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Science and Modern Thought

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Nineteen hundred years ago Jesus of Nazareth stood on trial before Pilate, and, in the course of his questioning of Jesus, Pilate asked, "What is truth?" To the scientist no more profound question could be asked unless it is "What is reality?" Earlier in his ministry Jesus had said: "Ye shall know the truth and the truth shall make you free." Every scientist realizes the truth of this statement for men have been freed from the handicaps of space and time and from the perils of many diseases through the truths acquired by scientists from their experiments and controlled observations.

This has been called a scientific age, and the man in the street has become so accustomed to hearing of new discoveries that he receives them and accepts them as matter of course, without giving much thought or having much concern as to the ultimate consequences of such discoveries. His thinking is unconsciously colored and influenced by these discoveries, most of which he does not understand or ever expect to understand. He reasons that they must be good for they bring him physical comfort, relieve his physical burdens, free him from many fears of disease and poverty, furnish him many foods and luxuries denied his forefathers, make available to him many pleasures, and, in general, give him on this earth what kings were denied in past centuries and what would have exceeded the prayers of and seemed heavenly to the suffering masses. At times he has had misgivings as to whether it could continue, and he has feared that too rapid advancement of scientific knowledge and invention might cause him trouble, but, with one development following another, his misgivings and fears have disappeared as new blessings are showered upon him. Many of his superstitions have passed away and he has learned to look upon many phenomena not understood by him, with curiosity rather than fear. He has developed a rather thoughtless and blind faith that science will eventually solve all his health, food, transportation, fuel, and sundry other problems involving his physical well being. In his daily newspapers and current popular magazines, some scientific, he reads of geological, paleontological, archeological, chemical, astronomical, and physical discoveries which involve tremendous stretches of time and space, and, not being discriminative, he accepts these statements as facts; for do they not come from the same general source that has provided him with other discoveries which he has found good? Does the same fountain give forth both sweet water and bitter?

Science has taught that all the phenomena of nature are manifestations of definite laws, which, if not already known, are capable of being known by man. Moreover, science further teaches that if the laws governing certain phenomena are known, these laws may either be made available for man's use, or man may adjust himself to them for his own welfare. Science teaches that nature is orderly, and anything that appears capricious or supernatural or contrary to known laws is due to ignorance of the laws governing such phenomena rather than the suspension of known laws. In other words the scientific attitude toward phenomena is one of curiosity, inquiry and hope for understanding and solution rather than one of fear and fatalism and all that goes with hopeless ignorance. Also the scientific attitude demands that scientific conclusions be based on experimental evidence and be subject to constant checking by further controlled experimental investigation.

It has not always been this way. There was a time when mere authority dominated beliefs, and to question this authority was to risk exile, prison, and even death. After the Greeks there was little scientific progress for many centuries. The church based what little that passed as science on the authority of Aristotle and on pure reason, and they built up the theological and philosophical doctrines through logic and speculative thinking, which, when applied to physical phenomena, have often brought the church into conflict with the conclusions derived from experimental investigation of these phenomena. Roger Bacon, an English Franciscan monk, who lived in the thirteenth century, was probably the first, after the Greeks, to insist that physical science be based on experiment, as Aristotle had taught that it should, rather than on arguments "deduced from premises resting on authority." Bacon held mathematics to be the basis of all sciences. He was deeply influenced by the works of the twelfth century Arabic philosopher, Averroes, whose commentaries on Aristotle had been translated into the Latin. However, Bacon was too advanced for his age, and although the works of Averroes continued to influence the thought of the Christian schoolmen, three centuries elapsed before Vesalius, Frabricius, Galileo, Gilbert, Brahe, Palissy, Harvey, and Francis Bacon appeared on the scene. All these men except Bacon were primarily experimenters; Bacon was a philosopher. Modern science may be said to have really begun with these men.

