fact that some of the meteorites are from the inside of the original body. These original bodies are probably much like the earth which is made up of core, mantle, and crust. As I mentioned before, samples of the earth have come, to date, only from the crust. Meteorite samples supposedly come also from the core and mantle of the larger body. We expect the stony meteorites to be comparable to the material in the mantle of the earth. It will be interesting to check this postulate. The project Mohole is an effort to drill through the earth's crust to obtain a sample of the earth's mantle. The elemental abundances obtained from meteorite analyses are thought to be representative of the solar system.

A third method of obtaining information on the abundance of the elements is to spectroscopically analyze the light from stars. This method has been extensively used to obtain the abundance of the elements in the sun. The logic of the method goes something like this. Nuclear reactions deep inside the sun produce light of all wave lengths, i.e., a continuum. As this light passes through the outer layers of the sun certain characteristic wave lengths of the light are absorbed by the elements in the sun. The particular wave lengths which are strongly absorbed by each element are known from laboratory experiments. The astrophysicist with his powerful spectroscope, a machine which analyzes the light, can determine the abundance of the elements in the sun by analyzing the residual light of the sun which reaches the earth. In a recent publication, the solar abundances were given for about 65 elements. If meteorites and the sun are both part of the solar system, they should have approximately the same elemental composition. Present indications are that this is the case except for light gases like hydrogen which will be chiefly present in the sun for energetic reasons.

The importance of the spectroscopic method lies in the fact that elemental abundances can be determined for stars other than our sun. One can go beyond our solar system to distant stars in our galaxy, the Milky Way. In addition, one can obtain information on elemental abundance in stars completely outside our galaxy. The method also allows one to measure isotopic ratios in certain cases. Isotopes are members of the same element with different mass. The mass change causes a small shift (isotopic shift) in the absorption wave length.

The fourth and last method which I will mention for determining elemental abundance is the rather new technique falling in the area of radio-astronomy. The earth receives radio waves from space as well as light waves. As I mentioned previously, when light from the incandescent gas in the interior of a star passes through the cooler outer layers of the star, the atoms of the cooler gas identify themselves by absorbing their characteristic wave lengths. These appear as dark lines against the bright background spectrum of the star. "Dark" lines can also be observed in the radio spectrum. One such line which radio-astronomers presently work with is the radio wave length absorbed by the cold hydrogen in interstellar space. One of the applications of this method at present is its use in telling us the hydrogen concentration in space between the stars and between the galaxies. The radio waves absorbed by hydrogen are 21 centimeters long. Waves of this length carry just the amount of energy needed to flip the single spinning electron of the hydrogen atom from a state in which its magnetic axis is opposed to that of the nucleus of the atom to a state in which the two axes are parallel.

Hydrogen is the most abundant element. In the solar system, 92.8% of the atoms are hydrogen, 7.1% of the atoms are helium. In terms of mass, hydrogen represents 75% of the mass of the solar system and helium 23%. This leaves about 2% for

the mass of all the other elements in the solar system. These results come from meteorite analyses and spectroscopic measurements of the light from the sun. The distribution of this 2% of solar matter among the other 99 elements is, however, a point of great interest and one which sheds light on the formation of the elements.

One of the most important discoveries in astrophysics is the recent observation that some stars have different elemental compositions. The variation in the elemental abundances of cosmic matter is such that young stars have larger concentrations of heavy elements than old stars.

For our purpose let us consider two extreme stellar populations, Population I and Population II. Population II stars are very old, have small heavy element contents and are distributed in a large spherical or ellipsoidal system in the galaxy. Population I stars, on the other hand, have enhanced heavy element content, are young and are found in a flat disk of the galaxy. Why is it that young stars have more heavy elements? Let us look at the life history of a star. The first phase of the life of a star is an accumulation of galactic dust which is contracting due to gravitational energy. As contraction continues the core of the star becomes very hot and hydrogen burning is the main source of energy. These stars are on the so-called main sequence of stars and our sun is a typical example. After the hydrogen in the core is depleted, further contraction occnrs, and helium burning begins. The star at this point is very hot and is known as a red giant. At this point rather drastic things happen to the star. It begins ejecting matter and may even suffer a major instability and explode. These exploding stars are called novae or supernovae. The difference between a nova and a supernova lies in the size of the explosion. A supernova ejects more than 90% of its matter back into intergalactic space. The energy liberated in one of these events is enormous compared to a hydrogen bomb. The remnant of the supernova is a white dwarf and this is considered the final state of the star. White dwarfs are often referred to as the graveyard of stars.

With such an efficient mechanism available for feeding matter back into space, it is of interest to examine these gigantic explosions in more detail. Each of these explosions can be represented as a giant furnace in which the elements of nature are synthesized. History records three of these events which occurred in onr galaxy. The earliest event was recorded by the Chinese in 1054 A.D. To my knowledge there is no record of this tremendous event in European history. The Oriental people were interested in astrology and kept a very careful rccord of the light intensity of this unusual star. All at once it became one of the brightest stars in the sky, and then it began to fade. The remnant of this explosion is known as Crab Nebula. Other such events happened in 1572 and 1604, the era of Kepler.

Excellent photographs of the appearance and fading of supernovae have been recorded. For a period of time following the explosion, a supernova is brighter than all the stars in its galaxy whidt in an average galaxy is about 100 million stars the size of our sun. The decay of supernovae have also been studied on a quantitative basis. The decay is unusual in that it follows the decay law of radioactive atoms.

With this background, let me ask again why the young stars have more heavy elements? Looking back into time, the old stars were formed at a time when few supernovae had occurred. With the passage of time more and more of these giant explosions have occurred. The observed frequency of Type I supernova is about one per galaxy per 300 years. Young stars were formed from intergalactic dust which contained the debris of all past supernovae in the galaxy. From these considerations it follows that young stars are expected to have more heavy elements.

Our most detailed information on elemental abundances comes from measurements of material in the solar system. The experimental abundances of the elements in the solar system decrease in an over-all way with atomic weight; however, there are a nnmber of local fluctuations. One of the tasks of the astrophysicist is to explain this structure in the curve obtained when the elemental abundances are plotted against the atomic weight. It is beyond the scope of this lecture to discuss in any detail the nuclear processes involved in element synthesis. I would, however, like to mention the neutron capture process. During the last ten years it has become particularly evident that element synthesis by neutron capture can follow at least two different paths which lead to rather different elemental abundances. One of these general paths is followed when moderate numbers of neutrons are available for long periods of time. This is approximately the situation in a nuclear reactor or in some of our stars such as red giants. Another rather different path of element synthesis is followed, however, when a large burst of neutrons is available for only a very short period of time. An example of a man-made device which produces a neutron burst of sizable magnitude is a hydrogen bomb. On the astronomical scale, it is thought that certain types of supernovae release enormous numbers of neutrons during a time scale of about a second.

Our experimental information on abundances of heavy elements can best be interpreted if both types of neutron sources contributed to element synthesis. The experimental elemental abundances should reflect the composition of the dust of our galaxy at the time the solar system was formed.

Except for minor changes due to radioactive decay and a small number of trace nuclear reactions, no significant changes in the elemental composition are expected to have occurred since the solar system was formed.

One piece of evidence for neutron fluxes of long time duration is the presence of technetium in red giant stars. The element technetium is not found naturally on earth since the longest-lived isotopes have half-lives of only a few million years, a period of time too short for them to still be present in our old solar system. The most reasonable explanation for technetium in the red giants is that the technetium is being currently produced by neutron reactions on the stable elements.

The most dramatic evidence for element formation from neutron bursts of short time duration comes from study of supernovae events. The observed decay curves of the energy of supernovae have the familiar characteristics of a radioactive decay curve, with a good possibility that such exotic elements as Californium are produced.

Any theory of element formation which attempts to explain the abundances of the nuclides in the universe has to account for the differences in abundances in various stars. In my opinion, such a theory will have as one of its important aspects the synthesis of elements in the interior of hot stars and during the more spectacular supernova events. The assumption often credited to Gamow, that all the elements were produced in a single catastrophic event of short time duration many billions of years ago is an oversimplified one. On the other hand the evidence is such that no positive conclusion can be reached on whether the heavy elements of our solar system were produced over a long period of time or during a single event prior to the formation of the solar system.

The age of the elements, rocks, earth, solar system, the stars in our galaxy, the Milky Way and other galaxies and the universe is in most cases a complex property of the system. A simple sweeping answer to the age question can without ample clarification lead to erroneous conclusions. The age of rocks on the surface of the earth are known to range up to approximately three billion years. This simply means that certain deposits have not been disturbed for long periods of time, and in terms of the age of the earth is only a lower bounds. Experimentation on meteorites has been interpreted in terms of the parent meteorite bodies crystallizing about 4.6 billion years ago. This age is commonly associated with the age of the solar system. The experimental age is related to the signal one uses as the initial time marker. This is usually the time at which the body is able to retain specified daughters of various radioactive nuclides. On the basis of retention of the gaseous element xenon, arguments have been advanced to show that the earth is about 200 million years younger than meteorites. Similar reasoning leads to a comparable interval of time between the solidification (retention of xenon) of meteorites and the last element synthesis. The last element synthesis is specified because the possibility exists that the elements of the solar system were not formed in a single "event" but over a long period of time in many "events."

The question can be raised whether the initial "ylem" was contained in a single, primeval, mammoth atom which exploded giving rise to an expanding universe. This subject is usually treated by also considering the opposing view of the steady state universe which advocates continuous creation of new matter. The two theories make very different predictions and lend themselves to experimental verification. The steady state theory predicts that the density of stars will remain constant in any given volume. The stars are receding from each other in the steady state theory, however, with the continuous creation of local matter the star density remains constant. The expanding universe leads to a reduced star density. The observed density of stars in distant galaxies should be greater than nearby galaxies on this view since the light from distant stars represents the situation as it existed billions of years ago.

The two theories also predict a different red shift. E. P. Hubble at Mount Wilson Observatory found the first evidence for the physical expansion of the universe. He correlated the distance of galaxies with the amount of shift in light toward the red end of the spectrum, and found the extent of the shift was in direct proportion to the galaxy's distance from us. The experimental information on the red shift of the light spectrum of near and distant galaxies is not good enough at this time to definitely favor either theory.

Just as the stars are sources of light, they are also sources of radio waves. The study of these radio signals is a currently exciting research field which offers tremendous potentialities in solving some of the unanswered questions of our universe. A recent press release indicates that a group of British astronomers have finally proved the expanding universe theory. This is a good note on which to close insofar that such a statement points out the fallacy of converting scientific results into popular statements. There is a considerable gap to jump between the recent experimental measurements of the intensities of radio signals from outer space and the conclusion stated in the press release. If the ability of the stars to transmit radio waves is not constant with time, then the press statement is untrue. Although our knowledge of the universe has increased very rapidly in the last few years, many puzzles are still to be solved and I'm sure the next few years will bring many surprises.

*Origin of Life**

WALTER R. HEARN**

Some of you may feel that I have a lot of gall to say some of the things I'm going to say this afternoon, so I may as well begin by rendering unto Caesar that emulation which is due him and divide *my* gall, like his, into three parts. (Now, Dr. Kraakevik told me this talk should be *semi*technical, and I assumed that the "semi-" part would cover puns as well as misinformation, but maybe I was mistaken.)

In the first part of my talk I want to discuss some recent technical developments pertaining to the origin of life; in the second part, a little about the attitude of scientists toward this kind of investigation—the "climate" in which this work is being done, as it were; and finally, I want to comment on the reactions of Christians to these matters. All of my remarks will be rather sketchy, a few of them will be impertinent (to stir up more lively response from you during the discussion later on), and what I say will of course bear the marks of my own personal orientation both as a biochemist and as an evangelical Christian.

You may be aware that some reviewers of *Evolution and Christian Thought Today* in the conservative Christian press have felt obliged to put that word, "evangelical," in quotation marks when referring to authors of some of the chapters, or to prefix it with the adjective, "so-called." I shall have an opportunity at the banquet tonight to speak more fully of my Christian experience, so may I suggest that you leave those quotation marks only tentative until after this evening, anyway? Now then, since none of the reviewers felt obliged to call me a "so-called biochemist," I shall proceed now to the technical discussion and you can all relax, knowing it is safe to follow me *that* far at least. (As a matter of fact, I hope most of you *can* stand the suspense of leaving me inadequately classified for a while—you're likely to get a lot more out of the talk that way. I've noticed that when a speaker addresses a Christian audience and they don't follow him at *all*, if they think he's a good guy they'll say "Boy, that guy is profound!"—and if they think he is one of the bad guys they'll say, "Well, he sounded sorta liberal to me!" In either case, if they've got him pegged, they don't have to bother to try to understand what he says. Well, this will be an *adult*-western-type talk, so hold on to your seats: it'll be hard to tell the good guys from the bad guys. I'll try not to spoil the plot by giving myself away).

Part I. (Technical)

The goal of *all* basic biochemical and biophysical research is increased understanding of the mechanisms of life processes: i.e., the translation of biology into the language of chemistry and physics. In a sense then, *any* advance in biochemistry is likely to shed some light on the scientific problem of the origin of life. If one concedes that the origin of at least *some* of what we think of as "life processes" may have preceded, or been concomitant with, the origin of life itself on earth, then learning the chemical details of *life* processes shows us what to look for in the *non*living realm so we can extrapolate intelligently back to the *pre*-living realm. Now, many exciting things are going on in fields such as intermediary metabolism, the study of viruses, and biochemical gentics particularly, which have a bearing on our ideas of the origin of life. Some of these have been spotlighted in the news, as when Severo Ochoa and Arthur Kornberg won the Nobel Prize for their work on the enzymatic synthesis of nucleic acids—work which should certainly make us ponder a bit before saying dogmatically that no possibility exists for the synthesis of new genetic material (which was said in a letter to the editor of *Christianity Today* a few weeks ago). In fact, I understand that in the discussion at the Darwin Centennial at the University of Chicago, H. J. Muller said that if the artificial "creation of life" could be defined as putting together a strictly chemical system that can synthesize new genetic material—well, then Kornberg has already done it! (I think this was regarded as a radical opinion, even in that environment.)

