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*of the*

# AMERICAN SCIENTIFIC AFFILIATION

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

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# THE AMERICAN SCIENTIFIC AFFILIATION BULLETIN

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## - FOREWORD -

The first issue of the A.S.A. Bulletin is now in your hands. We would like to indicate by this note the purpose of the Bulletin, the editorial policy to be followed in accepting papers for publication, and the mechanism of publishing the first few issues. It is also our purpose to encourage hereby the greatest possible participation by various members in this undertaking.

The purpose of the A.S.A. Bulletin is manifold. It is intended primarily for the benefit of the A.S.A. members, and interested friends, and it is hoped that it will be instrumental in helping the organization achieve its primary purpose of witnessing to the truth of the Scriptures and elucidating the relationship of both the ideology and fruits of science thereto. Furthermore we confidently expect that in the publication of papers presented at the convention and others received from the membership at large, a real service will be rendered each of us in creating an enlarged appreciation and understanding of the Christian position in other fields of science than that of our own specialization. Also thru the A.S.A. Bulletin, we plan to give every interested member the benefit of a constructive criticism and Christian evaluation of papers presented and of reviews of books of great interest or strategic importance.

If this purpose is to be fulfilled, the cooperation of many members will be necessary. Some will be asked to write book reviews, others will be requested to outline the main problems in their field of specialization relating to science and the Scriptures, and all are expected to submit for publication articles of general interest. Not only is participation in these respects greatly desired, but earnest prayer for the success of this undertaking is sincerely requested.

The Bulletin will contain editorials from time to time. The present and past members of the Executive Council will serve as an editorial staff. Papers submitted will be referred for critical appraisal to a committee consisting of members of the A.S.A. who are specialized in the field with which the paper is concerned. These committees, appointed for each separate paper by the editor, will serve as referees and their recommendations will determine whether a paper is published. Papers submitted at the National Convention will not be handled in this way since the discussion following each convention paper serves to evaluate it.

A word of explanation of the mechanism of publication seems in order. The editor receives, assembles, edits, and prepares all material for publication in accordance with the foregoing procedure. This finished material is then forwarded to the Secretary-Treasurer, Professor Russell L. Mixter in Wheaton, Illinois for mimeographing or printing, and mailing. The format of the Bulletin is largely left up to Professor Mixter, and the question of whether it is mimeographed or printed will depend primarily on the relative expense involved.

Finally, we would like to invite suggestions. While we realize perfection, at least in the eyes of all, is probably impossible, we would like to be sure that the Bulletin meets a fair standard of acceptability. This can probably best be assured by your comments and suggestions.

M.D.B.

Editorial

The Bulletin:

During the past year as the circulation of the symposium manuscripts decreased, too few papers, reviews, etc., have been sent out from headquarters. The executive council presents this Bulletin series as at least a partial answer to this condition. It will appear at least quarterly, and may develop into a regularly printed journal. Dr. Barnes, past executive council member, is acting as director of all our publication activities. I urge you to support him in every way, especially in responding to requests for comments on papers, for the selection of papers for publication in the Monograph series depends largely upon your comments on the papers appearing in this Bulletin.

1949 Convention:

The 1949 convention will be held in or near Los Angeles. This will be a long trip for some, but it will make possible attendance of many on the West coast who have been deprived heretofore. A surprising number of Eastern and mid-Western members have indicated their intentions of coming to Los Angeles for this meeting. The tentative plan includes a full week of activities, including several field trips of exceptional interest to our members. Plan your vacation trip to include Los Angeles about the middle of August, 1949!

The Symposium:

MODERN SCIENCE AND CHRISTIAN FAITH is having a good reception. The publisher reports that the small first edition (3000) will probably be sold out early in 1949 according to present indications. Several Christian schools have adopted it as textbook although it appeared too late to be used this semester by many other interested schools. ASA members report that the book is excellent in personal witnessing to men in scientific fields and to students.

However, our good friend Dr. Wilbur M. Smith, author of THEREFORE STAND, expresses a pertinent thought when he wrote recently, "The book is far too important to just appear, sell a few thousand copies, and then disappear. It deserves attention everywhere in this land." Let us work and pray that our book may be used of the Lord and not allowed to "die on the vine." The 75 members throughout the USA constitute the answer to the problem. If each member pushes this book in his own church, among his own friends, and in his own school, this will be an effective sales force. Let each of us augment the normal sales methods in this way so that many may be confronted by the Word of God who otherwise would never be reached.

A Challenge:

There are about 1700 institutions of higher learning in the United States. It would be a fine thing if we could send at least one copy to the librarian of each of these with a letter requesting a special display of the book because it treats an all important subject, vital in a world of tumbling mores and moral values. Our treasury cannot stand an expenditure of this magnitude. Do any of you know of wealthy Christians who might be challenged with this attack on the intellectual stronghold of materialism? Surely this is evangelism in the language of those we would reach.

In short, gentlemen, the work of the ASA is just what we few members, by the Grace of the Lord, make of it. If we are lethargic, the work will shrivel; if there is no vision, no progress. I urge each member to make a positive and definite contribution to the work of the ASA, unsolicited, during 1949 that these students might be reached with the claims of Christ.

F. Alton Everest,

President.

## THE THIRD ANNUAL CONVENTION

Twenty five members and friends of the American Scientific Affiliation registered for the convention held at Calvin College, Grand Rapids, Michigan, September 1 to 3, 1948. Edwin Monsma and Martin Karsten and their wives welcomed us to the dormitory with a fellowship hour before the convention.

You will receive in the Bulletins the substance of the ideas and discussions of a Biblico-scientific nature; also reports of sectional meetings of the past year. The suggestions and announcements from the business sessions follow.