The sixteenth century had seen the quickening of mathematics which prepared the way for the marvelous developments of the seventeenth and eighteenth centuries. The theory of Copernicus, put forth simply as an hypothesis, that the earth rotates on its axis and revolves around the sun in a closed orbit, followed by the astronomical observations of Tycho Brahe, and the enunciation of the planetary laws by Kepler, were simply consistent with the spirit of the times, which had led to the discovery of America by Columbus, the experimental proof of the rotundity of the earth by Magellan, and the invention of the telescope with its subsequent verification of the Copernican theory, which dealt death blows to the Ptolemaic theory of the universe and the theological doctrines built on such authority.

Up until the sixteenth century what little that passed as science was based on the Aristotelian method of reasoning by the deductive method, that is, reasoning syllogistically from general principles. Francis Bacon, influenced by the works of Gilbert and probably Palissy, insisted that the scientific method should be one where facts must be collected and investigated, that nothing should be taken for granted, but that general truths should be derived from these facts and then tested and verified by further experiment. Bacon's method is the inductive method, first definitely stated by Palissy, and all that Bacon lacked of giving what is now accepted as the scientific method was the recognition of the value of hypotheses.

The seventeenth century is remarkable for the fundamental nature of its discoveries and their influence today. Galileo established the first law of motion, determined the laws of falling bodies, and possessed clear notions of acceleration and the independence of different motions. He understood centrifugal forces and gave a correct definition of momentum. Galileo is considered as the founder of dynamics. Huygens invented the pendulum clock, improved the telescope, discovered the true nature of the rings around Saturn, stated the laws of centrifugal forces, and was the first to write a formal treatise on probability. Huygens also was author of the theory of light as due to vibrations in the ether which filled all space. Fermat and Pascal also made contributions to the theory of probability, and Halley published a mortality table and applied some of the ideas of probability in an attempt to ascertain the prices of annuities on lives. Römer, through a study of the eclipses of Jupiter's moons, discovered the finiteness of the speed of light. Newton, familiar with the works of Kepler, Galileo, and Huygens, enunciated the law of universal gravitation and the three laws of motion. He explained the decomposition of light and the nature of the rainbow, formulated some of the laws of optics, invented the reflecting telescope, and was the author of the corpuscular theory of light. Newton's law of universal gravitation is expressed in terms of mass, distance, and time, where time is included in the conception of force.

Also the seventeenth century saw the development of Descartes' philosophy which is still important today. Descartes, celebrated as a mathematician and philosopher, with his subjective method starting with, "I think; therefore I am," as his first scientific truth and major premise, upon which all other scientific truth must be based, approved of Bacon's methods in natural science and hoped through the dissection of the brains of animals to find something about the psychic processes. Spinoza, Leibnitz, Hobbes, Locke, and Berkeley, through intuition and speculative thinking, expressed many ideas that will be found to have much in common with modern thought.

The eighteenth century is very important in mathematical history on account of the great progress made in mathematical discoveries and their application to physical phenomena. Also the work of the great mathematical thinkers of the eighteenth century prepared the way for one of the profound developments in mathematical interpretation that came to fruition in the first half of the nineteenth century and revolutionized mathematical thinking. Euclid, who lived about 300 B. C., compiled all the geometry known to the Greeks at his time. This is the geometry taught in our high schools. Among the postulates or axioms used by Euclid was one known as the Fifth or Parallel Postulate. The history of this parallel postulate, or axiom, is very interesting for, since the time of Euclid, various mathematicians at various times had questioned it as an axiom. Many attempts were made to prove it, and then finally two mathematicians, Lobatschewsky and Bolyai, working independently, came to the conclusion that it was not provable simply because it was a definition instead of an axiom. Accordingly, they constructed a logical, consistent geometry and trigonometry by defining parallel lines independently of Euclid's Postulate. In their geometry, sometimes called hyperbolic geometry, the sum of the three angles of a triangle is always less than two right angles. This geometry, based on intuition, as is Euclid's, was the first geometry constructed that did not rely on physical experience or observation for its acceptance. In fact, it seems to contradict experience. Its discovery marked an epoch in mathematical thinking. The discovery of this geometry was followed by the discovery of what is known as elliptic geometry by Riemann in which the sum of the three angles of a triangle is always greater than two right angles and the straight line is not infinite in length. This is the elliptic or Riemannian geometry, which has served as the basis of representation for the physical space required by the theory of relativity. The well known Euclidean geometry is a limiting case of both the hyperbolic and elliptic geometries. Since the discoveries of these two non-Euclidean geometries, many other geometries have been discovered, as abstractions at least, which are logical and consistent. As a result of these discoveries, the foundations of mathematics have been subjected to severe and critical investigation.