Another recent news story dealt with the complete determination of the sequence of amino acids in the protein of the tobacco mosaic virus—work which may be of particular interest to this audience because at least two of the men who did it are devout evangelical Christians, C. A. Knight of the Virus Lab at Berkeley and Duane Gish, now at Upjohn and Co. One of the most fascinating and still most frustrating problems of current biochemistry is learning how the genetic information, encoded in the sequence of four repeating bases in the nucleic acid structure, is "translated" into the particular sequence of twenty repeating amino acids

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which gives each protein its specific biological characteristics. The TMV work is important because in this case a single protein is presumably associated with a single nucleic acid molecule, and now we know the "code" on the protein part. We still cannot read the code on the nucleic acid part, which will require a tremendous amount of chemical work to unravel—and we may still be frustrated even then if it turns out that the nucleic acid code gets translated in the infected plant, not into *virus* protein, but into a *different,* still unknown protein, specifically the enzyme or enzymes which put together the virus protein. I emphasize this difficulty for the benefit of students in the audience who may get the impression that the really interesting problems in biochemistry are just about all solved, so you might as well go into some other field. STOP! DON'T JUMP! We are *looking* for new students sharp enough to come up with a way of cracking this nucleic acid code, of studying what goes *on* in an infected cell when virus particles are being synthesized, and of attacking a "host" of other challenging problems. In particular, *I'm* looking for some sharp graduate students, and I'll be happy to give you some literature to lure you into *our* department for your graduate training if you're qualified. If I should happen to miss contact with you, by all means write to me if you are the least bit interested.

I think the work you really want me to discuss, however, is the work aimed *directly* at the problem of the origin of life, and there is a considerable amount of this. I shall discuss some research not unrelated to the subjects I have just mentioned; as you can see we now have protein molecules which can catalyze the synthesis of nucleic acids, and there is plenty of evidence that the pattern for synthesizing specific proteins can be built into the structure of a nucleic acid molecule. There is still a huge gap in our understanding of the origin of *metabolizing* systems, i.e., complex enzyme systems in which endergonic (energy-requiring) reactions are coupled to exergonic (energy-yielding) reactions to give us a steady state not at thermodynamic equilibrium. However, I think you can see that if we *can* show that under conditions likely to have existed on the pre-biological earth, proteins and nucleic acids are formed chemically, then we have taken a big step in our understanding of the origin of life.

The significant work of Harold Urey and his student, Stanley Miller, in actually trying out some postulated primitive atmospheres to see what might happen, has been cited in my chapter in *Evolution and Christian Thought Today.* You will recall that a number of amino acids, the building blocks of protein, were found in the reaction mixture after those experiments. Since that time, a number of other investigators have continued along that line, and have shown that at least the simplest amino acids can be produced under a wide variety of relatively mild conditions. One effect of these findings has been to remove some of the restrictions, from the biochemist's point of view, on possibilities for pre-biological environments, still an area of some disagreement among geologists and geochemists. In a sense, whatever the environment, the origin of the building blocks of protein molecules has been settled.

With regard to the polymerization of these amino acids into proteins, there have also been some interesting developments. After many years of feeling that thermodynamic considerations would make this step essentially impossible, there is a rather sudden shift to thinking of it as highly probable. In fact, it has been shown that with HCN as an intermediate in the formation of amino acids (as in Miller's 1957 experiments), the *amides* of the amino acids are also intermediates, and we know that the energy barrier for polymerizing amino acid amides should be much lower than that for polymerizing the amino acids themselves. One investigator I know personally, John Oro of the U. of Houston, has shown that the amides can be polymerized readily under quite reasonable "primitive earth conditions." This might even make the amino acids *products* of protein-like materials via subsequent hydrolysis rather than their *precursors* under some conditions. (To put it crudely, you get to the chicken first, and then the chicken lays the egg instead of growing the chicken from the egg. That's about as crude as it can be put!)

Another investigator, Sidney Fox of the Oceanographic Institute of Florida State, has, however, also made a "breakthrough" in the polymerization of amino acids themselves into what he calls "proteinoids." (Incidentally, Urey and Miller are now attached to the Oceanographic Institute of the U. of *California,* so you can imagine what sort of rivalry goes on in this field between Tallahassee and La Jolla—but a public lecture is no place for gossip.) Fox tried thermal polymerization—i.e., just heating up a mixture of amino acids. Now generally, as all of us know who've ever left something on the steam bath too long by mistake, such a mixture is liable to give you a mess—"intractable tars" is the way you describe it in the literature (if you have to admit a reaction of yours went wrong somewhere). I'm not sure whether Fox actually looked this up *before* he planned the experiment, or whether one experiment worked and *then* he looked it up (and I was polite enough not to ask him when I talked to him about it this fall), but at any rate he noted that many proteins from widely varying biological sources contain relatively large amounts of the two acidic amino acids, aspartic and glutamic acids, so he loaded his amino acid mixture with these two and fired away. Whether

to his surprise or not, this time he came out with a nice clean product, not crystallizable because it represents a heterogeneous mixture of polymeric molecules, but certainly much more pleasant to behold than the red-brown gunks he and everybody else had always obtained before. Recently he has been trying variations on this theme, tossing in phosphoric acid as a catalyst, etc., and has also been analyzing the polymers which he can make in this way. They deserve the term "protein-like" in almost every sense of the word, having molecular weights of around 10,000, containing all the amino acids, being hydrolyzed by proteases, etc. One feature of Fox's work, or rather of his description of it, that annoys some people in the field is his claim for "morphogenicity" of his proteinoids. In his paper in *Science* last July, Fox showed a photograph of "microspherules" which were formed by his proteinoid products and described these as models of primitive cells; you don't have to be from California to think that might be stretching the point a bit for effect. However, I think Fox's experimental work is important in spite of some annoyance at the way he writes: he has essentially proved the point that protein structures *do* form at temperatures under 100°C from mixtures of amino acids. There is even some indication in his work that the sequence of amino acids in these thermal co-polymers is not entirely random—i.e., preferred sequence patterns may show up even this early in the game.

With regard to the pre-biological synthesis of nucleic acid precursors, there is also some interesting work by the same investigators. While heating up things, Fox put together some malic acid and urea, both reasonable components of "pre-biological soup," and found he had synthesized ureidosuccinic acid with unexpected ease; this compound is a known biological precursor of the pyrimidine bases of nucleic acids. More significantly, Oro actually has produced adenine, one of the two purine bases, merely by heating ammonium cyanide at 70° C for half a day. Furthermore, from the same mixture he also isolated 4-aminoimidazole-5-carboxamide, and imidazole groups are now generally conceded to do a lot of the business in biochemical catalysis. The carbohydrate components of nucleic acids can be obtained, everybody agrees, if you have a little formaldehyde in the soup. So . . . we are on our way, and more and more biochemists are getting into the soup—I mean, into the act.

Part II. (Less technical—wake up!)

The kind of *psychological* atmosphere in which this work is going on is pretty obvious, even if the nature of the ancient earth's atmosphere is still being haggled over. There is an air of exhilaration from the results of the few experiments already done that is bound to lead to new theoretical thought and subsequently to accelerated experimentation. This is the excitement of a "new frontier" (if I may use such a Democratic phrase on a protestant campus)—and the assurance that "thar's gold in that thar soup!" This enthusiasm over "pre-biological evolution" is getting more biochemists interested in taking a closer look at mechanisms for biological evolution—and biology is liable to perk up considerably as a result. If you were under the impression that evolution was about to blow over, I think you've misread the weather signs!

The extent to which these ideas permeate the thinking of biochemists not actually working in the field was brought home to me only a few weeks ago when a manuscript I had submitted to a journal was returned to me with a referee's comment. The paper was on a laboratory synthesis of delta-aminolevulinic acid, a known biological precursor of the porphyrins (such as the heme of hemoglobin), and we mentioned that even though the yield was poor our method had some interesting analogies to the known biosynthetic pathway. The referee commented that our method did throw some light on a possible *pre*-biological pathway to porphyrins, but why didn't we use succinic anhydride instead of the acyl chloride? The anhydride was much more likely to occur in a pre-biological soup! Well, we wrote back to the editor that we hadn't had pre-biological evolution in mind at all when doing the work; and besides, we *had* tried the anhydride first and it didn't work—gave us only "intractable tars"!

Part III. (Danger—this is philosophical!)

Well, I've used up my time, so maybe we just won't have a third part and you'll never know whether the speaker was a bad-good guy or a good-bad guy—whether he belongs in quotation marks or not. I *would* like to say a few words about some of the people I've mentioned who are working in this field, in case you have *them* pegged as bad guys, a snarling bunch of vicious anti-Christian types plotting to do away with the necessity for God, or something. Well, they are certainly not vicious, and hardly plotting anything except how to do tomorrow's experiment. They know some interesting questions, they've found out how to get some good answers, and they're having fun. If you think of this as the Lord's universe, then you should realize that these are the men who are having the fun of exploring it for you. You ought to get acquainted, you know? Last year at the Federation meetings I met Stanley Miller through John Oro and spent a marvelous afternoon talking about these things; he is a delightful chap. I don't know whether he has any strong feelings about Christianity or not; he may not even be aware of it yet as a live option,

although I did get a chance to identify myself as a Christian in our conversation. John Oro has at least come in contact with evangelical Christians—I was on his graduate committee. I have given copies of *Evolution and Christian Thought Today* to both John Oro and Sidney Fox. Fox is probably a thoroughgoing logical positivist with no concept of the supernatural at all, but as far as I could tell from a long discussion with him he has little interest in philosophical argument and none at all in undermining anyone else's position. He did say he would like to get people to *think*, but you can hardly blame him for *that*.

I know that Dr. Fox continually comes in contact with Christians, however—at least by correspondence. His work has been widely publicized in the popular press, and he told me he has a huge scrapbook full of letters, some highly emotional, some denouncing him for monkeying around with God's Word (he receives Bibles in the mail regularly), and some calling him a fool for denying God by trying to do something *anybody* knows only God can do.

Now I ask you, if *you* are an evangelical Christian, is that the way *you* would go about trying to witness to Sid Fox?

I hope not. That's not the way I'm trying to go about it, anyway. Thank you.

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Summary of Comments by Walter R. Hearn, Wheaton Science Symposium Panel Discussion

February 18, 1961

In my talk on the "Origin of Life" I tried to point out that the success of recent chemical experimentation in this field has had a profound effect on scientific thinking: events interpretable as filling in the gap between nonliving and living systems are now regarded as being highly probable. At both the pre-biological and biological levels, there is great interest in *The Molecular Basis of Evolution* (see book with this title by C. B. Anfinsen, published by John Wiley & Sons, 1959).

Christians have sometimes taken refuge in the Second Law of Thermodynamics to argue against the evolution of complex living systems from simpler systems (R.E.D. Clark, for example). I consider this type of argument entirely invalid, and generally based on a misunderstanding of the Second Law. There is abundant evidence that local order can be produced in a system in which the general trend is toward disorder, as required by the Second Law. (For entertaining discussions of the "order from disorder" principle, see H. von Foerster, in *Self-Organizing Systems,* edited by M. C. Yovits and S. Cameron; Pergamon, New York, 1960.) Christians need not be upset by this idea if they are willing to focus their attention on God's universe as a whole, instead of only on minute parts of it, such as themselves. There is no less majesty in the view that the marvelous complexity of our bodies and minds was actually structured into the original creation, than in the view that there are limits to what God's matter can accomplish under His steady direction. I think there is also no reason in this view to think that God is any less personally interested in us, or that the Bible is any less His Word revealed to us.

However, many Christians have gotten into the habit of thinking of God's direct action in nature as *always* of a sudden, instantaneous type—*never* a steady type involving processes which could be studied by the scientific method. "Processes" are considered "natural" and iustautaneous eveuts "supernatural." This sort of thinkiug inevitably leads one to a "God of the gaps" philosophy, no matter how sophisticated he may be about the nature of the present gaps. I am for a "Science of the gaps"—that's exactly what science is for, to fill in gaps. I am also for a "God of Creation," who is involved directly in all natural processes (See W. B. Pollard, *Chance and Providence,* Scribners). I am baffled by the idea that God is "in" some events more than in others. An illustration in the spiritual realm: In what way was God involved in our becoming a Christian—in our own "New Birth"? Only at the "instant" of that birth? What a strange

view! Surely He guided us to Himself through the influence of others, the testimony of His Word, etc. And if so, then surely in the chain of events that led to our physical birth (and what a chain of events, stretching back centuries while God protected our germ plasm in the bodies of our ancestors—and even beyond that), in the preservation of the Bible, and in all the other events that eventually brought us together in Christ. Why pick out only the event that is particularly dramatic to us personally and say "*This* was God's doing!" Why not get in the habit of seeing God's creative handiwork in *everything* that happens? Only then can we honestly call ourselves His creatures, and Him our Creator, for surely we know that processes have been involved in bringing *us* into existence. Why shudder, then, at the idea that processes were involved in bringing Adam into existence? Granted that we do not yet know details of the processes, why may we not assume that God *did* use processes?

This outlook probably makes me a "General Creationist" rather than a "Special Creationist" (see my letter to *Christianity Today*, "Evolution Revisited," September 29, 1958), but gives me no less reverence for Genesis as the revealed Word of God. I cannot understand why people are disturbed at my statement that "The expressions in Scripture regarding the creation of life are sufficiently figurative to imply little or no limitation on possible mechanisms" (Chapter 3 of *Evolution and Christian Thought Today*). Genesis says that God breathed into Adam the breath of life, and he became a living soul; surely no one would question that "God breathed" is highly figurative, anthropomorphic, symbolic language (and I hope no one would be so immodest as to say he knows exactly what the figure of speech means!). To say that I don't take this passage literally—i.e., that I don't think the Creator exhaled through mouth or nostrils—does *not* imply that I don't take the passage *seriously;* I regard it as true, as God's Word, as intended to reveal something about God to me. In addition, I think it is a beautifully poetic expression and I value it for this reason as well. Biochemical descriptions of God's creative activity are almost invariably more complicated and less beautiful.