### Announcements

1. For Moody Monthly and Van Kampen Press, members have reviewed manuscripts of articles and books. It will help editor Barnes if any one reviewing a book will send him a copy of the review to be used in the Bulletin. Bibliographies on the Bible and Science are desired.
2. Constitution revisions will be considered by a committee and sent to the members for evaluation.
3. Dr. Alfred Eckert by letter reported on the progress made in producing a pamphlet called "Fourteen Prominent Scientists Look at Life."
4. Dr. Roger Voskuyl will head a membership committee to solicit new members and suggest revisions in types of membership.
5. The A.S.A. voted approval of the film "Voice of the Deep" which was reviewed by a large audience in the auditorium. Much credit belongs to our President, F. Alton Everest for the excellent planning and technique of the motion picture.
6. The pamphlet "Evolution," written by Dr. John Howitt, one of our members and the monograph "Christian Theism and the Empirical Sciences" by Dr. Cornelius Jaarsma, are available to members from the secretary.
   "Evolution," 20¢ each, $2.00 per dozen
   "Monograph," 15¢ each, in lots of 25 or more, 10¢ each
7. Drs. Laurence Kulp and Joseph Maxwell were nominated to succeed Dr. E. Y. Monsma on the executive council. The nominating committee were Drs. Cowperthwaite, Hartzler, Marquart and Prof. Oorthuys. Dr. Kulp has recently been elected.
8. President Everest invited the Affiliation to meet in Los Angeles in 1949. Possible side trips include the La Brea Tar Pits and Palomar Observatory.
9. "Modern Science and Christian Faith," the Christian Students Science Symposium, appeared in the hands of the editor, F. Alton Everest, whose remarks of gratitude to authors and publisher were matched by commendations of the editor's efforts. Copies of the book may be purchased from the secretary-treasurer for $1.80. If the book is sold by a member, he should charge $3.00, sending the profit to the treasury.
10. The publications committee, Dr. Voskuyl chairman, named Dr. Marion Barnes to be editor of a periodical, herein called the Bulletin.

### Suggestions

1. A complete set of Victoria Institute publications should be owned by the A.S.A. Selected articles could be lithographed for publication in the Bulletin.
2. Reviews of current books on atomic research are desired.
3. Broad surveys on the relation of the several fields of science to the Scriptures should be undertaken.

4. The library of the A.S.A. should be placed in a central location. Representatives of institutions desiring to shelter the volumes owned by the A.S.A. may write to the Secretary.

## Special Features

"Has Archaeological Research Proved Solomon to be a Myth" was answered authoritatively in the negative by Dr. Allan A. MacRae in the first public lecture. Officers of the A.S.A. formed a panel to discuss "The Role of A.S.A. in Christian Testimony" for the second public meeting. The colored, sound (theologically and physically) film "Voice of the Deep" climaxed the evening. Anyone desiring to present the picture may write to its producer, the Moody Institute of Science, 11428 Santa Monica Boulevard, West Los Angeles 25, California.

Dr. Gelmer Vannord of the Christian Psychopathic Hospital invited us to see the facilities of his institution. In the pleasant surroundings at Pine Rest, near Grand Rapids, we viewed the buildings and heard of the considerate treatment given to patients by the competent staff.

## Appreciation

To the local committee, E. Y. Monsma and Martin Karsten, to the program committee, Paul DeKoning, chairman, Paul Bender, Joseph Maxwell and Frank Cassel, and to Calvin College, goes our gratitude for careful and thoughtful planning and gracious hospitality.

R. Mixter, Sec'y.

# A CHRISTIAN VIEW OF THE DEVELOPMENT OF SCIENCE

## I Introduction

President Conant of Harvard has called attention recently to our great need of a better understanding of the history of science.[1] Such an understanding should show more clearly how scientific discoveries have been made and might guide both industrial and institutional research into more fruitful channels of thought and investigation in the future. A clear knowledge of the growth of science should clarify some of the great problems that have arisen concerning the relationship of science to the Christian Church and to the Christian faith. An enlightened appreciation of many factors contributing to the development of science should be of great advantage in formulating a Christian view of science. A Christian view of science should take into account not only the fruits of science and the Christian's relationship to them, but should also deal with the basic ideaology of science and bring that also into harmony with the Christian world and life view. It is the purpose of this paper to describe three factors that have made great contributions to the development of science and to present a Christian interpretation of these influences. The scientific method, the phenomenon of serendipity, and of the scientific revelation sometimes called a "flash of genius," but more familiarly known as a "hunch," will be described and illustrated. A Christian interpretation will be placed on these influences and some conclusions will be drawn regarding the relationship of the Christian to the ideaology and achievements of science. Finally, some suggestions will be made concerning the strategy of Christian apologetics and fruitful fields of scientific research and investigation.

## II The Development of Science

In considering a development of science the first major difficulty is a definition of science. The question "what is science" was proposed to President Conant as the topic of the Terry lectures at Yale University in 1946.[2] He chose instead the topic "On Understanding Science," but eventually gave an approximate definition as follows: "As a first approximation, we may say that science emerges from the other progressive activities of man to the extent that new concepts arise from experiments and observations, and the new concepts in turn lead to further experiments and observations. The case histories drawn from the last 300 years show examples of fruitful and fruitless concepts. The texture of modern science is the result of the interweaving of the fruitful concepts. The success of a new idea is therefore not only its success in correlating the then-known facts but much more its success or failure in stimulating further experimentation or observation which in turn is fruitful. This dynamic quality of science, viewed not as a practical undertaking but as development of conceptual schemes seems to be close to the heart of the best definition."[3]

"Almost by definition, I would say, science moves ahead."[4]

Sarton[5] is more direct: "Definition: Science is systematized positive knowledge, or what has been taken as such at different ages and in different places."

Thus Conant emphasizes the dynamic and Sarton the cumulative and progressive aspects of science. Mees[7] re-echoes these same ideas and portrays the history of science as a helix developing progressively upward. In view of these points of view a paraphrasing of N.A. Court's[8] definition of mathematics might be equally acceptable: Science is what scientists are doing. A consideration of the developmental role played by the previously mentioned factors will further illumine these definitions.

A. The Scientific Method. Since there are many different scientific methods[9] we wish, for purposes of this paper, to consider the method which involves the following steps:

(1) The observation of a number of phenomena.
(2) The inducing of some degree of consistent behavior which we are calling a

natural law.

(3) The formulation of an hypothesis or theory interpreting the law.

(4) The testing of the theory by experiment or comparison with other known data.

The first step is the accumulation of data which are essentially sensory, and may be either qualitative or quantitative in nature. The second involves an inductive inference from all of the available information. It may take the form of a statement of natural law, or be condensed as a mathematical equation. The third point above always consists of a bold step of the imagination. It may be a mechanical model, a mathematical equation or a statement of principle, and is intended to be integrative in nature making both the preceding steps seem more plausible and generally acceptable. It should also stimulate the accumulation of information by the suggesting of further experimental work. The last step involves a testing of the theory to establish its consistency or inconsistency with new data.