Naturally the question to be asked is: which is the true geometry? Mathematically they are all true since truth here means merely consistency. The question of truth in fact is replaced by one of reality as based on our sense experiences in the physical world. The answer at present is that, for practical purposes on this earth, the Euclidean geometry is sufficiently accurate, but for astronomical space the geometry must be elliptic. However, the chief importance of the discovery of non-Euclidean geometry does not lie in its apparent explanation of some of the phenomena of nature, but first in the fact that the application of mathematics to a phenomenon does not mean that the conclusions derived must be true or real; second, the reality or truth of the conclusions must be based on experimental evidence; and, third, great care and caution must be exercised in setting up axioms, definitions, and hypotheses in the explanation of physical phenomena. As is to be expected, the philosophers became interested in mathematics.

Mathematical reasoning is primarily deductive; that is, certain statements are accepted as basic and then conclusions are deduced from them. These basic statements may be the result of intuition or inductive reasoning or merely pure assumption. First, certain notions or concepts are taken as undefined. For example, in the ordinary Euclidean geometry, the concepts *line* and *point* are taken as undefined. Then a set of relations, called axioms, are set up and certain definitions may be given in terms of the undefined elements and axioms. Thus, "The straight line is the shortest distance between two points," is taken as an axiom and from this axiom and the undefined elements, the definition of the circle is given. Then certain conclusions, known as theorems, are deduced by correct reasoning from the set of undefined terms, axioms, and definitions. The whole body of undefined terms, axioms, definitions, and conclusions or theorems is said to constitute a mathematical or logical system. The check on this system is its consistency, and the question of its truth or falsity is meaningless. The axioms, of course, must be consistent, and in order to reduce their number to a minimum, the attempt is made to choose axioms that are independent of each other, that is, no axiom may be deduced from any one or more of the other axioms. The discovery of conclusions or theorems may occur as the result of inductive or deductive reasoning, reasoning by analogy, intuition, observation, statistical analysis, *et cetera*, but the proof of the conclusions, as was said before, must be established deductively.

Pure mathematics deals with abstract mathematical systems. It may happen, however, that the undefined terms, axioms and definitions, may be given physical interpretations, or certain physical assumptions may be appended to the abstract mathematical system, with the result that we have applied mathematics. Then the conclusions will be valid only provided they check with experimental results. Since the principal business of all science is to measure and to weigh, it follows naturally that mathematical methods will find application in all the sciences, and all sciences dealing with quantitative data must become mathematical in their methods and reasoning. Hence we should not be surprised to find, not only the astronomers, physicists, and chemists thinking and speaking in mathematical language, but also the biologists, psychologists, economists, and others.

The great advantage to be derived from stating a theory in mathematical language or terms lies in the possibility of making predictions, which suggest further experimental work. Thus the mathematical work of Maxwell in 1865 led him to predict that light is an electro-magnetic phenomenon and that an electric discharge must create disturbances in the ether which travel through space with the speed of light. This was verified by Hertz in 1888, and these experiments led to the modern radio. The discoveries of the planets Neptune and Pluto are two other excellent illustrations of the power of mathematical prediction. The prediction of eclipses, by means of mathematical computation, is, of course, a common affair in astronomy.