*Comments on the Origin of Species**

J. FRANK CASSEL**

Introduction

As we move in our thinking from the origin of the universe—to the origin of life—to the origin of species—to the origin of man, we move into a more and more charged atmosphere. We are moving into the areas encompassed by what is usually referred to as *evolution*. "The lover of paradox," says Bertalanffy (1952), "could say that the main objection to the selection theory is that it cannot be disproved." This statement gives us a hint as to the nature of the data we are discussing.

In the fall of 1959 the centennial of the publication of Darwin's *Origin of Species* (1859) was celebrated at the University of Chicago. Only recently the proceedings of these meetings, including lectures, papers, panels, and general discussions, have been published in three large volumes (Tax, 1960; Tax and Callender, 1960). These volumes summarize what is known about the subject of evolution and what some of the greatest minds of our time are thinking about it. Volume I, the largest, in 629 pages and 20 papers, deals formally with the subjects Dr. Hearn and I are discussing. Obviously we cannot do the field justice in one hour.

I have not had these volumes long enough to be able to summarize them for you. It was only this morning, in fact, that I came across a paper (Olson, 1960: 523-545), which questioned what I had felt was the generally if not universally accepted trend of the field. If then my presentation seems somewhat disjointed, it is partially because I have not yet adjusted my own thinking to these new ideas—I have seen my paper for this afternoon—as it were—go up in steam.

What *is* our purpose? What *can* we do here? It seems to me that the advantage of a gathering such as this is to find out what is being thought—to assess the facts that we have—to assess the interpretations of these facts not only in the light of themselves but in the light of the presuppositions that we make. I don't want to stand here today—in fact I'm not able to stand here and tell you what you should believe. But I think that here we can exchange ideas and thus come closer to a recognition of reality.

Over a hundred years ago (1831-36) Darwin sailed around the world in the Beagle. A short time after that, he tells us in his introduction to the *Origin of Species* (1859 (1909:21)) he began to

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keep notes—and after five years, he says, he allowed himself to think about what some of these observations might mean and two years later (1844) sketched some conclusions. It was some 15 years after that that the *Origin of Species* was published. I beleive the *Origin of Species* had the influence upon the biological and the rest of the world that it had, because of the intricate documentation that Darwin gave, showing the background of his ideas—stimulating other people to take this data and see what they could get out of it—stimulating others to find out more data and see how it would correlate. And so for a hundred years in various disciplines this has been done. Thus a great body of data has been accumulated, which formed the basis of the Chicago discussions and forms the basis of our discussions today.

Definitions

Origin

"Origin" or "origins" may be self-explanatory. This is not the key word in our discussion. Origin refers to the beginning. Where did something start?

Species

"Species" is defined in various ways. Perhaps the problem is best summarized by Mayr (1956) when he points out that there are three different species concepts.

1. Species can be thought of from the standpoint of a *type*. A biologist describes an animal. He says, "Hereafter this species will consist of all animals which are like this animal which I am describing which I will deposit in this museum." Thereafter a decision must be made with respect to any unknown animal as to whether it is enough like the one on deposit at the museum and like the original description to be called the same species, or whether it's different. This is the classical idea of species.

2. A second idea of species is based on *concept*. (This is my own term, not Mayr's.) It suggests that if we say "robin," for instance, each one of you in your mind gets a picture of a robin. It isn't a particularly detailed technical picture, but at least you know what a robin is.

3. The third view of species we call *biological*. This one is most useful in the discussions we are having. The biological species is conceived as a group of animals having a certain genetic make-up, the elements of which can be passed on to their offspring maintaining essentially the same genetic make-up. Hence, a species is a group of naturally occurring populations which freely interbreed at the periphery of their ranges (where they come together), or are potentially capable of doing so. Or, briefly, a species consists of those animals which freely breed with one another.

The division between species comes then when interbreeding cannot occur for some reason or other. This would seem rather easy to observe. But we find that there are some organisms which are partially fertile with other organisms. We also find organisms which are identical in their morphology and their external appearance, but cannot interbreed. We find other organisms which look very different in their outward appearance, but which do interbreed freely. We find all the spectrum in between these. So this is not an easy criterion.

Kind

What does "kind" mean as it is used in Genesis? I am not posing as an authority on this but in discussions that I have seen of this word it is taken often to refer to a certain category of organisms (Mixter, 1951:3; Bullock, 1952; Payne, 1957), but not consistently to any specific biological category. Oftentimes, I think, we create a problem by saying (or thinking) that "kind" *must* refer to "species." Undoubtedly "kind" sometimes *does* refer to species. But "kind" also may refer to other groups, perhaps to genera, perhaps to families, perhaps to higher categories. So that it is not accurate, it seems to me, to restrict the use of "kind" to *species*.

Origin of species—how could it take place? Darwin suggested, arguing from indirect or circumstantial evidence, that it seems as if it has in some cases by natural means. We know a great deal more about the possible mechanisms by which species might be formed than did Darwin. Our knowledge of chemistry is much greater (Hearn, 1961). What are these mechanisms whereby species could be formed? Is there a mechanism whereby organisms which can at one time freely interbreed might at another point of time not be able to interbreed? If such a situation can be shown to obtain, then we can say that *species* have been formed and that *speciation* has taken place. And the word that we use in the field to talk about this is *evolution*.

Evolution

Evolution means a number of things to a number of people. I raised my eyebrows when I saw that this symposium was going to be on "Origins and Christian Thought Today." We're talking about the book, "*Evolution* and Christian Thought Today" (Mixter, 1960). Perhaps "origins" is a much better word, because we all are in fair agreement as to what it means. On the other hand, practically every one of us has a different idea of what the word "evolution" means.

Indeed the word does have several meanings which are currently used in scientific or other literature. Some of the main ones follow.

1. Evolution is the process whereby all life has developed by mechanistic means *without God* from single cells or primordial protoplasm to all the different forms we have today. But with such a definition (equating evolution with atheism), if this be the only one allowed—as many affirm—we as evangelicals are left with no satisfactory word to use to

describe the phenomena relating to species formation, phylogeny, and similar scientific data.

2. Evolntion is the general theory that life as we know it on earth today has over a long period of time been developed by differentiation from a single or several primordial cells; descent with modification.

3. Evolution is any change in plants or animals which can be passed on to their offspring. Many writers say or infer that such changes must take place "in natural populations" to get away from the discussion of the significance of changes due to controlled breeding practices. Mayr (1959) puts it, "Organic evolution . . . refers to a change in genetic properties from generation to generation owing to reproduction." It is this connotation of the word which is most commonly intended, when modern writers discuss evolution in action. According to this concept evolution can be either progressive or retrogressive. In other words, the change may go toward the complex or toward the the simple.

4. One thing that evolution does not mean is that man descended from apes. The word may be used to refer to the idea that man and apes may have descended from some common ancestor. But straight line descent from anthropoid ape to man (or any other straight line descent) is no longer inferred.

I have often seen the word "evolution" used in the same paragraph in the same article several times with a different connotation each time. Therefore it is very difficult to talk about "evolution" and to understand just exactly what we mean when we're talking about it.

Speciation

What do we know more than Darwin knew about the formation of species? We know about genetics. We know something of the intricacies of cellular structure. We know much of the biochemistry of the cell, particularly of the nucleus. We know something of the operation of the particular factors which seem to influence the heredity of the organism.

Mutation

Although not all heredity is due to nuclear components, there being some cytoplasmic genes, "Synthetic Evolution" (Olson, 1960:527) is based mainly upon the concept of hereditary characteristics which are governed by those factors in the nucleus known as "genes." These genes can and do change. These changes we call "mutations." A mutation is a change in a factor governing the heredity of an organism. This can basically be explained as change in chemical structure.

Isolation

In a population of freely interbreeding organisms in nature a change within one organism is not likely to affect the population nnless something happens to favor the maintainence of this particular change. There are so many other genes in any group, or gene pool as we call it, that one mutation in and of itself has no effect npon the population, because the mutant gene does not often even come into enough abundance to be seen, that is to effect an observable change in any organism. In artificial breeding, if we find a characteristic in a plant or animal which we want to keep, we then separate or segregate this individual and breed it only to other individuals which have other characteristics whch we want to keep. In other words, these individuals have to be *isolated*. In the process of speciation (species formation) in nature, this is another necessary factor. The population must be so small that mutations will be maintained because the mutant genes form a significant portion of the genes in the gene pool.

Natural populations of organisms may be isolated or separated from other such populations by geographical barriers such as mountains or rivers, by habitat preference, by climatic responses, and eventually by morphological or physiological differences. Species, however, are not formed until reproductive isolation is developed, that is until the separate populations are no longer even potentially capable of interbreeding. There are numerous examples of this occurring in nature. Perhaps the most striking one is the circumpolar distribution of overlapping populations of gulls of the Herring Gull-Brown Gull complex. In Scandinavia the Brown Gull does not interbreed with (is reproductively isolated from) the Herring Gull and yet each population does freely interbreed with adjacent populations all round the pole in a continuous ring broken only where the Brown and Herring Gulls maintain distinct populations where they overlap in northern Scandinavia. (See Mayr, 1940).

Selection

In artificial breeding, we select for those factors which we want. Darwin suggested that this same thing happens in nature. With the proper isolation, selection can be achieved. He suggested that if any change in the organisms was of particular advantage to that organism, this would give that organism greater strength to carry on its life than if this change had not occurred. Actually it does not appear that great advantage is a necessity for the effective selection and development of a characteristic in an isolated population. It is obvious that if any change occurs in a plant or animal which is of disadvantage to it, that individual is not likely to exist or reproduce as well as it would otherwise. (The human species is an exception, because much of our medical work maintains life in those individuals that are not as well adapted to the environment as others). On the other hand, in nature, if there is a change within a small popula-

tion which is snfficiently isolated, this change can be maintained without any great advantageous selection. But if there is a factor which is of advantage to the existence of the organism so that it breeds more freely or produces more offspring which then contain these same genetic characteristics, this particular genetic characteristic is likely to be developed with a greater frequency than those which do not have such an advantage. It is usually held that such changes are quite slight (microevolution) and that it may take several to effect much visible change in the individuals of a population. It should be remembered, too, that speciation is not accomplished until reproductive isolation is established no matter how great or how little the other changes involved. This then very briefly, and sketchily, delineates the thinking at the present time of those who hold to the "synthetic theory." I have pointed out elements or mechanisms which must be considered by anyone contemplating on how changes might come about in populations of organisms.

In the paper I came across this morning, the author makes a point which is seldom emphasized. In our present state of knowledge he suggests that it is presumptuous in the face of a *variety* of interpretations of the data to hold that there is only *one* interpretation possible. "The statement is made, in effect, that those who do *not* agree with the synthetic theory do *not* understand evolution and are incapable of so doing. . . . Regardless of the apparent merit and strength of the synthetic theory, it seems to me that the more cautious and thoughtful attitudes . . . are more appropriate" (Olson 1960:526, 527). He then gives the several theories which must be considered.

In addition to the (1) *Synthetic theory,* he lists: " (2) *Saltation theories,* involving major, abrupt reorganizations . . . ," which hold that many changes in plants and animals are not minute but are rather large—large jumps can take place, changes which would be of great magnitude – macroevolution (Goldschmidt, 1940); (3) *"Metaphysical theories,"* calling upon some force outside or inherent in the organism which will govern and guide the changes which take place; and (4) *"Lamarckian* or *Neo-Lamarckian* theories, involving inheritance in one way or another of acquired characteristics"—the concepts involving the idea of use and disuse being controlling factors in the development of certain characteristics.

Olson inclndes the alternative of a *Metaphysical Theory of Evolution.* The discussion which we have here at this symposium wll he along the lines, I hope, of developing in a sound way some real contributions to this alternative. This, ladies and gentlemen, I suggest is our challenge as evangelical Christians. May we stop shadow-boxing. May we stop finger-pointing. May we be careful not to fall into the same fallacy for which Olson chides the synthetic evolutionists. From our Christian presuppositions of the creating and sustaining God, may we work eagerly to develop without apology an explanation for the biological phenomena which we see in the universe. Particularly with regard to the phenomenon of speciation, or the origin of species, should we do some of our most careful observation and our best thinking so that we can prepare as accurate and true a description of the reality as presently possible in the light of presently discernible revelation.

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Christian Thought Today—On Origin of Species[*]

J. FRANK CASSEL

I find myself this morning in a more accustomed role—a role I'm more at home in—that of a heckler. (Let me say in passing that some have objected to my use of the term "heckler" on previous occasions. In my use of the term I connote nothing evil, no criticism. I think this is the way we stimulate thinking—at least it's the way I'm stimulated. So

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when I use the word, I mean "thought provoking.")

Yesterday I had a chance to establish the positive side of what we know about the origin of species and last night a positive approach to a Christian philosophy of science. I don't think I need to expand this morning upon this aspect. Rather I would like to ask some questions—questions which I feel we as Christians must approach and deal with positively in our consideration of evolution—or admit we don't have enough data to answer and indicate that we are withholding judgment.

1. Speciation can be seen in action—in Drosophila, the fruit fly in both the lab and in nature, in moths around smoky cities in the British Isles, in frogs, in herring, gulls, etc. What are its limits? Some are content to point out that changes are only at the species level or at the family category at the most. Is this really true, or is our data simply too limited by virtue of time restrictions? But even if it is so at present, what are the implications? Does it not indicate at least that this is one of God's methods of creation? Might it be the only one?

2. Is a time difference necessary between creating and sustaining? Some hold (e.g., Tinkle, *J. Am. Sci. Affil.* 13:15-17, 1961) that God's creative work is finished—that He is now in His seventh day of rest. Is this what the Scripture really teaches? If so, then speciation cannot be held to be creation.