The application of the scientific method in its entirety may, on occasions, be made by one person, or its complete operation may involve the combined efforts of many different workers in many different lands. A convenient and classical example of the latter is the development of the kinetic-molecular hypothesis, sometimes called the Kinetic Theory of Gases. Many of the foundational measurements on the volumes, and pressures of gases were made by Boyle, who formulated a law known by his name, relating the pressure and volume of a given mass of a gas at a constant temperature. These experiments were made in the late 17th century and were followed some years later by similar work by Charles in France who related the temperature and and volume of a given mass of gas held at a constant pressure. These investigations and those of Gay-Lussac, Avogadro and others laid the foundation for the formulation of the Kinetic Theory[10] from the ideas of Bernoulli, (1738), J. J. Waterston(1845), K. A. Krönig (1856), and R. Clausius (1857). It was given methematical formulation by J. Clerk Maxwell (1860) and L. Boltzmann in (1868). After rigorous testing, modifications and refinements of the gas laws have been made to enable them to describe the behavior of real gases over wide ranges of temperatures and pressures. Thus Van der Waals (1873), and Dieterici (1899) in the 19th century and Beattie and Bridgman in the early Twentieth Century were continuing the work on gases which had been started by Boyle in the sixteenth century. Cumulatively they were applying the scientific method.

It seems apparent that if such cumulative achievements are to be made there must be both an unrestricted exchange of information making the work of each investigator available to the others, and an atmosphere unfettered by political or ecclesiastical hindrances that would at least permit, if not encourage the pursuit of scientific investigations. In this respect the scientific method is similar to the other factors under consideration but differs from them in other respects.

B. The Role of Serendipity[11]

The word serendipity is derived from The Three Princes of Serendip or Ceylon and not from a combination of serenity and stupidity as some have supposed. These three princes were travelers and "were always making discoveries by accident or sagacity of things they were not in quest of," according to Hugh Walpole. Thus we are using serendipity here to indicate accidental discoveries of which the following may be taken as examples:

(1) The discovery of X-rays. Wilhelm Conrad Röntgen was studying the fluorescence caused by cathode rays. He was working in a dark room, and had covered the cathode ray tube with a black cardboard box which prevented escape of visible and U-V radiation. Nevertheless he noticed a definite glow when barium chlorplatinate was accidentally brought near the cathode ray tube.

Similarly Oersted discovered by apparent accident that an electric current in a wire can move a magnet. He had been experimenting with a magnetized needle and a wire carrying an electric current during which he held the wire by intent perpendicularly above the needle and nothing happened. By accident he brought the wire into a position parallel with the needle's position and the latter immediately changed until it stood at right angles to its former position. Later Faraday confirmed this experiment and also demonstrated that a moving magnet can cause a current to appear in a wire. From these casual incidents has grown our immense electrical industry, with its vast outlay in equipment.

Incidences of serendipity are not confined to the physical sciences. In physiology some striking discoveries have been 'forced' upon investigators. Charles Richet tells how, unexpectedly, he happened upon the curious phenomenon of anaphylaxis or allergy. He was testing an extract of tentacles of a sea anemone to learn the toxic dose on laboratory animals. After giving an initial dose and permitting a lapse of time, he administered much smaller doses to animals surviving the initial treatment. The second dose was promptly fatal. These results were so amazing that Richet had difficulty believing that anything that he had done was responsible.

Similarly 'accidental' observations were responsible for the discovery by Becquerel of radioactivity, of the relationship of nerves and blood vessels by Bernard, of the galvanic effect by Luigi Galvani. A chance observation was responsible for work leading to the discovery of insulin. Other similar occurences were Nobel's invention of dynamite, Perkin's discovery of coal tar dyes, and even Columbus' discovery of the new world. Practically all of these discoveries were followed by intensive investigation and many likewise were made by prepared workers. In this respect they are similar to our next topic, "hunches."

C. The Role of Hunches.

"Hunch" has been defined as "a unifying or clarifying idea which springs into consciousness as a solution to a problem in which we are intensely interested."[12] The phenomenon has been considered scientifically by Platt and Baker who sent out 1400 inquiries to various scientists listed in "American Men of Science." They received replies from 232 men of which 33% reported definite assistance from a scientific revelation; 50% indicated only an occasional aid and 17% never any hunches at all.

Typically hunches have been known to occur after long periods of diligent labor. Characteristically the mind is at rest, passive, receptive. It is essentially an involuntary wild leap of the imagination and is selective in its action. It is noteworthy that 83% of the scientists replying to Platt & Baker's questionnaire were familiar with the idea of a hunch although only a relatively small percentage of all men contacted were affirmative in their conviction of the benefit of hunches. Some typical cases:

"Freeing my mind of all thoughts of the problem, I walked briskly down Tremont street, when suddenly, at a definite spot which I could locate today--as if from the clear sky above me--an idea popped into my head as emphatically as if a voice had shouted it."

"Sunday in church the correct principles came like a flash as the preacher was announcing the text."

"I decided to abandon the work and all thoughts relative to it and then, on the following day, when occupied in work of an entirely different type, an idea came to my mind as suddenly as a flash of lightening and it was the solution. Like other "hunches" I have experiences in my research work, the utter simplicity made me wonder why I hadn't thought of it before."

Professor W. B. Cannon relates a peculiar case of Otto Loewi who received a scientific revelation after falling asleep over a trifling novel. He made a few notes concerning it for future reference. On awaking the following morning, he could make nothing of the notes on the paper. He even went to his laboratory to see if familiar surroundings would help, but to no avail. On going to sleep the second night, he again awoke in the darkness with the same brilliant idea. This time he made careful notes which were intelligible on awaking the next day. The experiments he carried out as a result served to establish chemical intermediation between nerves and muscles. Vast amounts of similar work was stimulated as a result of his discoveries.

A large number of scientists have recorded the receiving of hunches. These include Newton, Helmholtz, Poincare,[13] and of course Archimedes. The testimony seems to be unanimous that a relaxed condition of the mind, preferably preceded by hard work on the problem, is required. Volition seems to play no roll at all.