Now the seeming absolute reliability of such laws as the laws of motion and the law of universal gravitation, which are expressible in mathematical language and which have led to new discoveries and have made predictions possible that have been consistently verified, naturally leads one to believe in complete dependence on results yet to be discovered or verified. This belief in one's ability to predict and forecast on the basis of supposed known laws is a sort of scientific extrapolation and leads to a deterministic philosophy toward the physical world, sometimes called the certainty principle. Out of it came the mechanistic ideas so prevalent at the close of the last century. In other words, if this idea is carried to the limit, one has scientific predestination.

The nineteenth century was rich in ideas which have had a tremendous influence on philosophical thought. Following the mathematical discoveries already discussed, came the principle of the conservation of energy, the principle of least action, the second law of thermo-dynamics, the kinetic theory of gases, the theory of evolution, the germ theory of disease, Mendel's Laws, and others.

The principle of the conservation of energy was supposedly firmly established through the work of Robert Mayer, Colding, Joule, and Helmholz. The idea was not new, for there are evidences of it in the works of ancient philosophers, and Descartes held that it was self-evident, but it required Joule's discovery of the mechanical equivalent of heat and careful verifications of chemical changes, *et cetera*, all done experimentally, to place it in the same category as the law of universal gravitation.

The second law of thermodynamics simply states that the amount of available energy in the universe is decreasing. As an ultimate consequence, if this law is true, the physical universe will eventually become a cold, static, lifeless system. Naturally any philosophy built on such a law will be pessimistic. Here is an expression of the certainty principle with its mechanistic and predestined conclusions which has brought about such a book as *The Degradation of the Democratic Dogma*, by Henry Adams.

The kinetic theory of gases, based on the molecular structure of matter, was formulated mathematically by Clausius, Maxwell, and Boltzmann. It states that the temperature of the gas is merely a manifestation of the average kinetic energy of agitation of the gas particles, and the pressure on the wall of the container of the gas is due to the "sum total of the innumerable impacts which the particles individually make upon it, and is measured by the total change in momentum imparted every second to the walls." The kinetic theory is a macroscopic study of the results of the movements of the gas particles and is based on the idea of probability. Thus, no attempt is made to record the history of any one particle nor to predict what any one particle may do, but only the composite effect is forecast. An analogous method of reasoning is used by a life insurance company. Mob psychology is based on similar reasoning. The concept of probability is fundamental in modern thinking. It enters all kinds of scientific thinking. For example, in genetics it is possible for a mulatto couple to produce a white child without a single Negro gene or a Negro child without a single White gene, but the probability is small. Nevertheless it exists and consequently the concept of race mixture is quite different from the mere mixture of blood.

The controversies that have arisen over the theory of evolution are well known. Many of these were due to misconceptions. Now the theory of evolution deals with that part of nature which involves living matter, whereas the physical laws just discussed are primarily concerned with inanimate or mechanical systems. Accordingly, the theory of evolution immediately came into conflict with certain notions or dogmas of the church, particularly as the theory of evolution applied to man. The idea of a slow orderly change was accepted in astronomy and geology long before it was accepted in biology as based on research. The idea of evolution can be traced back to Aristotle and other Greek philosophers. "Scientifically, evolution is a law of nature and is proved or established as firmly as is the law of gravitation, and precisely in the same way. Just as the theory of gravitation was an inference derived from facts and has served to explain and rationalize other facts, so the theory of evolution was offered as an explanation of facts and has served to make intelligible enormous numbers of facts obscure on any other grounds."[1] Looked at in an unbiased and dispassionate way, the theory of evolution is merely an attempt to explain the methods used by the Creator in bringing about the 800,000 different species of animals and the 300,000 species of plants already known and described in biology. It states that the physical manifestations of life are not static, and its principles, supplemented by the practical applications of Mendel's Laws and genetics, as applied in modern agriculture, animal and plant breeding, *et cetera*, have changed and are now changing modern thought. It influences our thinking and actions in ways which we accept unconsciously, as, for instance, that no two individuals are identical physically, which serves as the basis of identification by finger prints.