3. In understanding the first chapter of Genesis, what of the sequence problem? If we hold to the creative days being a period of geological time, then we have particular trouble explaining the sequence of events on days 3 and 4. To review, the creation sequence briefly is as follows:

Day I —Light
Day II —Firmament
Day III —Earth, and plants (including Angiosperms - "seed bearing")
Day IV —Sun, moon, and stars
Day V —Aquatic life and *birds!*
Day VI —Cattle, creeping things, beasts, and man

It can be seen that plants, including the most complex forms were created before the sun. To be sure there was light on the first day—but what was its source? How strong was it? And in a heliocentric solar system, what of the earth before the sun? On day five, compared with the fossil record, how do birds fit before "creeping things" for instance? I do not mean to indicate, let me emphasize, by asking these questions that they are unanswerable. Nor do I mean to throw doubt on the Scriptural account. I simply mean that these are questions which have to be faced and handled in a sound and scholarly manner. Let me say again, as I did yesterday, that I am not questioning the authority of the Scripture, nor that God is speaking in it—our question is "Just what is God really saying"—but I'm getting ahead of myself!

4. In understanding the fossil record, what of the sequence problem, particularly in the vertebrates? In the Cambrian, the first fossil-bearing beds of any significance as far as number of organisms are concerned, are found representatives of all the major phyla—except chordates! Then briefly the sequence in time shows fish being the earliest vertebrates found, later amphibians, still later reptiles, and then (although there is some discussion just when) mammals and then birds. And the earliest birds have teeth and tail vertebrae—like a feathered lizard's tail. Some more recent birds had teeth but no tail vertebrae, while modern birds have no teeth and no tail vertebrae. Why this sequence of creation or how *did* it come about? To be sure we have trouble affixing ancestory, particularly for classes as in mammals—but we do have the sequence to explain.

It should be recognized also that there are many problems inherent in our present methods of dating and of assigning and defining taxonomic categories.

5. Natural processes, as we pointed out last night, are God's processes, hence in a manner of speaking "supernatural." Is the miracle of birth (and of the life that follows) any less miraculous than the second birth? Does God not use His own methods? I'm more and more impressed by the wonder-working hand of God in all things—why pick out only the rare occurrences to give Him the glory? And because these occurrences are rare does not necessitate a different method of operation or sustaining—simply a point of time occurrence and perhaps a speeding up or acceleration of process. In other words, I expect the wine at Cana was alcoholic, and that it could have been chemically analyzed as such—and because molecules of water changed so that there were molecules of alcohol—God working with this material—His creation—to achieve His ends. Is this not the daily course of things as well?

I've always promised myself that I would work up an opening lecture in zoology in which when I discussed biology as the study of life, I would include eternal life in the consideration. I haven't yet figured just how to do it well, but I think it illustrates the point.

6. Let me reiterate what we said last night. The Bible reveals God. The universe reveals God. Each can be used to interpret the other. They cannot, as far as I can see, be contradictory. This use of creation to interpret Scripture, does not question the authority of the revelation—simply the authority of the *interpretation*, for example Scofield's much-used notes. These are often very helpful, but they are not Scripture, and they do not deserve

being accorded the reverence, authority, or infallibility of the Word itself. God speaks in the Bible. God speaks in nature. What is He saying?

7. Someone else has mentioned Carl Henry. In writing on this subject several places, Carl has said that to be a Creationist one must believe in three principles,

a. Creation in divinely graded stages of living organisms
b. Creation by fiat command
c. Creation *ex nihilo*—out of nothing (Henry, *Christianity Today 2* [23]: 20-22, 1958)

I suppose I must go along with the first in the light of what I've been saying. If there are levels or stages—categories of living organisms—and there are—then certainly God did it.

But I do not see at present the necessity of "fiat command" in the sense that "Let there be" demands instantaneous, point of time appearance. Can it not possibly mean "Let there become"? This is a question to be answered from the context and connotation of the original language to be sure. Does this really restrict the connotation to "fiat"?

Nor do I see the necessity for *ex nihilo*. This seems a problem perhaps in logic, or as Dr. Buswell points out in realms of theology in which I am not versed. It has seemed to me that God possibly created out of Himself. Col. 1:17. God the Almighty, All Powerful—is a God of all energy. Might $e = mc^2$ be a *creative* formula?

Here I need the Hebrew scholar and the theologian to point out to me where I'm off base and this I think is the advantage of symposia such as this one. Might I suggest further that in the light of these discussions, the next step might be (and it might logically be sponsored by Wheaton) to get together a smaller group of authorities by invitation, to sit down together in a retreat situation, for two or three days or more, toss these ideas back and forth, come to such understanding as is possible at present and summarize their findings for publication and hence wider and more extended discussion. Missouri Lutherans have been using this technique effectively, I believe—for example, "What, Then, Is Man" by Paul Meehl, *et al.* (Concordia, 1958).

Well, that's enough of a heckle for now—but seriously I feel these are all questions which have to be faced if we are to demand the ear of a thinking world.

*The Origin of Man, and the Bio-cultural Gap**

JAMES O. BUSWELL, III**

I.

It is indeed significant that the planners of this symposium have directed the focus of attention upon origins. They are to be congratulated for thus precluding continuing confusion over the details of evolutionary process. For it is largely the genetic and geological processes of life and earth history with which evolutionists have dealt. Thus it is within these areas that the most scientific progress has been made, and concerning which, consequently, there has been a decreasing basis for argnment. But with matters of origin, evolutionists have been admittedly hesitant to deal. The noted physical anthropologist William Howells wrote sixteen years ago,

> We are totally bewildered, of course, about the beginning of life and the reasons for our existence, and these are questions which have been grist to the mills of philosophers and mythmakers alike. But we know, roughly, what happened along the way, and that is the story of human evolution.[1]

Recently, however, there has been increased interest shown in the problems of origins, and, as one might expect, it has served to bring into unprecedented prominence the significance of one's philosophy of science. In another context, but with far-reaching application, Dr. J. O. Buswell, Jr., speaking here before the recent annual philosophy conference, pointed out that

> . . . Whereas 35 years ago Christian thought was most seriously challenged by the natural sciences, the crucial problem today is philosophy.

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1. Howells, 1944, p. 3.

This is, in part, due to the fact that large segments of evangelicalism have paid increasing attention to what may be called true scientific progress, and have broken away from the straight jacket of certain interpretations of Scripture which ran headlong into conflict with factual scientific data. It is also due to the fact that, with Bible-believing scientists taking an active part in this scientific progress, the focal points of concern have shifted from a broad, over-all question of science vs. the Bible, or evolution vs. creation, which led inevitably to a high degree of fruitless controversy, to a much finer focus upon problems of positive interpretation with basic creationist presuppositions. Thus in the volume which has stimulated this symposium,[2] it is clear that Schweitzer is not attempting to debate *whether* God created the universe but *how* God created it; and that Hearn and Hendry are not examining *whether* God created life, but *how* God created it. Thirty-five years ago, and less, it would not have been likely that a fundamentalist, doctrinally speaking, would have found himself able to state, as Schweitzer does, that there is no conflict between the best scientific theories as to *how* the universe came into being, and the Biblical view (p. 50). Nor could it have been admitted, as Hearn and Hendry stated, that "The expressions in Scripture regarding the creation of life (are) sufficiently figurative to imply little or no limitation on possible mechanisms" (p. 69). Thus it is not the natural sciences themselves which challenge Christian thought today, but it is the underlying naturalistic and mechanistic philosophy of their leading practitioners.

With reference to considerations of the origin of man, the situation is found to be the same. It will be unnecessary to review here the differences between the interpretations of man's origin from a naturalistic point of view, as contrasted with the creationist, or supernaturalistic approach. Suffice it to say that it is not necessary to quibble with the evolutionist over any of the data pertaining to prehistoric man, in order to maintain a sound Scriptural position which does not jeopardize any of the conservative doctrines such as the creation of a single pair of humans, their original perfection and subsequence fall, and the unity of the human race. One's interpretation of this data will depend upon one's underlying philosophical presuppositions. Indeed, there is perhaps more active debate today over the exact interpretation of man's origin *within* creationist circles than there is elsewhere.

II.

Turning now to an examination of some of these problems, it will be remembered that in the chapter on prehistoric man[2a] in the Mixter volume, we came to certain tentative conclusions regarding the interpretation of the Australopithecinae, the so-called South African man-apes, in the context of a consideration of the question, What is man? These conclusions were that "so far no definite indication of any cultural assemblage has been identified" in connection with these types, and that, "should such a cultural assemblage be identified for the Australopithecines, it will necessitate perhaps a drastic revision of what we are used to considering 'human' but nothing more as far as the creationist position is concerned" (p. 187).

Even then mention should have been made concerning stone tools which had indeed been discovered *in situ* in deposits which also contained the remains of Australopithecus. These had been discovered by C. K. Brain in 1956 at Sterkfontein and were reported by the British paleontologist Kenneth Oakley the following year as proving "that pebble tools were made at the very site where Australopithecus occurred."[3]

There remained, however, some doubt as to the likelihood that the man-apes were the manufacturers of these tools. Brain himself reported in 1958 that no trace of the stone culture existed in the lower levels of the deposits where most bones including Australopithecus were accumulated.[4] Oakley felt that since the pebble tools thus ". . . have no background . . . at this or any other Australopithecine site" that judgment must be reserved. Although more stone pebble tools have been discovered subsequently at two other sites bearing Australopithecus remains, there is no proof that these animals made them. Oakley's expression regarding the 1956 discovery, which he considered "possibly the most important discovery in the field of paleo-anthropology since the finding of implements with Peking man," was almost identical to our own conclusion, as he stated that, "If in fact Australopithecus was the maker of the Sterkfontein tools, it would involve almost a revolution in our conception of 'man.' "[5]

Parenthetically, it should be emphasized at this point, as the British anatomist LeGros Clark has pointed out, that in using the terms "man" and "human" we tend to think only of modern man. But the terms must be taken to include extinct races such as the Pithecanthropus and Neandertal as well. As LeGros Clark puts it, "the terms 'man' and 'human' have come to assume, by common usage, a much narrower and more rigid connotation, which for most of us (however we may try to persuade ourselves otherwise) also involves a real emotional element."[6] If we could divorce from our

2. Mixter, R. L. (ed.), *Evolution and Christian Thought Today*. Grand Rapids: Eerdmans, 1959. London: The Paternoster Press, 1960.
2a. Buswell, 1959.
3. Oakley, 1957, p. 441.
4. Sabels, 1959, p. 248.
5. Oakley, 1957, p. 443.
6. LeGros Clark, 1955, p. 6.

thinking any preconceived notions of what man *should look* like, discussions of human paleontology might involve less strain on our powers of interpretation. As I mentioned in the chapter under review, "I believe that the question of human or nonhuman cannot be answered categorically upon morphological grounds. The question must be answered on spiritual grounds, which, I presume, are only indicated by cultural remains" (p. 187). The noted paleontologist Franz Weidenreich some years ago made the same point in a remarkably parallel fashion, although his reference to "spiritual life" applied merely to his German conception of man's mentality and culture. He wrote that

> . . . studies made on skeletons alone will never enable us to make statements about either the mentality of the individuals concerned or about mental change or progress over a period of time. Cultural objects are the only guide so far as spiritual life is concerned. They may be fallacious guides, but we are completely lost if those objects are missing.[7]

Raymond Dart, discoverer of the first Australopithecus fossil, has noted recently in an article describing the rather extensive use of bone weapons,

> It is important to recognize that one of the outstanding effects of the South African man-apes upon physical anthropology has been to display its limitations in assisting us to define what is man and what is ape anatomically.[8]

That is why the consideration of the Australopithecine weapons and tools is a crucial one. To the anthropologist the manufacture of tools in distinguishable traditions becomes the archaeological hallmark of mankind. It must be remembered, however, that these pebble tools which are found elsewhere widely distributed over Africa at this early pleistocene horizon do not show any distinct variation of tradition or style or method of manufacturing such as we have become accustomed to identifying in connection with the undisputed prehistoric culture complexes elsewhere in the world beginning only slightly later. As J. Desmond Clark, paleontologist from Southern Rhodesia has pointed out, "The stone tools of this time show no significant typological variation from one end of the continent to the other."[9] This, together with the total absence of any more conclusive cultural associations in the comparatively extensive recovery of Australopithecus remains, such as the use of fire, would seem to warrant a certain degree of caution in assigning them a completely human cultural status.

The recent discovery by Dr. L. S. B. Leakey of an Australopithecine skull in the summer of 1959 in Tanganyika, however, prompts us not to make too permanent a place for the South African man-apes on the nonhuman shelf. Here, about 22 feet below the surface of Bed I, the earliest cultural horizon exposed in the famous Olduvai Gorge, was uncovered a part of a living floor of Oldowan culture, stone tools of that culture, and the nearly complete skull of a manlike primate which Leakey and others described as "Australopithecine." With the tools was a hammer stone and waste flakes from the manufacture of them. These pebble tools had long been know at this site, but there had been no evidence of their makers. Clark Howell of the University of Chicago, who examined the find shortly after discovery has written that "it is clear that an Austarlopithecine group was responsible."[10]

The Australopithecines have not generally been considered directly ancestral to later Hominids despite their marked physical resemblance such as dentition and bipedal locomotion, and despite their certain classification, morphologically, with the Hominids rather than with the Pongids, or great apes. The reason for this has been that they occur too late in time. Pithecanthropoid man is found soon afterward in geological time, if not contemporary with some of the Australopiths. Thus it has been held that processes of racial or evolutionary differentiation could not have produced the former, with its yet marked morphological differences, from the latter. This position on the Australopiths is expressed by Ashley Montagu when he concludes,

> In the present state of our knowledge one can only point to the Australopithecines and say, that while no one of them may have been directly ancestral to man, a type very like them must have been.[11]

III.

In view of these recent, fast-moving, and important developments in African prehistory, activity in another and vastly more important area of concern has been stimulated as never before in anthropology and related sciences.