## III A Christian Interpretation of the Development of Science.

Science has presented a number of problems. A fundamental conflict seems to be involved in our hymnology regarding this world and the things of it, i.e. science. "This world is not my home ----etc." and "This is my Father's world ----etc--" Thus there is the Christian's relationship to the achievements of science. Many devout Christians accept, practice and preach the doctrine of faith-healing. Are we like the man in Pilgrim Progress who was rowing one way, and looking another if we employ the services of a physician, or appropriate and enjoy the manifold achievements of science and technology?

Then of course the non-Christian has claimed that the marvelous edifice of science is of the world's doing and Christians are parasites thereon. Finally there is the problem of the Christian scientist's relationship to the non-Christian scientist on a professional level.

To answer these and other questions we assert:

(a) God has builded the edifice of natural science through human instruments to reveal His handiwork, to bless mankind and to provide a means for accomplishing His purpose in the world.

(b) God has employed the phenomenon of the scientific method, as a modus operandi in dealing with man, the phenomenon of serendipity as a directive influence in channeling the growth of science and the matter of hunches as a superposition of His revelation on man's effort.

In evaluating this position we might well ask ourselves several questions:

(1) Is it consistent with pertinent Scripture?

(2) Does it place a plausible or permissible interpretation on the observed or observable phenomena?

(3) Does it violate any major positions in 'Christian Philosophy,' so called?

Let us consider first the application of the scientific method in the light of these questions. In the achievements resulting from the methodology, great mental abilities and physical skills are required. Many of the achievements of science have been accomplished by un-believers. Can it then be said that God had used such for His purposes?

In Matthew 5:45 "--for he maketh his sun to rise on the evil and on the good, and sendeth rain on the just and on the unjust." Thus God in common grace has poured out His blessing on all mankind regardless of their view toward Him. If as this verse states, they are receivers of material blessings, why not talents and abilities as well. And again, "The wrath of man shall praise Thee, and the remainder of wrath wilt thou restrain."[14] Surely if the wrath of the wicked shall praise the Lord as the Psalmist has said, their intellectual efforts should likewise do so.

In the second place, for the proper application of the scientific method an atmosphere in which scientific pursuits may be followed and in which free exchange of information can take place is required. We believe that Christianity has supplied this atmosphere and it seems that the great growth of science that has occurred since the Reformation is primarily a result of the atmosphere of freedom created by the latter. Natural science, like freedom itself, had its birth in Western Culture.[15]

But what about the scientific method and Christian Philosophy? Involved is first the philosophy of 'fact'. In the first step of the scientific method, we observe what I have called phenomena. It is not necessary at this point to take a profound epistomalogical stand on the nature of fact. Conant has avoided any epistomalogical question of fact very subtly by saying that "new concepts arise from experiments and observations, and the new concepts in turn lead to further experiments and observations."[16]

An interesting point arises in connection with the third step in the scientific method. We have referred to the formulation of a theory as a bold voluntary step of the imagination. The Scriptures tell us that "the imagaination of man's heart is toward evil continually." This may be only a moral inclination, but we suspect that it is intellectual as well, and would therefore expect that the work of the unchristian scientist would be most susceptible to error in regard to his theories. Since he is endowed by common grace with the same senses as ours we would expect that his observation of phenomena would be practically the same as ours.

Finally concerning the scientific method a very interesting point arises concerning theories. According to Huxley's exposition of the scientific method, a theory is tested by comparing it with 'facts' gained from experiments. He thus concludes that a theory is 'justified by works, not by faith." In contrast, Conant declares "We may put it down as one of the principles learned from the history of science that a theory is only overthrown by a better theory, never merely by contradictory facts."[17] Thus theories seem to be amoeboid in their operation in that when facts are encountered which may not be assimilated, the theory simply flows over and around them. If we accept Conant's principle, there are two points of importance both in the tactics and strategy of our Christian Apologetic:

(1) If we are to wage war successfully with any erroneous theory, we must formulate, propogate and support a better theory. Our action must be positive and comprehensive. The urging of a few conflicting facts will never deal a death-blow to any popularly help hypothesis.

(2) If, in the evaluation of our own theory or in defense of some Christian position we find a difficult or contradictory fact, this single item need not cause any capitulation on our part. We can, with complete intellectual respect invite the 'fact' to be seated in the waiting-room of our mind until we have the time and the necessary information to deal with it properly.

It seems in order now to inquire about God's handling of serendipity. We have seen that these incidences are in their occurrence, free of the volition of man. It is extremely doubtful if the results obtained by accident could have been obtained any other way. It is perfectly conceivable that if one had visualized the great need for x-rays, a research program involving easily a million dollars in men and equipment could have been carried out without achieving anything at all except the accumulation of files of well classified negative results.

In Ephesians 1:11, we are told that God worketh all things after the counsel of his own will. If all things, then surely the growth and development of science. Also in the book of Proverbs 16:33, "The lot is cast into the lap, but the whole disposing thereof is of the Lord." Thus, what to man appears chance, here is ascribed to the directing of God. Further, Jeremiah 10:23, "O Lord, I know that the way of man is not in himself: it is not in man that walketh to direct his steps." Thus we believe that God is employing serendipity or so called chance as a directive influence in the development of science. Surely if, as some claim, we can see the hand of God in history, we can see the hand of God in the history of science.

In the operation of 'hunches,' it appears that volition may have some indirect part in that a scientific revelation seems to follow a period of conscious effort on the part of the individual. Thus man's mind is prepared for sudden illumination. Volition is powerless, however, to produce a hunch if, after much effort, followed by a relaxed passive state, no "eureka" appears. Intense, self-willed intellectual effort is then a necessary but not a sufficient condition. There must be some additional influence. Poincare and others have attributed this action to the sub-conscious mind. While we are not hereby attacking the theory of the subconscious, we believe that it makes a plausible, fruitful, dynamic theory to claim that scientific revelations so called, are direct influences of the Holy Spirit superposed on man's effort.

It seems in order to inquire to what purpose is God erecting the edifice of science. We believe, as in the creation of man, for His own glory. Likewise our personal experience of the benevolent goodness of God, and the direct statement thereof in Scriptures constrains us to believe that He intends to provide means for the propogation of His Gospel and the provision of means of ministering to the intellectual, the physical and mental needs of man.

