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.

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(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 accumu-

lation 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.