Man has been the central subject of anthropological concern. Since the underlying basic assumptions of man's origin which have held sway for most anthropologists have been those of organic evolution, it has followed that physical anthropology has traditionally carried this study to its greatest refinement in its attention to the variations of man's body in time and space, and to corresponding refinements in the related sciences of genetics and geology. Early attempts of cultural anthropology to view man's culture in evolutionary

7. Weidenreich, 1948, in Washburn and Wolffson, 1949, p. 23.
8. Dart, 1959, p. 87.
9. J. D. Clark, 1960, p. 312.
10. Howell, 1960a, p. 76.
11. Montagu, 1960, p. 147.

constructs, lacked historical and ethnological validity and were destined to be repulsed by the refinement of its own methods. Not only were the data, by comparison, more imponderable than the data of physical anthropology, but the anthropologists were more prone to indulge in independent speculation since they were relatively bereft of any stabilizing body of theoretical antecedents. But, as Professor Hallowell of the University of Pennsylvania has pointed out, when the constructs of *cultural* evolution were rejected by most 20th-century anthropologists, rejected as well was their basic notion that present-day primitives represented stages of physical evolutionary development.[12]

Origins of the various aspects of man's culture were no longer sought among the remotest tribes. With the advent of Franz Boas and the rigorous methodological house cleaning of anthropological theory undertaken by him and his followers, who established the foundations of American Anthropology, the mind of the savage was seen to be the potential equal of every man's, and all human culture behavior, primitive and civilized, was seen to be explainable in socio-historical, or cultural terms rather than biological or evolutionary ones. "The conclusion was drawn," Hallowell points out, "that culture change and development in Homo sapiens is not primarily linked with an evolution of mentality."[13]

The consequence which Hallowell deplores, however, was that this left the pursuit of evolution largely in the hands of the biologists, and, as he regretfully observed, "the psychological dimension of evolution, which to Darwin himself was an integral part of the total evolutionary process and of vital significance for our comprehension of man's place in nature, fell upon evil days."[14] Physical anthropologists concerning themselves with problems of fossil man, growth, race, and later, population genetics, were nevertheless devoting their entire attention to the evolution of man's body. Cultural anthropologists, concerned now almost wholly with culture as such, and cultures in synchronic instead of diachronic perspective, were paying no attention to the evolution of man's behavior.

Furthermore, most significant was the result that, whereas development of evolutionary theory had served to close the vast *biological* gap between man and his nearest relatives, the living primates, at least by the assumption of their respective derivation from a common ancestor, the cultural anthropologists by their refinement of the concept of culture and the distinctive human possession of language were driving a fundamental conceptual wedge deeper and deeper *between* man and ape. "In effect," Hallowell explains, "this preoccupation with culture led to a re-creation of the old gap between man and the other primates which it was once thought the adoption of an evolutionary frame of reference would serve to bridge."[15]

The biological continuum has been postulated for so long, and the behavioral continuum so subconsciously assumed, that the present investigators are faced with a highly sophisticated body of culture theory which has man's distinctive and unique characteristics as its foundation and major supports. "All these characterizations stress man's difference from other living creatures," declares Hallowell. "Like the criteria of culture and speech, they emphasize discontinuity rather than the continuity that is likewise inherent in the evolutionary process."[16]

There are two bodies of data available, according to the evolutionary perspective, for the investigation of man's behavioral evolution, that is, for the attempt to get at its original cultural development from a nonhuman ancestry. These are the fossil evidence for early man, and the study of the complex social behavior of the various species of living primates. Since the cultural remains of fossil man are so limited in what they can reveal about behavior and mentality, the accumulation of data on the man-apes has been bringing about the focus of a very high degree of research upon the study of the living primates. Their social organization, their communication, their aesthetics, their use of tools, and their response to varied social changes are being scrutinized for some new light on the original development of man's kinship, language, art, manufacturing of artifacts, and social dynamics.

One of the pioneers in primatology, C. R. Carpenter, observed a few months ago that "for thirty years field studies of monkeys and apes have been the lonely fate of a few hybrid scientists. Now, upsurges of interest and effort are occurring. . . ."[17] For example, the January issue of *Natural History* includes a report of recent research on "Primate's Aesthetics."[18] The subtitle reads, "An ape provides clues to the origins of artistic activities." A chimpanzee named Congo had been provided with opportunity and facilities for drawing and painting, and the results had been analyzed with the aim of "probing the biological origins of aesthetics." Naturally the resulting "art" provided a great deal of unique data on the mentality of chimpanzees, as well as for the analysis of nonhuman projective visual representations as such. However, in line with the primary aims, the author reports:

> The early results reveal that in the chimpanzee there is what we might call the germ of visual

12. Hallowell, 1959, p. 37.
13. *Ibid.*
14. *Ibid.*, pp. 37, 38.
15. *Ibid.*, p. 38.
16. *Ibid.*, p. 39.
17. Carpenter, 1960, p. 403.
18. Morris, 1961.

composition . . . even now it is . . . quite clear that the basic visual rules that control composition and design in painting by human beings are shown in a rudimentary form in the work done by Congo.[19]

Charles F. Hockett, distinguished linguist and anthropologist at Cornell, in a recent article on "The Origin of Speech" stated that "with this comparative method it may be possible to reconstruct the communicative habits of the remote ancestors of the hominoid line, which may be called the protohominoids. The task, then," he continues, "is to work out the sequence by which that ancestral system became language, as the hominids—the man-apes and ancient men—became man."[20]

One thing which characterizes all such efforts to be found in the literature is the readiness of the investigator to admit that his investigations are being undertaken in a theoretical context of pure speculation. Marshall Sahlins of Michigan, in a recent article on "The Origin of Society" states plainly that,

> This discussion of the early phases of human society considers events that occurred a million years ago, in places not specificially determined, under circumstances known only by informed speculation. It will therefore be an exercise in inference, not in observation. This means juxtaposing the social life of man's closest relations —monkeys and apes—on the one side, with the organization of known primitive societies on the other. The gap that remains is then bridged by the mind.[21]

Among other statements embodying the same admission regularly occurs the assumption that "deductions from comparative behavior are as methodologically legitimate as those from comparative anatomy."[22] It is plain to see that the logic involved is only valid within a framework of evolutionary presuppositions.

At least one other candid statement of the rationale for nonhuman social investigations may actually underlie existing theory more widely than is often admitted. That is the point made by N. C. Tappen in a recent article on the distribution of African monkeys:

> Assuming that there was nothing miraculous about the evolution of man from primate ancestors, it follows that the potential for paralleling the process is still present and could be realized, given the right circumstances.[23]

Perhaps the physical anthropologist with the least reservations on the matter in his writings is Dr. S. L. Washburn of the University of California, who states in no uncertain terms:

> Complex and technical society evolved from the sporadic tool-using of an ape, through the simple pebble tools of the man-ape and the complex tool-making traditions of ancient men to the hugely complicated culture of modern man.[24]

According to Washburn this may be "seen in the scanty fossil record and can be inferred from the study of the living forms."[25] Such a generalization is just as naive and invalid, from the creationist standpoint, as the more sweeping unilineal evolutionary generalizations of Edward B. Tylor in 1871 and Lewis H. Morgan in 1877 were to Boas and Lowie in the 1920's. Some scientists of today who would not claim to be creationists still see the fallacies of this comparative method for achieving its stated goals. Marston Bates, for example, in a volume published this month, deplores the basic theory behind the method,[26] and further states very simply, that "The method of comparing different kinds of living organisms is not, in itself, an adequate basis for reconstructing a plausible evolutionary story. . . ."[27]

Modern anthropology is seeking desperately to bring the study of behavioral evolution to the status of settled certainty which organic evolution is assumed to have, by seeking to close the gap between human culture and nonhuman behavior and re-establish the evidence for a behavioral continuity equal to the evidence for the assumed morphological continuity. One of the most remarkable things that consistently occurs, however, is that every attempt to get at human cultural origins, no matter whether it uncovers new information about primate behavior and social structure or no, *always* serves to sharpen and reinforce the gap between them more explicitly. Long ago Thomas Huxley in his famous work *Man's Place in Nature* in which he established the incontrovertible fact that anatomically, man is more similar to the great apes than the apes are to the monkeys, mentioned ". . . the great gulf which intervenes between the lowest man and the highest ape in intellectual power," and " . . . the vast intellectual chasm between the ape and man."[28] But, whereas Huxley was only speaking of brain power, as it were, the modern investigators, by the most detailed and illuminating descriptions of behavioral distinctions, sharpen the understanding of the very nature of the differences between learned, cultural, human behavior, and instinctive, genetically controlled, animal behavior. The late A. L. Kroeber in his famous text, *Anthropology*, pointed to the relative insignificance of the anatomical differences which he considered merely "differences of detail and degree, and mostly of no very great degree. But the difference as re-

19. *Ibid.*, pp. 27, 28.
20. Hockett, 1960, p. 4.
21. Sahlins, 1960, p. 2.
22. Hallowell, 1959, p. 44; Etkin, 1954, p. 140.
23. Tappen, 1960, p. 116.
24. Washburn, 1960, p. 15.
25. *Ibid.*
26. Bates, 1961, pp. 162, 163.
27. *Ibid.*, p. 168.
28. Huxley, 1863 (1959), pp. 120-122.

gards culture is one of so enormous a degree . . . as to become virtually equivalent to a difference in kind".[29]

Now the exact reason behind this vast difference between man's culture and the behavior of the nonhuman primates, and the bearing it has upon the attempts to derive human culture from pre-existing primate heredity is so fundamental that its importance can hardly be overestimated. The crux of the matter is that man's culture is not genetically inherited nor genetically controlled. Virtually all of man's behavior is learned after birth, while typically, though learning plays a part, nonhuman behavior for each particular species is "given" at birth and pre-determined so that each member of each species behaves in essentially the same restricted patterns of his species, without having any choice in the matter. Thus the attempted comparative studies of living primates and the entire preoccupation with closing this bio-cultural gap is based upon the contradiction of deriving something cultural from something noncultural; of producing something nongenetic and nonphysiological from something that is genetically controlled. Sahlins puts it very precisely as follows:

> There is quantum difference, at points a complete opposition, between even the most rudimentary human society and the most advanced subhuman one. The discontinuity implies that the emergence of human society required some suppression, rather than a direct expression of man's primate nature.[30]

Thus a suppression of instinctively controlled behavior is seen as a necessary step in cultural origins. Sahlins refers to this "overthrow of human primate nature" as "the greatest reform in history."[31]

Loren Eiseley, the distinguished anthropologist, author, and Provost of the University of Pennsylvania, speaks of "the 'new' brain, denuded of precise instinctive responses . . ."[32] and of man's "societal universe, with its institutions supplanting his lost instincts . . ."[33] and of his supreme and characteristic capability of symbolic language. Eiseley also points out that

> What must have been the frightening withdrawal of instinct in man and its replacement by the culture-building brain is a passage that the Darwinian world failed to grasp or appreciate clearly.[34]

He, too, refers to this event as "of the nature of a quantum step,"[35] and Bartholomew and Birdsell refer to the transition in the same terms as they presume that the first bipedal tool-using primates "were entering a period of rapid change leading to a new kind of adaptedness. In the terminology of Simpson (1944) they were a group undergoing quantum evolution."[36]

It is at this point that the question of the origin of man is lifted from the level of mere concern with bones and morphology to the level of phenomena of a very different order. Creationists have too long entered into heated controversy among themselves as well as with evolutionists over various aspects of the fossil record, to the exclusion of the consideration of the very area where the modern evolutionary explanation is totally at a loss. This admitted perplexity on the part of anthropologists is being expressed as never before in the context of primate studies as the renewed preoccupation with origins forces recognition of the reality of this elusive increment.

Thus Chance and Mead in their article "Social Behavior and Primate Evolution" state that,

> The anatomical features which differentiate man from the other primates, and the fossil evidence make clear the major changes which have led to his emergence from the primitive mammalian state to his present taxonomic position. Yet we are still without an adequate theory to explain this process in terms of adaptive evolution.[37]

Kroeber refers to man's original acquisition of language and culture as "an event of unusual novelty on this planet,"[38] and, in speculating as to whether or not it could have been due to some "supermutation—in the genes" he remarks that if it was such a mutation "this one was different in that the genetic change set something going outside of heredity also."[39]

Regarding the problem of the identification of culture with a biological base, Kroeber writes:

> There is no new organ, no new layer, no new chemical substance that we know of, peculiar to the human cortex.[40]

There are those who hold that the supposed transition was purely due to genetic processes. Dobzhansky and Ashley Montagu stated in 1947 that

> The biologist insists that the evolutionary changes that occurred before the prehuman could become human, as well as those which supervened since the attainment of the human estate, can be described casually only in terms of mutation, selection, genetic drift, and hybridization—familiar processes throughout the living world.[41]

Washburn likewise would pass completely over the question of the nongenetic nature of culture ori-

29. Kroeber, 1948, p. 70.
30. Sahlins, 1960, p. 3.
31. *Ibid.*, p. 12.
32. Eiseley, 1955, p. 73.
33. *Ibid.*, p. 74.
34. *Ibid.*, p. 75.
35. *Ibid.*, p. 67.
36. Bartholomew and Birdsell, 1953, p. 492.
37. Chance and Mead, 1953, p. 395.
38. Kroeber, 1948, p. 58.
39. *Ibid.*, p. 71.
40. *Ibid.*, p. 70.
41. Dobzhansky and Montagu, 1947, p. 587.

gins, preferring to think of it as a unified and inseparable process with organic changes. Thus he asserts that

> Selection produced new systems of child care, maturation and sex, just as it did alterations in the skull and the teeth. Tools, hunting, fire, (sic) complex social life, speech, the human way and the brain evolved together to produce ancient man of the genus *Homo* . . .[42]

Perhaps the most candidly qualified explanation is that of William Etkin in his study of "Social Behavior and the Evolution of Man's Mental Faculties." He states that "If this uniqueness of man is to be understood in terms of evolutionary biology it can only be as the resultant of a biological history that includes unique conditions."[43] Then, after making the observation that animals do not develop behaviors beyond their functional requirements any more than structures or physiological capacities, he offers the following conclusions to his examination of possible preadaptive pressures toward the development of culture:

> On this basis we expect selection pressure to push language development only to the point where it serves a function of identification of concrete objects and of socialization but not to the level of its use in abstract thought. Similarly the evolution of co-operative behavior can be explained to the point where it permits a degree of stabilization of the male into the family and pack but no further. In this view the origin of abstract thought . . . and of truly ethical behavior . . . are not explicable in the biological terms developed here.[44]

He calls this "the limitation of the biological explanation" only claims that "These biological factors are held to account for only the first steps toward a culture-capable organism."[45]

IV.