If this is true, it would be expected that we as Christians will find great fruitfulness in research in those fields of endeavor that may be used by God in the accomplishing of His purpose. In retrospect, we can see that major scientific discoveries in the past have practically perfected the two facilities most urgently needed for filling the great commission, i.e. communication (telephone, telegraph and radio) and transportation (land, sea and air). Furthermore tremendous advances in medicine have placed in the missionaries' hands great tools for a ministry of mercy as well as for his own protection. We believe that there remain great discoveries to be made that will assist in the Christian program and will make God's providential care more obvious. In all of these, the Christian man of science should surely find a place.

## IV Conclusions & Summary

(1) Science may be viewed as having arisen through the operation of the Holy Spirit on man endowing him with talents, creating an atmosphere wherein scientific efforts may be carried out, placing directly in his path new subject material for investigation and constantly attending his way with much needed illumination.

(2) In view of this action of the Holy Spirit, the Christian man of science may meet his non-Christian colleague on the common ground of common grace being fully persuaded that it is the same God that worketh in all. The Christian, however, in interpreting the achievements of the scientific world will pay particular attention to the results of man's imagination since this faculty is probably particularly liable to error.

(3) In actually combatting erroneous theories, he will strive to construct a more perfect hypothesis which is consistent with the Scriptures, in agreement with

the tenets of sound Christian philosophy and which places a permissible and logical interpretation on experimental observation.

(4) In his relationship to the achievements of science, the Christian should take full advantages thereof and use them all to God's glory; and remain a man of God among men of science.[18]

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DISCUSSION OF PAPER BY CONVENTION AUDIENCE

Dean Miller: (Presiding) I believe it has been your habit to discuss each paper after it is presented. What questions will you ask Dr. Barnes?

Dr. Marquart: There are a number of things here that bear upon the subject of psychology. In the first place, here is a question concerning the acceptance of the subconscious and evil by modern man, who is afraid to accept the fact of the subconscious. If we stop to think of the history of the subconscious and realize that it was used by the early psychologists and was formulated by Augustine, I think we could well accept it, so why should we go around trying to tear something apart that is described by Fraud erroneously?

Then there is this question of hunch and intuition which involves not only a lot of psychology, but also philosophy. They are hooked together by modern psychology and are considered to be nothing but chance. They are considered to be nothing at all by the modern psychologist. There is such a thing as insight but modern psychology is more like what is described in this paper.

How about the modern concept of the benzene ring which was discovered by a man who under those same conditions was riding along on the bus, and in the distance he thought there appeared the figures of six little imps. What was the man's name? I seem to have forgotten it, but I'm surprised that Dr. Barnes didn't mention it.

Dr. Barnes: The man was a chemist named Kekule. He was in an intoxicated condition at the time of his 'vision.' I did not mention him because as a fellow chemist I was trying to maintain our professional integrity. (Laughter)

Pres. Everest: I would like to ask Dr. Barnes if there is a difference of degree or a difference of kind between the two illustrations cited, the one of Roentgen, and his cathode ray tube, and the illustration of some of these other sudden flashes in the relaxed mind, in one's sleep or during a relaxed period. It seems to me that there is quite a difference between those two.

Dr. Barnes: I would say that I endeavor to draw the line of demarcation by saying that the first of these is what was considered conventionally a matter of chance. It might have been fairly probable that Roentgen would bump into this fluorescent phenomenon if he were working with this equipment; the latter however is not a matter of chance. Poincaire and a few others of his ilk seemed to put very great emphasis on the relationship between previous preparation and occurrence of what I have referred to here as a hunch. This is apparently an effort to bring the phenomenon into realm of naturalism. I have indicated that an obvious connection of hunches with volition is completely lacking. It would appear that if hunches are natural results of previous preparation, they should always follow such. This is not the case.

Prof. De Koning: I would like to ask what you mean by the reference to imagination. I don't understand what you mean by the implication that no results are obtained as regards the non-Christian, and that no man but a Christian can apply theories in a proper way? If that is true, I think I would disagree with that.

Dr. Barnes: My intended use of that reference was for purposes of analogy more than anything else. I am simply endeavoring to state that if the imagination, perhaps in regard to moral matters or something of that nature, is toward evil, then the bold step of the imagination in the production of scientific theories would likewise be expected to be colored by the same inclination and it may not be a volitional error, but it is nevertheless an error and of the two activities of the non-Christian scientist, I feel most suspicious of imagination rather than this business of actually discerning phenomena or "facts."

Dr. Marquart: There was an article that came out in the Christian Digest a couple of years ago about this question of imagination which may elucidate things a little here. As I remember it, it spoke of the word "imagination" as used in various parts of the Old Testament and New Testament, and although the meaning is not quite what we call imagination, it refers rather to a kind of thinking which is emotionalized in such a way that it would include such things as we commonly call rationalization. To use a modern psychological term, an intellectual type of thinking but one which is so emotionally distorted that it is rather untrustworthy, and I think that in that sense it fits in very nicely with what Dr. Barnes just said with regard to imagination.

## THE MEANING OF MATHEMATICS

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A word of explanation may be in order concerning the inclusion of a paper with the above title on a program of the American Scientific Affiliation. Most of the papers presented at our previous conventions have been apologetic in character and contained only a relatively small amount of scientific information. As individual members of this affiliation we cannot be equally competent in the various areas of science including mathematics, astronomy, physics, chemistry, biology, sociology, geology, archaeology, anthropology, psychology and philosophy. It seems to me that we need a series of papers presented at our annual meetings, each of which will attempt to explain the essential character of that field of science so that those whose special training does not lie in that area might be aided in their understanding of the problems involved.

Since mathematics has been called "the queen of the sciences" and also their handmaiden and since its essential character is so very poorly understood by many, it seems desirable to delve into the mysteries of this subject. In the first place I would like to point out that mathematics is much more than the art of computation. This reminds me of the young mathematics student who had recently returned from Germany after spending three years there earning the doctor's degree. He was greeted by an old acquaintance in his home town who asked him what he had been doing while abroad. "Studying mathematics" was the reply. "Studying nothing but mathematics for three years" exclaimed his friend as he gazed at a brick wall across the street, "why I suppose you could count the bricks in that wall at a glance." This illustrates a popular misconception in regard to the nature of mathematics. To be able to compute with ease and to perform a few simple mathematical tricks is often taken to mean that one is gifted in mathematics. Such, however, is not necessarily true. In fact, some noted mathematicians have been rather slow at numerical computation.