The germ theory of disease, based on the work of Jenner, Pasteur, and Lister, has had as profound but more subtle influence on thought as has the theory of evolution. Since it directly concerned the welfare of mankind it also came into conflict with dogma, scientific or otherwise, and, while it is not yet generally accepted and probably never will be, nevertheless, its effect on human thinking has been sufficient to remove visitation of disease from the realm of the supernatural. An epidemic of typhoid fever or smallpox is no longer ascribed by thinking people to the wrath of a vengeful God, to be submitted to with resignation and despair or accepted as blind fate or predestination. Fortunately or unfortunately the fear of disease does not have the same power nor the same kind of power that it once had to control man's moral and spiritual actions.

As a result of the scientific developments of the nineteenth century there grew up among scientists a feeling that all the phenomena of nature might be explained on the basis of motion of the particles or atoms of the bodies concerned. As long as this conception was limited to inorganic matter it was of interest to the scientists only, but when it was made a working hypothesis in biology by considering life itself "an expression of the transformations of energy and of matter in a large group of materials, differing in detail, but alike in certain fundamental respects—materials known technically as protoplasmic and which constitute what Huxley termed 'the physical basis of life,'"[2] it came into conflict with the vitalistic conception that life involves in part at least manifestation of laws and forces not to be found in the inorganic world. While at one time the question of the mechanistic conception versus the vitalistic conception produced more heat than light because of the dogmatic attitudes assumed by those taking sides in the controversy, the present attitude is one of uncertainty. However, the discovery of the genes as controlling the heredity of physical characteristics and possibly mental characteristics, the discovery of the organizer center of the embryo which seems to control the differential growth of the embryo, and the discoveries of the chemicals known as hormones which

[1] The Nature of the World and Man, H. H. Newman, Editor, p. 193.
[2] The Nature of the World and of Man, H. H. Newman, Editor, p. 165.

play such a fundamental part in the bodily growth and functions, both mental and physical, tend to support the mechanistic conception; but until life is actually produced by purely physical and chemical conditions, the question must remain open. Nevertheless, these mechanistic discoveries have influenced and will continue to influence modern thought in its consideration of many social problems, such as involve behavior, individual responsibility, freedom of the will, *et cetera.*

The present century has been very productive of scientific discoveries and theories that are moulding thought. The theory of relativity, the quantum theory, the theory of an expanding universe, the discovery of cosmic rays, the discovery of radium and radioactivity, and the discoveries in subatomic physics are too recent to determine just what the ultimate effect on philosophic thought will be. Of one thing we can be certain and that is their scientific discussion must be confined to the very few who have the mathematical training to interpret the mathematical symbolism which serves as the means of their expression. In other words, the deductions from the theories may be made by only a few, and their conclusions must be accepted or rejected by the great majority in exactly the same way that religious dogmas are accepted or rejected. There is this one difference, however, namely, that any one with the proper skill and resources at his command is free to verify the experimental results and thus check the conclusions.

The theory of relativity grew out of the famous Michelson and Morley experiment, first performed in 1887, in an attempt to detect the earth's motion relative to a supposedly stationary luminiferous ether, the expectation being that the speed of light would be slightly different when measured along and at right angles to the earth's orbital motion. No such difference was detected, and the only possible explanation was that the measuring apparatus became shorter when placed in line with the earth's orbital motion than when it was placed at right angles to the orbital motion. The idea that space was filled with this ether came about through the acceptance of light as a wave phenomenon which seemed to require some medium for the propagation of the waves. Newton, who believed light to be corpuscular, considered space to be empty. The theory of relativity rejects the idea of a stationary ether and makes assumptions whereby the ether medium is not necessary. The special relativity theory makes two fundamental assumptions, first, that there is nothing definite out in space like an ether or a fixed condition whereby absolute motion may be detected, and, second, that the speed of light is independent of the motion of the light source, that is, the speed of light is the same to all observers regardless of their motion or any motion of the light source. There are, of course, other assumptions which bring about a conception of space and time that is different from the Newtonian conception. "It appears that the universe is four dimensional, its dimensions being length, breadth, thickness, and *time;* and this 'space-time' is curved in a fifth dimension, the curvature being the greatest in the neighborhood of bodies of greatest mass."[3] Since the results differ from the Newtonian theory only when the speeds are very great or the masses are enormous, the theory of relativity finds its verifications in the

