Introduction: Science, Facts, and Values
Philipp Frank
[c. 1956-1963]

I. Science and Poetry

Before the 18th century it was understood that human values, or, in other words, the rules of human behavior were provided by theology and philosophy. In his book, The Existential Revolt (Milwaukee, 1952) Kurt Reinhardt writes: "In the course of the 19th century, in the adoption of the 'scientific method' by historians, jurists, sociologists and 'humanists,' the Western world began to reject the guiding principles provided by these two disciplilnes (philosophy and theology). 'Truth' henceforth was to be found exclusively by those sciences which analyzed and described extended and measurable physical reality." However, it has been repeated again and again that science can only teach us 'facts' but cannot provide any 'values.' Hence, by basing the rules of human behavior upon the sciences, the influence of moral principles disappears and the life of men becomes more and more empty of spiritual guidance. This distinction between facts and value has also served in the 19th and 20th centuries to bring about a "truce" between science and religion. While science was to provide 'facts,' the task of providing 'values' was assigned to religion. By this method, a division of labor could be established. When the institutions of higher learning put the emphasis on science, they failed to develop a sense of values among the students. Distinguished speakers at commencement celebrations, like Adlai Stevenson at Smith College in 1955, deplored that the "contemporary environment in America is an environment in which 'facts,' the data of senses, are glorified and 'value judgments' are assigned inferior status as 'mere matter of opinion'….philosophy is not only neglected but deemed faintly disreputable because 'it never gets you anywhere.'"

The overemphasis on facts and the neglect of values in our education have been made responsible for a great variety of evils on our contemporary scene; for the irresponsible way in which scientists produced the atomic bomb, for the decline of religion among educated men, and even for juvenile delinquency. This kind of argument has almost become commonplace among raders of magazines and college graduates. However, this sharp distinction is based on a rather vague concept of what is a 'fact.' It is interesting to note that Archibald MacLeish, a prominent contemporary poet, who certainly has not bee partial to science, accuses science of placing too little emphasis upon fact. In his article, "Science and Poetry" (Atlantic Monthly 1956), he asserts that 'science' is very remote from 'facts' if we mean by it 'facets of reality.' [cf. Frank in Daedalus, 1958, p. 58]

He makes the point that 'science' never speaks about real facts that happen in nature. For instance, when science describes an atomic explostion, it describes neither the human sensations nor the human emotions connected with it, but a set of abstract symbols like electric forces, chemical affinities and so on. Science 'interprets' facts but it does not 'present' them. MacLeish tries to

formulate the basic difference in the way sin which science and poetry approach reality. "Science has abstract ideas about apple from apple… But poetry, we know, does not abstract. Poetry presents. Poetry presents the thing as the thing…. It should be possible to know the thing as the thing it is—to know apple as apple—this, the true child of the ti[m?]e will assure you, cannot be done. To the true child of abstraction, you can't know apple as apple. You can't know tree as tree; you can't know man as man. All you can know is a world dissolved by analyzing intellect into an abstraction—not a world composed[?] by imaginative intellect into itself."

His main point is that science does not teach us the real facts but an 'impoverished' picture of them. He writes: "Young men and young women graduate from American schools and colleges by hundreds and thousands every year to whom science is the only road to knowledge, and to whom poetry is little more than a subdivision of something called 'literature'." According to Macleish, the emphasis on science in education and the neglect of poetry as a way of 'knowledge' leads to a world picture which is based essentially upon 'abstractions.' He continues: "This sort of thing has consequences… Abstractions have limiting, dehumanizing, dehydrating effect upon the relations of things to the men who must live with them. The result is that we are more and more left, in our scientific society, without the means of knowledge of ourselves as we truy are, of our experience as it actually is. We have all the tools,—we are suffocating in tools—but we cannot find the actual wood to work on or even the actual hand to work it. We begin with one abstraction (something we think of as ourselves) and a mess of other abstractions (standing for the world) and we arrange and rearrange the counters….but we simply do not know what we are doing."

While in the 19th century it was a generally accepted truth that science was the beacon which guided mankind towards a bright future, in the 20th century there have been quite a few critical voices. Science has not only been accused of being unable to provide a sense of values among its students, it was even claimed that science cannot provide a knowledge of facts if one means by it a knowledge of the real world. We learned this clearly from Macleish, but we find similar opinions expressed by other representatives of the arts. We may quote some words of Aldous Huxley who claims in his book, Science, Liberty and Peace, New York, 1946, that the scientists and their followers "tend to accept the world picture implicit in the theories of science as a complete and exhaustive account of reality" and "to regard those aspects of experience, which scientists leave out of account, because they are incompetent to deal with them, as being somehow less real that the aspects which science has arbitrarily chosen to abstract from out of the infinitely rich totality of given facts." [cf Frank in Daedalus 1958, p. 58]

II. Charges Against the Monopoly of Science [F writes "Bankruptsy of science" top of next page]

The confidence in science in the 19th century was a double one. First, one believed that science would provide us with the 'truth about the universe.' This knowledge an insight would improve more and more along with the advances in science. Secondly, the advances in scientific knowledge would increase the satisfaction and happiness of men. Scientific knowledge and personal happiness would increase simultaneously. Towards the end of the 19th century quite a few authors had cautioned against this confidence. One started to doubt whether scientific knowledge actually gives us insight into the nature of the universe, and whether the advances of the 19th century actually had enhanced the happiness of men. These doubts were voiced in an impressive way by F. Nietzsche, in 1866, Birth of Tragedy: Preface, "What I got hold of that time was something terrible and dangerous, a problem with horns, not necessarily a bull, but certainly a problem; the problem of science itself, science comprehended for the first time as something problematical and highly questionable."