Our final consideration involves the origin of the human brain, and will take us back once more to the African man-apes.

Two of the difficulties with any present attempt to put the Australopiths into the status *or* ancestry of man, are (a) the time factor mentioned above, and (b) his brain. The span of time in which the man-apes seem to have lived runs from the end of the Pliocene through the earliest phases of the Pleistocene. Thus they meet, or even possibly overlap men whose cultural status is unquestioned. It is felt by some (although not by all authorities) that in order for them to have been ancestral to man they would have had to live much further back in Pliocene times. My colleague Don Wilson has reminded me in a recent letter that "the most vital period for the understanding of the development of man (from an evolutionary standpoint) is the Pliocene and in this 10 million years fossil primates are presently almost unknown." A number of authorities, however, feel that the earlier Australopithecines could have been ancestral to Pithecanthropus-type man.[46]

The *brain* of the man-apes is the single most outstanding morphological characteristic which does not compare with the hominid proportions. It is only about one half as large, and clearly within the range of the modern anthropoids. With these considerations in mind let us follow Eiseley in his presentation of Alfred Russell Wallace's remarkable anticipation of this crucial aspect of the problem of man's origin. In 1876 Wallace said that either man would be found very early " 'spread in dense waves of population over all suitable portions of the great continent—for this on Mr. Darwin's hypothesis is essential to rapid developmental progress . . .' or, on the contrary, if 'continued researches in all parts of Europe and Asia fail to bring to light any proof of his presence (during the Pliocene and before), it will be at least a presumption that he came into existence at a much later date and by a more rapid process of development.' In that case, Wallace continued, it will be a reasonable argument that man's origin 'is due to distinct and higher agencies.' "[47] Eiseley adds that "It should now be apparent, through these propositions of Wallace, where the rearrangement of our remaining human fossils is leading us. It is leading us straight toward Wallace's second proposition . . ."[48] though Eiseley would not accept Wallace's idea of a supernatural agency. Neverrheless he does add:

> If our briefly sketched confinement of the major rise of the human brain to the Pleistocene is even approximately correct, it would appear to demand some other evolutionary mechanism beyond that of the old Darwinian struggle of man with man or group with group. The movement would appear much too fast[49] . . . some other more rapid process of evolution . . . must have been at work in the production of man.[50]

Washburn, too, stresses the fact that by the time of the first known man who used fire and had clearly defined tool traditions, "the brain had doubled in size" over that of the man-apes.[51] He then points out that, "It then appears to have increased much more slowly; there is no substantial change in gross size (of the brain) during the last 100,000 years."[52] Chance and Mead in their study quoted above come to the conclusion that "No adequate explana-

42. Washburn, 1960, p. 3.
43. Etkin, 1954, p. 129.
44. *Ibid.*, p. 140.
45. *Ibid.*, p. 141.
46. Washburn and Howell, 1960; Washburn and Avis, 1958; Washburn, 1960; and Howell, 1959 and 1960b.
47. Wallace, 1876, pp. 64, 65; quoted by Eiseley, 1955, p. 67.
48. Eiseley, 1955, p. 67.
49. *Ibid.*
50. *Ibid.*, p. 69.
51. Washburn, 1960, p. 9.
52. *Ibid.*, p. 11.

tion has been put forward . . . to account for the development of so large a cerebrum as that found in man."[53]

The question should also be raised, Why are mankind's mental traits and spiritual traits so uniform the world over when racial and cultural traits are so exceedingly varied. With reference to the latter two, natural selection and heredity control the one, and freedom from these has permitted the other. But concerning the uniform nature of man's mind which, Eiseley reminds us, could not have resulted from a long, slow evolutionary process of Darwinian struggle, he concludes, "Something—some other factor—has excaped our scientific attention."[54]

V.

Conclusions:

1. If the Australopithecinae have any relevance for the consideration of man's organic ancestry, it is at present within an evolutionary frame of reference which presumes that there must have been such a stage because it fits perfectly the present state of theory.

2. The tendency to refer to the known man-apes as representing the earliest known stage in a continuum of human cultural development occurs frequently in the literature but is dependent upon the interpretation of the factors of time, and brain size in comparison to other examples of early man.

3. The whole question of theistic evolution, as defined in the chapter under review, should seem to hinge on the matter of the bio-cultural gap. As we have seen, evolutionary science approaches it via the comparative examination of ape and man, fossil and living, but when all is said and done, the gap remains clearer than ever. Loren Eiseley, himself an evolutionist, examining the problem of man's origin meticulously from the historical as well as the contemporary point of view, finds that "the key to the secret doorway by which he came into this world is still unknown."[55]

(a) If one wishes to handle this in the evolutionary frame of reference, but with supernaturalistic assumptions, he may interpret God's creation of man as itself constituting the crucial transition—mental, cultural, spiritual. This would be the position of theistic evolution held by many Christian people, and the position most widely held by Roman Catholic scholars,[56] allowed by the Church, if God's intervention is safeguarded.

(b) If, on the other hand, one wishes to handle the problem not as a transition, but as a definite origin—physical, mental, cultural, spiritual—one may interpret God's creation of man as constituting the origin of man's body as well as his culture, mind and soul.

Genesis has been interpreted to include both of these positions by conservative Bible scholars. The facts of the fossil record do not at present demand the adoption of either position necessarily; but neither do they conflict with either one.

(c) The alternative, of course, would be the common evolutionary interpretation based upon naturalistic assumptions.

Summarizing: the problems of the nature and antiquity of the fossil bones are vastly overshadowed by the importance of the intangible problems of the spiritual and the cultural spheres in the consideration of the origin of man.

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53. Chance and Mead, *loc. cit.* Also quoted by Eiseley, 1955, p. 67.
54. Eiseley, 1957, p. 91.
55. Eiseley, 1955, p. 75.
56. E.g., Hauret, 1955, p. 97: "God drew the human body . . . from an animal organism, which He transformed and adapted so as to receive a human soul."

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BIOLOGY

Irving W. Knobloch, Ph.D.

Transpecific Evolution

In the hundred odd years since Darwin's book on Natural Selection appeared on the scene, countless thousands of books and papers have appeared in the literature and one would think that certainly the last word on the subject of evolution would have been said. Some writers like the late Dr. Goldschmidt were very dogmatic and even today there are many who do not realize that an historical theory can never be finally settled. Evolution is still a very lively topic and much active research is going on. The finding of the "living fossils" Metasequoia and the Coelocanth have revised our ideas a lot. The growing knowledge that phylogenetic evolution occurred before the Cambrian is another point, as for example—"it is well known that in the Cambrian, all animal phyla except the vertebrates already existed and that the latter probably originated during this period or during the Ordovician" (Rensch, *Evolution Above the Species Level,* p. 83).

Throughout these hundred years there has been a lot of fuzzy thinking and writing done. People have equated natural selection with evolution. They have written about natural selection as a species-producing process. They have confused the speciation going on today, which they can see and understand, with phylogenetic evolution. Only a very few scientists have noted this later point in their writings and have realized that not only are speciation and phylogenetic evolution different, but that one cannot prove the latter by citing examples from the former without a tremendous extrapolation of inferences (and without violating common-sense logic).

The difference between these two processes has at last merited a book on the subject (Rensch, *Evolution Above the Species Level).* This German work has recently been translated into English. It is a book filled with detail and will undoubtedly become a classic in the study of evolution. Rensch knows that phylogenetic evolution occurred before the Cambrian and that all phyla-jumps are missing from the fossil record. For this reason he does not expect to find phyla intermediates in the rocks. He lists many class and order links in his book and with these we can find no fault because some changes have taken place and we are not certain whether God created the equivalent of our classes or our orders.

The question Rensch asks is—are mutation and

selection, his idea of speciation agents, sufficient to account for phylogenetic or transspecific evolution? He believes that they are sufficient and that there is no need to assume other autonomous factors. Various revolutions or natural catastrophisms which have occurred throughout geological time, have speeded up evolution enormously. This is supposed to take care of the objections of many including the paleontologists who have always said that mutation and selection are too slow (and not always progressive) to account for evolution. Rensch does not believe that transspecific and infraspecific evolution are necessarily identical with each other, but he sees no need to invoke vitalism or supernaturalism at any stage. I suppose to be realistic about the matter we shall have to say that Rensch's idea will have to be treated as a theory until someone produces a new order or class by one of the mechanisms of speciation on an experimental basis.

Vascular Plants

The beginnings of this high group were always placed in the Silurian. Then a Russian found a plant, *Aldanophyton*, which was quoted as being from the Cambrian. Dr. Wilson Stewart *(Plant Sci. Bull. 6* (5):1-5, 1960) believes this plant to be either an alga or a nonvascular land plant. Although the Cambrian origin of vascular plants is not in doubt, it is interesting to note that he believes that this plant may be a land plant. No doubt, Stewart's ideas will be subjected to further tests.

Research

The general subject of research is complex and vast. Hundreds or thousands of young people enter this field without any instruction other than a few words now and then from their major professor. What makes it difficult to offer a course in research methods is that each field has certain peculiarities which may not be applicable to other fields. If a course cannot be had, one should at least read books on the subject. One such book is *The Art of Scientific Investigation* by W. I. B. Beveridge, published by the W. W. Norton Co., Inc., New York. It is impossible to condense this fine book adequately but to show its range, we shall paraphrase certain aspects of it.

Teaching students versus leaving them alone—throwing students into research without instruction is like teaching people to swim by throwing them into the water. It might develop initiative but it is generally wasteful.

Asking "why" as well as "how"?—asking "why" is justified as a stimulus toward imaging the cause, since all events do have causes. Structure and function have survival value and in that sense have a purpose although the organism may not realize the purpose.

Incentives—some reasons why we engage in research are to do good to mankind, to satisfy curiosity or the creative instinct, to justify the confidence of others, to satisfy one's ego, to earn a livelihood, and lastly, to see one's name in print.

Tactics—research can sometimes be compared to warfare because it is, after all, warfare against the unknown. We marshal all our forces of data, materials, and equipment bringing into play any newly discovered techniques. We concentrate on a small area first and master it, making exploratory attacks here and there to find the soft spots. When a breakthrough occurs, we advance rapidly and overrun a large area, then we pause for reflection and consolidation.

Chance—many great discoveries have been found by chance incidents striking a prepared mind. Some examples of these are: the attenuated pathogen work of Pasteur, the gram stain by Gram, the hormone function of the pancreas, Ringer's Solution, anaphalaxis, the agglutination of bacteria, the discovery of penicillin, quinine, sulphanilamide, current electricity by a physiologist Galvani, the relationship of electricity to magnetism by Oersted, Bordeaux Mixture effect on mildew and the first aniline dye.

There are so many other parts of this book worth reading that it becomes difficult to pick those of most interest. Let us recommend the book heartily for all neophytes in research.

PHILOSOPHY

Robert D. Knudsen, Ph.D.

Modern Thinkers, II

Another monograph in the series, "Modern Thinkers," published by the Presbyterian and Reformed Publishing Company, is the essay by G. Brillenburg Wurth, *Niebuhr*. Like Dr. Herman Ridderbos, whose *Bultmann* we reviewed in our last column, Brillenburg Wurth is a professor at the theological school in Kampen, the Netherlands.

In dependence upon Davies, Brillenburg Wurth approaches Niebuhr's development through his experiences as a pastor in Detroit, which led to his break with liberalism and his development of a realistic theology. Not without some redundancy, a second factor in Niebuhr's development is discovered in his struggle against liberalism, orthodoxy, and Marxism. After this discussion, which revolves around the anthropology of certain of Niebuhr's earlier major works, Brillenburg Wurth turns to a discussion of some other aspects of

Niebuhr's mature theology, namely, his view of the redemptive work of Christ and the revelation of the kingdom of God. The monograph then closes with a general evalution.

In assessing this monograph, it is impossible for me to be unequivocal. It is possible to raise objections to certain details in the presentation. It is, for example, very doubtful that Niebuhr is as directly under the influence of Heidegger as Brillenburg Wurth claims (p. 30). It is also quite doubtful that Niebuhr now believes in the literal resurrection of Christ from the dead (p. 35). As late as his reply to his critics in the *Library of Living Theology* he threw doubt on the literal resurrection. To my mind Brillenburg Wurth also sadly overrates the major American denominations as a "model of powerful activity" (p. 12).

It might also be possible to question this monograph on more fundamental scores. In his concluding criticism of Niebuhr, Brillenburg Wurth finds Niebuhr to be ". . . one of the most dangerous representatives of a new type of theology, usually classified in America as neo-orthodoxy" (p. 40). Like that of Bultmann, Niebuhr's theology is one of accommodation, having received its stamp from the dominant philosophy of the day, existentialism. Niebuhr lacks a clear-cut Biblical starting point, misunderstanding the doctrine of creation, etc. "In its place is substituted the Kierkegaardian dialectical opposition between time and eternity. And this dialectical tension is characteristic of Niebuhr's theology in all its manifestations" (pp. 40, 41). And yet, in an unwarranted irenic mood, Brillenburg Wurth says, "But, in the last analysis Niebuhr is gripped by the message of the Gospel. The Gospel has again become the only word of redemption, the only solution to the needs of a spiritually uprooted society" (p. 39).