A fair competence in manipulation is admitted to be a necessary prerequisite to understanding a mathematical argument. But no amount of technical facility will of itself teach anyone what mathematics is or what proof means; nor will it suggest what is probably the most important reason why mathematics is today an even more vital human need and social necessity than it was in the past. Manipulative skill may suffice for the average technician in the trades but it is inadequate as an aid to self-respecting citizenship in even a moderately intelligent society.

Now just what constitutes the essential character of mathematics? I think that we may say that the essential element is reasoning and that it is mainly deductive in character, although not exclusively so, since in the formulation of many theorems, we use the inductive approach.

First of all we start with elements, the undefined terms concerning which all our mathematical reasoning is done. These elements have nothing whatsoever to do with the constituents of matter which are studied quite extensively in chemistry and physics. In fact, as far as the mathematician is concerned, they have no necessary relation to anything in the world of the senses. They constitute the building blocks, quite few in number, out of which is built the entire methematical structure. Examples are number, point, line, and plane. These elements or objects or concepts are so fundamental in character as to be incapable of definition. In mathematics we freely admit that there are some things which we cannot define. These are the elements. This lack of definition for the elements is a most important point of distinction between mathematics and other fields of knowledge. Most, if not all, definitions found in the dictionary are circular ones. That is, they define an object in terms of the thing itself. Now, really, a circular definition is not a definition at all. For example the definition of the word number as found in Webster's new international unabridged dictionary: "The total aggregate or amount of units (whether of things, persons or abstract units)". Here we find the word number defined in terms of aggregate or amount of units. But what meaning have these terms if not in terms of number?

After we have the elements of the subject, we next have definitions, axioms or postulates, propositions and theorems. The axioms are pure assumptions concerning the undefined elements. They may have been suggested by experience or they may have been chosen on the mere whim of some mathematician interested in seeing what he could make. In no sense are the postulates or axioms eternal truths or necessary; nor are they guaranteed by any extra human necessity or supernatural existence. The laying down of postulates is a free act of human beings.

The totality of the axioms of any branch of mathematics provides the implicit definition of all undefined terms in that area. For applications it is important that the concepts or elements and the axioms or postulates of mathematics correspond well with physically verifable statements about real tangible objects. The physical reality behind the concept of point is that of a very small object such as a pencil dot, while a straight line is an abstraction from a taut thread or of a ray of light. The properties of these physical points and straight lines are found by experience to agree more or less with the formal axioms of geometry. Quite conceivably more precise experiments might necessitate modification of these axioms if they are adequately to describe physical phenomena. But if the formal axioms did not agree more or less with the properties of physical objects, then geometry would be of little interest. Thus there is an authority, other than the human mind, that decides the direction of mathematical thought.

We usually require that the postulates be simple and not too great in number. Moreover, the postulates must be consistent, in the sense that no two theorems deducible from them can be mutually contradictory, and they must be complete, so that every theorem of the system is deducible from them. For reasons of economy it is also desirable that the postulates be independent, in the sense that no one of them is deducible from the others. The question of the completeness and of the consistency of a set of axioms has been the subject of much controversy. Different philosophical convictions concerning the ultimate roots of human knowledge have led to apparently irreconcilable views on the foundations of mathematics. If, as in the Kantian philosophy, mathematical entities are considered to exist in a realm of pure intuition, independent of definitions and of individual acts of the human mind, then of course there can be no contradictions, since mathematical facts are objectively true statements describing relations considered as real in the realm of pure intuition. From this intuitionist point of view there is no problem of consistency. Unfortunately, it has turned out that the intuitionist attitude, if applied without compromise, would exclude a large and important part of mathematics and would hopelessly complicate the rest. Radical intuitionists deny a legitimate place in mathematics to the number continuum. They completely reject all non-constructive proofs, and admit only the denumerably infinite as a legitimate child of intuition.

Perhaps we should add a word concerning the concept of the denumerably infinite. This brings in the added concept of one-to-one correspondence. Most of us have made use of this latter concept from our earliest attempts at counting material objects. As children many of us started to count by the use of our fingers. In fact, our word digit comes from the Latin, meaning finger. When you say that you have five objects and hold up five fingers to show the number, you are making use of the principle of one-to-one correspondence, which principle is very important in the consideration of infinite classes. In using this principle it is necessary to have two sets or classes of objects and then to add that if for every object in the first set there corresponds but one object in the second and conversely that for every object in the second there corresponds but one object in the first, then the number of objects in the two sets is the same. Now when we speak of the denumerably infinite we mean that we have a set which can be put into one-to-one correspondence with the set of the natural numbers: 1,2,3,4,... This set of the natural numbers is infinite, which simply means that if you name any number N, as large as you please, then there are still numbers in the set.

Quite different is the view taken by the formalists. They do not attribute an intuitive reality to mathematical objects, nor do they claim that axioms express obvious truths concerning the realities of pure intuition, their concern is only with the formal logical procedure of reasoning on the basis of postulates. This attitude has a definite advantage over intuitionism, since it grants to mathematics all the freedom necessary for theory and applications. But it imposes on the formalist the necessity of proving that his axioms, now appearing as arbitrary creations of the human mind, cannot possibly lead to a contradiction. Great efforts have been made during the last twenty five years to find such consistency proofs, at least for the axioms of arithmetic and algebra and for the concept of the number continuum. The results are highly significant, but success is still far off. Indeed, recent results indicate that such efforts cannot be completely successful, in the sense that proofs for consistency and completeness are not possible within strictly closed systems of thought. Remarkably enough, all these arguments on the foundations of mathematics proceed by methods that in themselves are thoroughly constructive and directed by intuitive patterns.