[3] Astronomy, Third Edition, J. C. Duncan, p. 329.

study of the masses of the stars, the motions of the planets, the motions of atoms and electrons, particularly in the spectrum studies of the elements, and the phenomena of light. It affords a much simpler explanation of the laws of the physical universe by establishing fundamental relations between mass and energy, electricity, gravity, and radiation in general. It is this unification or integration, which is accomplished through the relativity theory, that is important and which is influencing modern thinking.

Closely allied to the theory of relativity is the quantum theory. This grew out of a study of radiation from the heated ideal black body. Also, in what is known as the photoelectric effect, electrons are liberated from a metal surface upon which light is falling. The remarkable fact about this liberation is that, while the total number of electrons liberated is proportional to the intensity of the light, the energies of the emitted electrons are independent of the intensity. This fact leads to the conclusion that the atom is capable of existing only in certain definite stationary states, each state having a certain definite energy. Since the change in state results in radiation and light is a form of radiation, another conclusion is that light is corpuscular in its structure, which is similar to Newton's idea. But light obeys also the wave theory and the attempt to explain interference and diffraction by means of the corpuscular theory alone has not been satisfactory. Thus a seeming contradiction exists. The most recent theory reconciles the two theories by assuming "that atoms emit wave fields as in the electromagnetic theory, emitted by certain oscillators connected with the atom, and vibrating with the emitted frequencies. These waves do not carry energy, but serve merely to determine the probable motion of the photons. The rate of emission of waves by the oscillator determines the probability of emission of photons."[4] The relations between the photons and waves are statistical, and a similar relation exists between electrons and waves. Based on experimental results the theory is extended to mechanics and leads to what is called statistical mechanics or wave mechanics of which the Newtonian mechanics is a limiting case.

As you may have observed, the ideas of probability are fundamental in the quantum theory. Probability is a means of securing macroscopic results as against microscopic results. Where probability is applied, it is assumed that knowledge of the actions of any one individual may not be predicted with certainty, in fact may not be determinate. Moreover, any attempt to observe the individual may disturb the normal condition, for all we may know, and the results may be different from those that would occur had there been no disturbance. This reasoning leads to the uncertainty principle, now generally accepted in modern physics, and its application is being extended to biology and psychology. This principle of uncertainty strikes at the root of mechanistic determination or scientific predestination. In other words, philosophically, the question of free will enters, and physics is becoming somewhat metaphysical in its interpretations. Modern relativity and the quantum theory are highly mathematical and deal with abstract symbolism that often is impossible of physical interpretation in terms of sense pictures. For their validity

[4] Introduction to Theoretical Physics, Slater and Frank, p. 332.

they must rely on the physical verification of their predictions and not on any possibility, at least at present, of simple pictures of the phenomena which they attempt to explain.

Modern science is dealing with the macroscopic effects of the unseen. The electron, atom, molecule, gene are all invisible. Many laws that seem to be valid are macroscopic laws; that is, they are conclusions based on high probability. Some of these laws do not hold in atomic or subatomic processes. The scientist Dirac has recently stated that, on the basis of certain experimental results, the principle of the conservation of energy does not hold in atomic processes. In like manner, the question as to whether the second law of thermodynamics holds has been raised. The studies in cosmic rays have suggested that the second law of thermodynamics represents only one aspect of the transformation of energy in that the existence of radiant energy in space, both inaccessible and invisible, is ignored. Thus we find modern physics faced with uncertainty in the universality of its important laws.