It is nevertheless true, that in the course of his discussion Brillenburg Wurth opens up perspectives which to my mind are indispensable for the understanding of Reinhold Niebuhr, and which have not received enough attention among Niebuhr's American evangelical critics. I refer to Brillenburg Wurth's somewhat sporadic discussions of the dialectical structure of Niebuhr's thought, which he himself summarizes in his statement that the Kierkegaadian dialectic is characteristic of Niebuhr's thought in all its manifestations. If one keeps in mind that Niebuhr does not view the time-eternity dialectic precisely as Kierkegaard did, this statement is quite true. Brillenburg Wurth introduces his discussion of dialectic in connection with Niebuhr's *Moral Man and Immoral Society*, and he continues to remark on it. To my mind, his comments are often valuable. It is only regrettable that when he was organizing his monograph he did not give Niebuhr's dialectic the prominent position he himself claims for it. The work would have been greatly improved had it been built more consistently around Niebuhr's dialectic and a criticism of this basic structure of Niebuhr's thought.

In spite of its weaknesses this monograph can serve as a corrective to certain American efforts to criticize Niebuhr, which offer splendid criticisms in detail, but then go on basically to accept the very dialectical structure around which Niebuhr's theology is built. For this reason I believe this monograph can make a contribution to our discussion of Reinhold Niebuhr.

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SOCIOLOGY

Russell Heddendorf, M.A.

Problem Areas of Sociology: Demography

Part I

In the past, this column has stressed that area of sociology which would seem to be of the most general interest to the reading audience; the sociology of religion. In consideration of the more diverse and specialized interests, however, an attempt will be made in the next few issues of the Journal to cover those problem areas in science and education with which sociology has also concerned itself. While looking forward to the coming annual convention and its emphasis on population growth, this issue will be concerned with the problem of demography. In the future, the problems of the sociology of education, science, medicine, and mental illness will be considered.*

Perhaps one of the indicators of a mature science is the fact that it becomes more interdisciplinarian in structure and attitude with development. This has certainly happened in the physical sciences where overlapping of subject matter has become well accepted and the specialist is one who ventures into the newly developed field. Such has been the more recent growth of the social sciences in which demography has been a prime example.

Demography did not start as a specialty within the larger field of sociology. Rather, it developed from statistical emphases in such diverse fields as economics and biology. Demography and sociology have grown closer together, however, as they have become aware of the mutual contributions which

*This series will be based on *Sociology Today: Problems and Prospects*, edited by Robert K. Merton, Leonard Broom, Leonard S. Cottrell, Jr., Basic Books, Inc., New York, 1959.

they have to make. Although there have been no major developments in population theory since Malthus, there have been a number of recent conceptualizations which have resulted from the closer co-operation of demography and sociology. The ones to be mentioned here are changes in fertility in industrial and underdeveloped countries as they are influenced by attitudes and social institutions, general population change resulting from social change, the use of population regarding the labor force, and the effect of demography on the family.

Original attempts by demographers to predict population change have not proven adequate. Several decades ago when population was not increasing at a rapid rate, predictions were made concerning the rate of increase which were far too conservative. At this time, it was realized that raw statistics were inadequate; there had to be an understanding of the motivation for childbearing. The major contribution made by sociology here was in the development of interview techniques which allowed for the study of women's attitudes on the desirable family size. It was fonnd that in industrial societies, motivation for children fluctuated with unique circumstances such as conditions at time of birth, finances, sex of child, etc. Since then, it has been realized that mass media may have an influence on decisions concerning reproduction in industrial societies. The middle class family, subject to the pressure of conforming to class standards, has been typified as an institution which is interested in limiting family size. There are very definite functional reasons for such an attitude. Hence, our media of cultural exchange have created the image of the child not only as a vital part of family life but also as a liability in certain circumstances.

Demographers have also been wrong concerning the rapid rate of population growth in underdeveloped countries. The error here has been the inability to anticipate the significant decline in the death rate of these societies. Hence, there has been a conservative estimation of population growth in spite of the recognition that the birth rate would remain high. Although interview and survey techniques have also been used in underdeveloped societies, there has been a greater reliance on cultural analysis and awareness of the social structure. It has been found that attitudes toward fertility and reproduction are not merely individually or culturally controlled phenomena. In the real situation, the structure of social organizations has a modifying effect on what could be called the "ideal" attitudes toward reproduction. In particular, the organization of the family and economic institutions are of great importance. It has been shown, for instance, that family instability and reproductive behavior are correlated in certain circumstances.

One of the original problems in demography has been the possible effect which population growth would have on the economic progress of a nation. Again, there has been a need to go beyond raw migration, fertility, and mortality statistics. The demographer has realized that population change is usually one aspect of the total social change occurring in the society and that it must be interpreted in terms of its total social consequences. Such an analysis requires historical research and sensitivity to population structure, spatial distribution, group differentials, and other factors which the sociologist can best understand and appreciate.

The trend in demography has placed less emphasis on size of population and more on its nature and structure. Population has also been considered more in terms of its component parts as exemplified by the concept of labor force. Such a concern deals directly with the sociologist's interest in occupations and status-role theory.

One practical problem in this field is the proper use of women in the labor force. This is not just a cultural problem dealing with the social view of the status of women but it also involves functional considerations. How can the full technical abilities of women be used without hindering the functioning of the family? The problem here is one of institutional priority; namely, whether the family or economic enterprise is of more importance to the society. Since Russia makes greater use of professional and skilled women, it would be assumed that less emphasis is placed on the importance of family functioning or that other techniques have been developed to resolve the difficulty. The need for interdisciplinarianism is obviously very strong in this case.

Possibly the strongest symbiotic relationship between sociologist and demographer exists in problems concerning the family. Probably more than in any other case, there is a need for the specialist who is equally at home in either area. Although the sociologist is using more statistical data in his research, he often duplicates readily accessible demographic material. It is just such duplication of work and misdirected effort which exemplifies the need for an interdisciplinarian approach.

Though the development of predictive statistics in sociology is of importance in demographic work, probably the greatest contribution to be made by the field is in the area of social change. In the future, greater understanding of the mechanisms which change an underdeveloped society into an industrial, associational society will go a long way in allowing for prediction of broad population trends. In particular, a clearer conceptualization of the middle-class family in its role of limiting family size will provide a stronger basis for control, as well as prediction, of population problems.

BOOK REVIEWS

Darwin's Vision and Christian Perspectives. Edited by Walter J. Ong, S.J. New York: The Macmillan Co. 1960.

Reviewed by R. L. Mixter, Professor of Zoology, Wheaton College, Wheaton, Illinois.

The Roman Catholic Church has analyzed its beliefs regarding evolution in this volume by professors at Fordham and St. Louis Universities. The impacts upon biology, philosophy, American economic history, and theology are noted from Darwin's time until the present.

In the introduction, Walter Ong comments that "evolution is a term which can still disconcert or hypnotize" but the authors conclude that all the transformations which the biological evolutionists have indicated may be accepted if one believes that "human souls are immediately created by God." "If we accept the fact that the human came into being at the end of a series of sudden mutations directed to this end by the Creator God, then these changes reveal God's providence throughout."

Alexander Wolsky mentions that biologists face a new difficulty: "a certain complacent belief that owing to the neo-Darwinian synthesis evolutionary biology has solved its main problems and that all that remains to be done is to work out a few minor details" but he is confident that this attitude will pass as new research is done. ". . . there are serious objections to the view that Darwin's principle of natural selection acting on numerous small hereditary variations (micromutations) has all the answers . . ." so the writer quotes with approval the work of Goldschmidt and Schindewolf who hold to sudden "outbursts" of macroevolutionary changes followed by smooth "orthogenetic" microevolution.

The longest chapter of 70 pages on Darwin's impact on philosophy will be appreciated by philosophers even more than by us biologists who may be somewhat deficient in our ability to comprehend philosophical terminology. Treating both Thomas and Julian Huxley, Spencer, Wright, Pierce, and Dewey among others, the author James Collins shows the variety of philosophical responses that have been evoked by the evolutionary findings in biology. But evolutionary philosophy alone is insufficient. "In addition, however, the philosophical inquirer must bring to bear some other human resources which may not figure as components in some prevailing evolutionary position."

In considering theology Robert Gleason writes, "While all theologians agree that history is expressed in the assertions of Genesis, nevertheless today they admit that it is a peculiar type of history whose rules are still partly unknown to us." The "dust" from which Adam was made may refer "to organic matter oriented by God through a long process."

You will be interested in Vincent Hopkins' account of how evolutionary philosophy was used by power magnates in the United States to carry out their schemes.

The final chapter on "Evolution and Cyclicism in Our Time" by Walter Ong concludes that the universe is not eternal and undergoing cycles . . . "but the universe is created in one state and at the end of time will somehow be transfigured different from what it has been." Man is the culmination of the products of time. "Against the backdrop of the infrahuman universe which has given him birth, man remains more impressive than the rest of the universe. For he, as nothing before him, really includes it all. It comes to life and fruition in him." "Against this backdrop the Incarnation took place."

This Protestant reviewer wonders why it is said that the evolutionary "theory also mirrored the kind of competition which was common in a world in the throes of the industrial revolution, dominated by the Protestant ethic. . . ." However, he received stimulating ideas from this clear and forcefully written symposium.

Natural Law and Divine Miracle, by R. Hooykaas; E. J. Brill Publication, Leiden, Netherlands. 1959.

Reviewed by Raymond H. Brand, Assistant Professor of Biology, Wheaton College, Wheaton, Illinois.

Fortunately for the reader with a hierarchy of values as to what to read next, the subtitle of this small volume delineates a precise area of consideration. Hooykaas wisely narrows his broad and general topic to "A Historical-Critical Study of the Principle of Uniformity in Geology, Biology, and Theology." The scientist will appreciate this attempt at integration by a professor of the history of science, since it presents issues clearly from a perspective that includes an understanding of the limitations and usefulness of the scientific method. Perhaps most readers would agree that the "historical" outweighs the "critical," but over-all balance is achieved as the principle of uniformity is skillfully traced through the disciplines of geology and biology. The latter sections of the book concerned with philosophy and theology indicate the influence of metaphysics and religious beliefs upon the principle of uniformity. The avowed objective methodological basis, upon which the scientist claims to frame his hypotheses, is shown to often reflect current opinion or long standing *a priori* convictions.

Historical characters are portrayed in a refreshing style which records the vivid interplay of personalities who are engaged in vital struggle over controversial issues. Often this takes the form of personal communication between such notables as Charles Darwin, Asa Gray, Charles Lyell, and William Whewell. The following brief quote (p. 115) from one of Lyell's letters to Darwin illustrates the dynamic of this style. "I cannot admit that my leap at p. 505, which makes you 'groan,' is more than a legitimate deduction from 'the thing that is' applied to 'the thing that has been' as Asa Gray would say, and I have only put it moderately, and as a speculation." The leap in question here was one that is quite relevant today. Lyell could not accept Darwin's theory for the total explanation of man. Rather, he believed that man's moral nature was not subject to the principles of the physical world and thus for him uniformity was not dethroned despite the obvious fact of the uniqueness of man. A sampling of others mentioned in the book might include: Hutton, Lamarck, Cuvier, Buckland, Sedgwick, Chambers, T. H. Huxley, Pascal, Schindewolf, Goldschmidt, Simpson, and Dobzhansky. The author is to be commended for restricting discussion to those attitudes and opinions of the above men on the topic of uniformity or closely related concepts.

Early in the development of the section on geology the boundaries are marked off (and later erased) between strict uniformity on the one hand and catastrophe on the other. The meaning of Hutton's adage "the present is the key to the past" has apparently undergone as many shifts as the crust of the earth itself. If nature is not strictly uniform in certain processes perhaps the rate of the process is. Again, if rates bow down to certain stubborn facts, "cyclic events of regularity" are put forth to save this all-important methodological (and philosophical) foundation underlying modern scientific research. A word of caution is inserted to theory-holders in suggesting that "it would be preferable to follow nature instead of torturing facts in order to force them into a preconceived scheme." In the same vein and later on in the book the scientist is reminded rather forcibly that perhaps the function of a scientific theory is to account for the data available and not to introduce suppositions in order to save theories.

Turning from geological considerations the adherents of uniformity then discover biological difficulties in saltations or major leaps (or gaps) in the fossil record. Darwin and later neoDarwinians have consistently opposed saltations. Such gaps (representing negative evidence) are assumed to gradually close as more fossil remains are uncovered and studied. From a Christian biologist's viewpoint this section on the modern controversy about saltatory evolution is most significant. Seldom have the crucial issues of evolution been placed in such clear juxtaposition. Schindewolf maintains, "that an experimental basis of phylogenetics is impossible. The real course of evolution belongs to paleontology and not to genetics." Further statements (p. 126) point out that experimental genetics can only suggest "possible" mechanisms, not the "only" possible one, and not necessarily that one chosen by nature. Empirically, the saltationists seem to have the edge since they start with facts (i.e., glaring and rather numerous gaps). Micromutationists, such as Simpson, counter with a few orthogenetic graded fossil series within some groups. Upon this scanty evidence the objective scientist is then requested to extrapolate to a general continuity of change in a climate of *a priori* belief that has already concluded that gaps are unreal. Hooykaas points out that although viable macrosaltations have never been observed, the end result of observed micromutations to large transformations is likewise unconfirmed by direct observation. In defense of orthodox evolutionists, Simpson argues that where gaps exist the population was likely small and the rate of evolution high. (That nonuniform evolutionary rates are essential is pointedly illustrated by Simpson's statement that the origin of the bat's wing from a normal mammalian hand would have had to take place before the earth existed!)

Perhaps a major contribution of this book is the clear conception it presents of the principle of uniformity. The author's position on various issues is generally obscured (and perhaps rightly so), bnt his very mention and discussion of saltations probably assigns him a place among a much-needed vocal minority in opposition to the overwhelming tide of convinced micromutationists.

A delightful yet humbling epilogue of selected verses from the Book of Job appears to the reader who now thinks he knows all (e.g., Job 38:4 . . . Where wast thou when I laid the foundations of the earth? declare, if thou hast understanding).

Much more could be said but interested theologians and scientists are urged to read about these lively issues for themselves. In conclusion, I can only voice my approval of a plea similar to that of von Hoff (p. 8) that loose speculation be avoided and the framing of hypotheses be restricted to those phenomena capable of scientific investigation.