Let us consider a case where mathematical reasoning of the purely formalistic type has led to a contradiction. This involves the use of the concept of set without any restrictions being put upon it. This paradox, first shown by Bertrand Russell is as follows: Most sets do not contain themselves as elements. For example, the set A of all integers contains as elements only integers; A being itself not an integer but a set of integers, does not contain itself as an element. Such a set we may call ordinary. There may possibly be sets which do contain themselves as elements; for example, the set S defined as follows: "S contains as elements all sets definable by an English phrase of less than twenty words" could be considered to contain itself as an element. Such sets we might call extraordinary sets. However most sets will be ordinary, and we may exclude the erratic behavior of extraordinary sets by confining our attention to the set of all ordinary sets. Call this set C. Each element of the set C is itself a set; in fact, an ordinary set. The question now arises, is C itself an ordinary set or an extraordinary set? It must be one or the other. If C is ordinary, it contains itself as an element, since C is defined as containing all ordinary sets. This being so, C must be extraordinary, since the extraordinary sets are those containing themselves as members. This is a contradiction. Hence C must be extraordinary. But then C contains as a member an extraordinary set (namely C itself), which contradicts the definition whereby C was to contain ordinary sets only. Thus in either case we are led to a contradiction. What shall we do with the set C? I leave it to you to decide the matter.

Let us suppose that we have agreed upon some set of postulates or axioms for the undefined elements. One postulate for our points and lines might be, "two points determine a line," another, "two lines determine a point." The latter, by the way, would not usually be admitted in High School geometry, for in that subject are the exceptions introduced by parallels which, by definition, are lines having no point in common. But if we introduce an ideal point at infinity, all a matter of words without any clutter of mysticism, the postulate becomes intelligible without any exceptions.

Thus far we have the undefined elements and postulates about them. To the postulates we now apply common logic, or the laws of thought, and see what the postulates imply. The three so-called laws of thought of Aristotle are: (1) A is A (the law of identity), (2) nothing is both A and not-A (the law of excluded middle), (3) everything is either A or not A (the law of contradiction). These postulates of reasoning were once thought to be superhuman necessities and not, as they are regarded today, mere assumptions which human beings have made and agreed to accept. So let us refer to Aristotle's classical laws as the postulates of deductive reasoning. Deduction proceeds by an application of these postulates to those of the system, it may be geometry or algebra, which may be under investigation.

It is possible to make different kinds of assertions about the undefined elements. The most important of them are the propositions. A proposition is a statement which is either true or false. A true proposition is sometimes called a theorem. If true, we try to prove propositions by deductive reasoning. If false, an attempted deductive proof will sometimes reveal the falsity by the indirect method. Proof consists in seeing what the postulates of the system imply. Thus if P and Q are propositions and if Q follows from P by the postulates of deductive reasoning; and if further it is known or assumed that P is true, then Q is true. In particular, if P is one of our postulates which we have assumed at the beginning to be a true proposition, Q is true. But if it is not known whether Q is true, we may tentatively assume that it is false. If from this assumption we can deduce that Q is also true, we have a conflict with the postulate of excluded middle. But we agreed to abide by the postulates of deductive reasoning. To avoid the conflict we say that Q is not false, which we tentatively assumed; namely, Q is true, which we wished to prove.

The whole game is exceedingly simple. There are but two rules. First state all the postulates and second see that no other postulate slips into a chain of deductive reasoning. In geometry, for example, it looks as if a straight line which cuts one side of a triangle at a point other than a vertex must also cut another side. This is the sort of assumption which Euclid or some of his modern imitators might easily make. If it cannot be deduced from the remaining postulates it should be put in plain view with them as another postulate.

From the foregoing sketch of the nature of a mathematical system emerges the distinguishing feature of any such system, which is paradoxically stated in Bertrand Russell's epigram, "Mathematics is the science in which we never know what we are talking about nor whether what we say is true." The postulates from which everything starts are assumed to be true; to ask whether they are really true is to ask a question which is wholly irrelevent to the mathematics of the situation. The deductions from the postulates have the same truth value as the postulates themselves.

Although Russell's remark may tend to overemphasize the view of the older British school that mathematics is identical with logic; a view which, outside of Great Britain, is now generally regarded as untenable; it does call attention to a distinction between pure mathematics and applied mathematics. To see this, consider the statement often seen in elementary texts that the a,b,c,.....x,y,z of algebra represent numbers. Rather it should be stated that the letters are mere undefined marks or elements about which certain postulates are made. The very point of elementary algebra is simply that it is abstract, that is, devoid of any meaning beyond the formal consequences of the postulates laid down for the marks. Some of the elementary algebra is true when interpreted in terms of rational numbers; some of it is false for these same numbers; for example, the statement (which might be taken as a postulate in a first course) that every equation has a root. But we miss the whole point of algebra if we insist on any particular interpretation. Algebra stands on its own feet as a hypothetico-deductive system. An interpretation of the abstract system is an application.

To illustrate what has been said about mathematical systems let us glance at an elegant set of seven postulates for common algebra, from E.V. Huntington (Transactions of the American Mathematical Society, vol. 4, 1903, pp. 31-37). The system defined by these postulates is usaully called a field, and is identical, abstractly, with common, rational algebra. The fundamental concept involved is that of a class in which two rules of combination (or operations), denoted by ∅ b and a ⊙ b are uniquely known elements of the class. This is sometimes expressed as "the class is closed under operations ∅, ⊙." Neither a ∅ b nor a ⊙ b belong to the class unless so stated explicitely. These remarks are merely by way of introduction; the postulates follow.

Postulate A1. If a, b and b∅ a belong to the class, then a ∅ b = b ∅ a.

Postulate A2. If a, b, c, a ∅ b, b ∅ c, and a ∅ (b ∅ c) belong to the class, then (a ∅ b) ∅ c = a ∅ (b ∅ c).

Postulate A3. For every two elements a and b (a = b or a ≠ b), there is an element x such as a ∅ x = b.

Postulate M1. If a, b and b ⊙ a belong to the class, then a ⊙ b - b ⊙ a.

Postulate M2. If a, b, c, a ⊙ b, b ⊙ c and a ⊙ (b ⊙ c) belong to the class, then (a ⊙ b) ⊙ c = a ⊙ ( b ⊙ c).

Postulate M3. For every two elements a, b (a = b or a ≠ b), provided a ∅ a = a and b ∅ b ≠ b, there is an element y such that a ⊙ y = b.