During the past twenty years, owing to the remarkable discoveries in astronomy, science has become popularized. Eddington, Jeans, Slosson, and others have written for the masses. In fact the public interest in science is so great that the recent book by Hogben, entitled *Mathematics for the Million*, has been among the six best sellers in non-fiction during the past few months. President Roosevelt's birthday balls, the 200-inch telescope, the planetariums, the scientific rearing of the Dionne quintet, the great atom smashing machines, the stratosphere explorations, and numerous other scientific studies hold the interest of the general public. Almost any form of scientific speculation built around a few experimental facts, when told in an interesting way, arouses public interest and too often is accepted by the public as proved conclusions. There is, accordingly, danger that modern thinking will become extremely superficial unless scientists are careful to state what is fact and what is speculation.

Modern science has become what it is through co-operative and group effort. It knows no national boundaries, and practically all nations, without regard for race or color, have made contributions. National self sufficiency is no longer possible, and, once this has become generally recognized, co-operative effort on the part of nations should follow.

Science has led to intense specialization with its attendant narrowness. Also this implies absolute honesty and good faith on the part of the research scientist, for his fellow men must accept his findings without the means of checking them. Modern thinking demands faith, a faith as great if not greater than that required to believe the miracles of the Bible. To accept the picture of the atom with its high speed electrons spinning around a nucleus with space relations similar to the space conditions for the sun and its planets, the whole atom invisible and infinitessimally small, requires faith. To believe that invisible genes, estimated to be one two millionth of an inch in length in the Drosophila, for example, contain the whole mechanism of heredity, and in a physical sense, at least, immortality, requires faith on the part of one not a specialist in biology. This faith to be sure is not the same as blind faith for the observations upon which it is based are subject to check.

The greatest contribution of science to modern thought is the idea of unity in nature. Thus all living creatures are unified through the theory of evolution. All the chemical elements may be built up from electrons and protons, and the disintegration of the atom is an experimental fact. Matter and energy are two aspects of the same phenomenon. Radiation theory unifies the phenomena of light, electricity, heat, cosmic rays, X-rays, *et cetera*. Astronomy has unified the physical universe. Moreover all the sciences are becoming united through the bond of mathematics, and, as they become more mathematical, they become more abstract and are subject to conditions which mathematics imposes. The application of the laws of probability to both physical and natural science tends to unify these fields.

Finally, what is the relation of science to man? Science has been held responsible by some for the cruelty and bitterness that is now in the world, but science should not be blamed for man's misuse of scientific discoveries. Undoubtedly, man considered as an object among objects has little significance, in the light of the discoveries of galaxies and supergalaxies. Science has undoubtedly undermined such beliefs as the suspension of laws in the physical world. Man, reasoning about the immense stretches of space and time which science demands, questions the validity and reasonableness of threats of eternal punishments for moral failures. Moreover science shows that moral delinquency may be often due to functional disturbances in hormone secretions. These facts may in part also account for the apparent decline in interest in personal salvation and personal immortality. However, the failure of man to maintain moral control of himself cannot be chargeable to science. Morality and the things of the spirit are not, at present, at least, the province of science. But we must face facts, and it would be well for the scientists, philosophers, and theologians all to follow the Apostle Paul's advice to the Thessalonians: "Prove all things; hold fast that which is good." Possibly the scientific method points the way for a more demonstrable religion. Science deals with things that can be weighed and measured. There are other things, many of us believe, that cannot be weighed and measured. Science, philosophy, and religion must work together, each recognizing the strength and limitations of the other, each recognized as a manifestation of the Supreme Creator. Both the scientist and the man of religion must realize that ultimately "truth will prevail and error will be confounded, whether it comes from conviction or observation."[5]

[5] Discovery or the Spirit and Service of Science, R. A. Gregory, p. 53.