The Firmament of Time, by Loren Eiseley, New York; Atheneum; 1960; 184 pp.

Reviewed by J. Frank Cassel, Professor of Biology, North Dakota State University, Fargo, North Dakota.

Originally given as a series of lectures at the University of Cincinnati by one of the University of Pennsylvania's outstanding anthropologists, these essays probe the meaning of nature. As I

read, I reacted. And these are my reactions essentially as I jotted them down at the conclusion of each chapter. Can we of A.S.A. meet this challenge?

I. *How the World Became Natural.* The general history of evolutionary thought is viewed from our modern scientific perspective, with the caution against falling into the tenor of the time. Eiseley, like many other modern scientific philosophers, fails to distinguish, however, between scientific and religious dogma—and truth. If indeed modern science comes closer to delineating reality than did the 17th and 18th century savants, then is it simply the dying gasp of a capitulating religionist who says, "Well, that's the way God did it"? Why is it continually assumed that the better we understand the machine the more remote becomes the Machinist, even if the machine be a perpetual motion machine?

II. *How Death Became Natural.* Looking on myself from the modern perspective, I had never thought of the problem extinction might be to the concept of the fixity of species. It is with this Eiseley here deals, being so caught up with the sheer magnificence of an idea that his prose in spots is poetry, and one feels as well as understands the force of ideas in time. Is this revelation?

III. *How Life Became Natural.* He's caught me in his web as he moves up to Darwin, although thoughts here really don't seem to hang together as well. Hot on the heels of extinction comes the concept of natural selection through the struggle for existence. Some little-known sources of such ideas are probed—we find that before a Malthus there's a Brückner, before a Lyell a Hatton, and before a Darwin a Blyth.

IV. *How Man Became Natural.* Moving into his own field, Eiseley traces in the broadest of terms the import of certain fossil finds—the isolated Neanderthalians, and the African ape-men identified here only by their discoverers, Dart and Leakey. He reflects his anthropologist's bias by accepting man as "the toolmaker." He traces in this chapter not so much the history of thought as of his own upon these fossils.

V. *How Human Is Man?* In a startling switch Eiseley probes into natural man to find a "within" and a "without" and with great force and concern deplores the neglect of the "within" by modern "asphalt man." Only when man faces his responsibility to resist the "whirlpool" of the modern world, and acts in love welling from his unique soul does he become "truly human."

VI. *How Natural Is Natural?* But, he concludes, man, the "toolmaker," is not enough. As we consider time, both past and future, we find that by our dim comprehension we have transcended it and begin to grasp the miracle of life itself—and of man. "He stands at the point where the miraculous comes into being, and after the event he calls it 'natural.' The imagination of man in its highest manifestation, stands close to the doorway of the infinite, to the world beyond the nature that we know" (p. 179). But Eiseley, it seems, never really sees the Infinite, nor quite conceives that He visits the son of man.

Herein lies our challenge—in bonds of understanding and love, to answer with depth, majesty, and true reverence the soul's cry of every Eiseley—and to show that hope lies not in what man is, nor even in what God makes of him—but in God Himself—because of the One who gave the "despairing cry from the dark shadow of a cross on Golgotha long ago" (p. 180). Would God we may give the answer with the same probing poignancy that graces the question.

The Molecular Basis of Evolution, by Christian B. Anfinsen; John Wiley & Sons, Inc., New York, 1959; 228 pp. $7.00.

Reviewed by Walter R. Hearn, Associate Professor of Biochemistry, Iowa State University, Ames.

My enthusiasm about this book dates from the time the publisher sent me a prepublication copy of the preface and asked for my comments on the need for a book with this point of view. After browsing through it at the Wiley booth at a scientific meeting soon after its publication, I have been recommending it highly to A.S.A. members and others interested in current trends of evolutionary thought. Recently I sat down and read every word of it carefully while preparing some lectures on biochemical aspects of evolution, and now I find that my attitude toward the book has changed somewhat. Perhaps I expected too much and feel disappointed because on careful reading it failed to come up to my expectations.

The subject matter dealt with is extremely complicated, but I found the style of writing too technical for a good popularization and too sketchy for a satisfying technical work. The author is a biochemist who has distinguished himself by leading a research group at the National Institutes of Health in a highly successful attack on the primary structures of proteins. Essentially the entire covalent structure of the enzyme ribonuclease, a polypeptide chain of 124 amino acids with four disulfide cross-links holding it in a particular looped arrangement, is now known through the work of Anfinsen's group and another group at the Rockefeller Institute for Medical Research. The part of the book describing the ribonuclease work as an example of elucidation of protein structures is excellent, as one might expect. The general theme of the book is that knowledge of the fine structure of proteins, especially of differences in homologous proteins between species or mutant strains, plus modern methods of "gene mapping" are paving the

way for a real understanding of the mechanisms of evolution right down at the molecular level. In the preface the author implies that he asked himself what we should do next if we want to shed some light on evolution with these new tools of protein chemistry and genetics, and that *The Molecular Basis of Evolution* is his "highly personal" answer. Having had to go through a process of self-education in genetics in order to lay his own long-range research plans, he is sharing with the reader what has been "both a revelation and a struggle." Unfortunately, too much of the struggle has been communicated and not enough of the revelation!

Modern genetics, such as the bacteriophage work of Seymour Benzer, is extremely hard to follow even when reading the complete account in a research paper or detailed review; when Anfinsen *explains* Benzer's work he does so sketchily and it becomes even worse. Furthermore, he seems to realize that readers will be confused, and even *expects* them to be, as shown in a comment on p. 27: "It is to be hoped that the foregoing discussion of the simplest elements of genetics will be sufficiently irritating in its compactness (and incompleteness) to cause some readers of this book to look into a few of the volumes listed at the end of this chapter." That hope was fulfilled in my case, anyway. However, I do find the book stimulating as well as irritating, and still recommend it. Biochemists, for whom it was written, will get some ideas for research from it, and others should take a look at it to see what is going on in biochemical genetics. I mean that literally: *Take a look* at this one. Then sit down and *read* a good review on amino acid sequence studies and one of the books suggested by Anfinsen "for further reading" at the end of almost every chapter: *The Chemical Basis of Heredity*, edited by W. D. McElroy and B. Glass, Johns Hopkins Press, Baltimore, 1957. That one manages to be stimulating without being irritating, and at less than half the cost per page (864 pp., $12.00).

NEW MEMBERS

The following have been elected members of the Affiliation

Albert, Jerry D., Department of Biochemistry and Biophysics, Iowa State University, Ames, Iowa, is a Graduate Assistant in Biochemistry at Iowa State University. He earned his B.A. degree in Chemistry from Occidental College (1959).

Anderson, Robert D., 217 Pettis Avenue, Mountain View, California, is an Instructor at the College of San Mateo, San Mateo, California. He holds an A.B. degree from the University of California, Berkeley, in Physics (1957).

Beattie, Lillian M., Liverpool School of Tropical Medicine, Pembroke Place, Liverpool 3, England, is a Medical Missionary, Canadian Baptist Foreign Mission Board, Toronto, Ontario, Canada. She earned her M.D. from the University of Western Ontario (1954) and F.R.C.S. (C) in Obstetrics and Gynecology from Royal College of Physicians and Surgeons of Canada (1960).

Benton, Clifford S., 590 Apple Grove Lane, Santa Barbara, California, is Associate Professor of Chemistry, Westmont College, Santa Barbara, California. He holds an A.B. in Chemistry from Cornell College (1941), an M.S. in Organic Chemistry from the University of Illinois (1943), a Th.B. from Tabor College (1949), and a Ph.D. from the University of Minnesota (1957) in Organic Chemistry.

Block, Stanley M., 3415 Parthenon Way, Olympia Fields, Illinois, is Associate Professor of Production Management at the University of Chicago, Graduate School of Business, Chicago, Illinois. He received his B.M.E. (1943), M.B.A. (1950) and Ph.D. (1956) degrees from the University of Minnesota.

Bower, Robert R., 255 S.W. Main, Beaverton, Oregon, is Biology and Physical Science High School Teacher for the Beaverton School District. He holds a B.S. in Forest Management from Colorado A. & M. (1951).

Brubaker, Kenton K., Shenandoah Street, Park View, Harrisonburg, Virginia, is Assistant Professor of Biology, Eastern Mennonite College, Harrisonburg, Virginia. He received his B.S. degree in Biology from Eastern Mennonite College (1954). He received his M.Sc. (1957) and Ph.D. (1959) degrees in Horticulture from Ohio State University.

Cannon, Theodore W., c/o Westmont College, 955 La Paz Road, Santa Barbara, California, is Instructor in Mathematics at Westmont College. He holds a B.S. degree in Electrical Engineering from Oregon State College (1956), and an M.S. in Physics from the University of Oregon (1960).

Ford, Wendell, 8316 Chase Avenue, Los Angeles 45, California, is a Member of the Technical Staff, Hughes Aircraft Company, Culver City, California. He received his B.S. (1958) and M.S. (1960) degrees in Electrical Engineering from the University of Southern California.

Franzen, James, 1928 Sherman, Evanston, Illinois, is a Post Doctoral Research Associate, De-

partment of Chemistry, Northwestern University, Evanston, Illinois. He holds a B.S. in Chemistry from Wheaton College (1955), an M.S. (1958) and a Ph.D. (1960) in Biochemistry from the University of Illinois.

Gavriloff, Thomas J., 4 Kingslea Court, Toronto 18, Ontario, Canada, is Director, Division of Dental Public Health, East York-Leaside Health University, Toronto, Ontario. He holds a B.Sc. in Biology from McGill University (1947), a D.D.S. in Dental Surgery from McGill University (1951), and a D.D.P.H. in Dental Public Health from Toronto University (1959).

Griffiths, Robert B., Physics Department, Stanford University, Stanford, California, is a Graduate Student at Stanford University. He holds an A.B. in Physics from Princeton University (1957) and an M.S. in Physics from Stanford University (1958).

Harley, Willard F., 300 North Sierra Vista, Santa Barbara, California, is a Professor of Psychology, Westmont College, Santa Barbara, California. He received the B.A. (1938) from Wheaton College, and the M.A. degree in Psychology (1940) from the University of Pennsylvania.

Harvill, Lee L., 1561½ Barry Avenue, Apartment 3, Los Angeles 25, California, is a Fellow in Geology at the University of California at Los Angeles. He received his B.S. and M.S. (1958) degrees from the University of Houston in Geology.

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Norris, Daniel H., 4340 Sutherland, Knoxville, Tennessee, Department of Botany, University of Tennessee, Knoxville, Tennessee, is a Graduate Student in Botany at the University of Tennessee. He earned his B.S. degree in Botany from Michigan State University (1954).

Phifer, Kenneth O., 3507 Heyward Street, Columbia, South Carolina, is Assistant Scientist for the United States Public Health Service. In 1956 he received the B.A. degree in Biology from Rutgers University, and in 1959 he received the Sc.D. from Johns Hopkins University in Parasitology.

Scheffler, Lewis F., Jr., 968 Harris Avenue, Newark, Ohio, is Major Research Project Manager, Owens-Corning Fiberglass Corporation, Pioneering Research Laboratory. He earned his A.B. degree in Theology from the University of Cincinnati (1950) and has done graduate work in Crystallography.

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Stevens, George R., 212 Porter Street, Easton, Pennsylvania, is Assistant Professor of Geology, Lafayette College, Easton, Pennsylvania. He has earned the following degrees from Johns Hopkins University: A.B., Geology (1954), M.A. Geology (1955), and Ph.D. Geology (1959).

Tan, Peter L., 1320 21st Street, N.W., Apartment 5, Washington 6, D.C., is a Research Assistant at George Washington Medical School, and a Graduate Student in Chemistry at the American University. He holds a B.S. degree in Pre-Medicine from Davis and Elkins College (1954).

Wagner, Andrew J., 15 Langdon Street, Cambridge 38, Massachusetts, is a Research and Teaching Assistant at Massachusetts Institute of Technology. He earned the B.A. in Physics from Wesleyan University (1956) and the S.M. degree from M.I.T. in Meteorology (1958).

Walker, Clarence Eugene, 100 West Stadium, West Lafayette, Indiana, is a Graduate Student in Psychology at Purdue University. He earned the B.S. degree from Geneva College in Psychology.

Weaver, Gilbert B., John Brown University, Siloam Springs, Arkansas, is an Instructor in Electrical Engineering at John Brown University. He holds a B.S. in Electrical Engineering from John Brown University (1952), and a Th.M. from Dallas Theological Seminary (1960).

Wiersma, Daniel, R.R. 9, Lafayette, Indiana, is Associate Professor of Agronomy at Purdue University. He holds a B.S. in Agronomy from South Dakota State College (1942), an M.S. from Wyoming University in Agronomy (1952), and a Ph.D. in Soils from the University of California (1956).

Winter, David K., 506 East Seminary, Wheaton, Illinois, is an Instructor in Anthropology at Wheaton College, Wheaton, Illinois. He holds a B.A. (1953) and an M.A. (1955) in Anthropology from U.C.L.A., and an A.A. in Liberal Arts from Pasadena City College (1951).

Wright, Charles D., 2579 Elm Drive, White Bear Lake 10, Minnesota, is a Chemist at Minnesota Mining and Manufacturing Company. He holds a B.A. degree from Augustana College in Chemistry (1952) and the Ph.D. degree in Organic Chemistry from the University of Minnesota (1956).

The following have been elected associates of the Affiliation:

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Brady, Harold W., 3258 East Fall Creek Boulevard, Indianapolis, Indiana, is an Insurance Agency Owner in Indianapolis, Indiana. He attended Indiana University Extension and Butler University.

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Davison, Allan J., 20 Marvin Lane, New Brunswick, New Jersey, is employed by the Bureau of Biological Research, Rutgers University, New Brunswick, New Jersey. He received his B.Sc. in Chemistry from the University of Cape Town (1957).

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