Postulate [illegible] If a, b, c, b ∅ c, a ⊙ b, a ⊙ c and (a ⊙ b) ∅ (a ⊙ c) belong to the class, then a ⊙ (b ∅ c) = (a ⊙ b ) ∅ (a ⊙ c).

The unusual ∅, ⊙ instead of the familiar +, x are used to prevent any possible misconception that we are talking about numbers as in arithmetic. We are not; the marks or undefined elements a, b, c ... are marks and nothing more, and the seven postulates state everything that we are assuming about these marks and ∅, ⊙. It is easy to see, as already suggested, that the postulates define common school algebra (including the ban against attempting to divide by zero) up to the point where radicals are introduced. Perhaps the complete freedom, the arbitrariness of what we are doing will be more obvious when we realize that the seven postulates are independent of one another. That is, it is possible to exhibit a system which does not satisfy any particular one of of the sven postulates, but which does satisfy the remaining six. You may easily verify that the set of all positive rational numbers with a ∅ b and a ⊙ b now defined to be b and ab respectively, that is, a ∅ b equals b and a ⊙ b equals a, b, satisfies all the postulates except A1. In the same way, a system satisfying all except M1 is the system of all integral numbers with a ∅ b = a + b and a ⊙ b = b. A system which satisfies all integral numbers with a ∅ b = a + b and a ⊙ b = a + b. Perhaps you are getting bored with this discussion so I shall pass on to two very fine cases of mathematical reasoning which more nearly approach everyday experience.

The first case is that of the proof of the theorem which states that the number of prime numbers is infinite. As you will recall, a prime number is one divisible only by itself and unity. By the number of such numbers being infinite is meant that if one attempts to name any very large number as representing all the primes, that there are sti more primes to be found. The prooof is as follows. Let us assume that a largest prime number exists. C ll it P. Now let us form a number N as equal to the product of all the primes from the first one which is two to the last one which we have assumed to be P and then let us add one to this product. Therefore N = (a.3.5.7.............P) + 1. Now the question is whether this number is prime numbers starting with two and ending with P. Hence we see that this number.

is not divisible by any number other than itself and unity. Therefore it is prime and surely larger than P which we had assumed to be the largest prime. Hence we have a contradiction and we conclude that there does not exist a largest prime number and therefore the number of prime numbers is infinite.

The next case we wish to prove is that the square root of the number two is irrational, that is, it is a real number which is not the quotient of two integers. To prove this let us assume that the square root of two is rational and denote it by the ratio p/q, where p and q have no common divisor, that is, they have been reduced to lowest terms. Now square both sides of the equality and we have $2 = p^2/q^2$ or $p^2 = 2q^2$. Here we have applied the axiom that when equals are multiplied by equals the results are equal. If, however, $p^2 = 2q^2$, then $p^2$ is even and hence p is even since only even numbers when squared result in even numbers. If p is even we can express it in the form $p = 2n$. From this equation we have $p^2 = 4n^2$, again by the application of the axiom that when equals are multiplied by equals the results are equal. Now applying the axiom that things equal to the same thing are equal to each other we have $2q^2 = 4n^2$ or $q^2 = 2n^2$. This latter equation states that $q^2$ is even and hence q is even. This is a contradiction with out previous statement that p and q have no common factor since, if they are both even, they have the common factor two. Since our assumption that the square root of two was rational has led us to a contradiction, we conclude that the square root of two is irrational and the proof is complete. In both of these cases we have used the method of proof known as reductio-ad-absurdum.

We come now to the question of the application of mathematics to the physical world and to all of God's creation. We have emphasized the fact that pure mathematics is an invention of the human mind. The more nearly that the elements and the postulates of the subject correspond with what we consider as physical realities, the more closely will the results correspond and can be used to predict the manner in which physical phenomena will perform. Hence as was stated in the beginning of this paper, mathematics becomes the handmaiden or servant of the sciences. But just to say that something has been proved mathematically, does not insure that the results will correspond with physical phenomena. For example, it was proved a number of years ago that it was impossible for a heavier-than-air craft to fly through the air. This is no discredit to mathematics, but rather it serves to warn us that we need to be very careful in the applications of mathematics. Since all sciences are continually making more and more use of mathematical methods, we need to keep constantly on our guard that the results obtained correspond as closely as possible with physical phenomena.

Finally I would like to say a word concerning the relationship existing between mathematics and the Christian idea of God. Since I believe with Professor Jaarsma in his paper entitled, "Christian Theism and the Empirical Sciences" that "the God of Christianity as the Creator is the unconditioned Conditioner of all things, including the very facts and conclusions of science," I feel that even the thoughts of mathematicians have their ultimate source in God. However to say, as some have said, "that the Great Architect of the Universe now begins to appear as a pure mathematician," appears to me to belittle the idea of God. The pure mathematician is just a puny little man with a quite finite mind doing a small bit of purely human reasoning. If some of this reasoning does seem to aid us in delving into the mysteries of God's creation, we should give more glory to His name for allowing us this privilege. But to put the infinite God, creator and sustainer of the universe, as well as savior of our souls, into this category seems to me to be quite a serious blunder. May we then, as Christian men of sicnece, make more use of the mathematical method in science, since it has proved so fruitful in leading us into a deeper understanding of God's creation.

# DISCUSSION OF DR. HARTZLER'S PAPER

Dean Miller: Thank you again, Dr. Hartzler. Now who has the questions written down on the back of the envelop for this one? I dare you to ask him.

Dr. Bender: Maybe these postulates are purely arbitrarily chosen, but I think the fact reamins that Euclid's postulates are not arbitrarily chosen.

Dr. Hartzler: I don't know how he chose them, yet I think they are chosen in such a way to agree with the space relationships that we know of, so that the results of the Euclidian geometry and the reasons for the Euclidian geometry are usable, and the engineer can use them. Let's put it this way, is it correct to say that the postulates of the particular mathematical systems that we ordinarily use in applied mathematics, such as geometry and the number system---these postulates for these systems have been arrived at inductively by determining what postulates would be needed in the system which we are familiar with?

For instance, in the number system, we learn that A plus B equals B plus A by inductive reasoning. We try it by using several sets of numbers and finally by inductive reasoning we arrive at a generalization, at that conclusion regarding A plus B we may use it as a postulate in that system; and when we have our postulates chosen in that way, then we have the application that we want to use in applied mathematics.