These doubts about science were encouraged by the mounting conviction that science in its 19th century form with its belief in "progress" had actuall failed to achieve its promise. Technical progress had rather produced suffereing and despair among the people who were supposed to serve as the guinea pigs of technical advance. Towards the end of the 19th century and particularly around the turn of the 20th century two strong political and social groups, or, more generally speaking, two schools of human conduct grew up. On the one side a certain longing towards the society and the philosophy of the Middle Ages, and on the other side, the strong belief in Marxist Socialism. Both groups strongly opposed the political and religious way of life which was based on what one had called "objective science." They were, above all, opposed to the belief that science could by its own methods derive 'objectively' without any help from political or religious creeds, a way of life which would guide the world to happiness.

The right-wing movement against "scientism," (i.e., the over-rating of science) has been known by names like Christian Socialism, National Socialism, Fascism, Religious Revival, and, occasionally, New Conservatism. The left-wing movement has been known under the name of Marxism, or, in a more philosophical parlance, Dialectical Materialism. Both movements, left and right have been strongly opposed to what has been called the 'science' of the "liberal bourgeoisie."

By this word, one has denoted the science which is taught in all Western universities. This science is allegedly infiltrated by the political and religious ideas of the liberal bourgeoisie to which groups the faculties mostly belong. [top of page: F writes "3 Fight against 'scientism"] Specifically it is infiltrated by the ideas of "free thinking" and "free economy." The rightist and leftist groups of which we spoke have stressed the point that the belief in free thinking and free economy are not the result of some 'objective' science, but of the political and religious predilections of the scientists. Science claims to provide objective truth but is actually a manifestation of the political and religious creeds which are dominating our universities.

It has been a conspicuous phenomenon in our 20th century that 'anti-scientific tendencies' have been advocated with great fervor. The heat which drives these movements certainly has its source not in any longing for 'ultimate knowledge of the universe' but in the belief that by demoting science as the only source of truth one can promote human happiness. This drive against science has accumulated strength after science had enabled mankind to liberate nuclear energy and to produce the atomic bomb. IN a significant way, our 20th century repeated the attitude of Greek paganism by which Prometheus was accused of having 'liberated atomic energy'; it enabled man to produce at will the 'reaction between carbon and oxygen,' and to pave the way for the destructive forces of fire. According to Greek tradition, Prometheus was punished because he had 'stolen' the method of fire-making from the gods to do a favor to his fellow man. He was tied to a rock in the Caucasian Mountains and his liver was eaten by the vultures.

We must think of this tradition when we note how scientists nowadays are accused of having 'stolen' the forces of nature, the nuclear forces from God, and of having taught their manipulations to their fellow mortals. A great many people who think along traditional lines would wish that the vultures should get at the livers of the nuclear scientists.

As a matter of fact, there have been everywhere old myths about the jealousy of the gods against the technical and scientific advances of men. We have only to remember the story of the 'Tower of Babel' in the Old Testament where the Lord is reported to have intervened personally against the construction of the first skyscraper. All these ancient myths reflect an antagonism which has existed between two activities of mankind: research in the natural sciences and the search for moral and spiritual advice by superior beings. [top of page: "4 Science is no picture of reality"]

What we experience today as the conflicts between science and the humanities in education are the effects of these mythos upon the human mind. In particular, the arising of 'anti-scientific tendencies' about which we spoke is due to the, sometimes subconscious, reminiscences of ancient myths. It has been stressed in line with these traditions that 'science' cannot reveal to us the 'real nature' of the universe, but that we have to expect if from other sources.

III. A New Conception of Science

While 'anti-scientific tendencies' have attempted to undermine the prestige of science, there has been within science a critical movement which has advocated a new conception of science. It approved some of the objections raised against the claims of science, but it would not admit that other sources can do better in revealing to man the 'real nature of the universe.' The "new conception" no longer defined the task of science as giving a 'true picture' of the universe. However, it denied that a 'true picture' of the real world could be given at all, and, more specifically, it denied that the expression 'true picture of reality' has any meaning.

This would mean that statements like “our physical universe consists, in reality, of matter,” or “consists, in reality, of mind” cannot be confirmed or refuted by science: they lack scientific meaning. This means, in turn, that philosophical creeds like materialism or idealism are not actually supported by science. Moreover, the new conception of science has been opposed, in general, to the doctrine of “realism” according to which science explores the “real world.” The new conception of science stresses the point that there is no language by which the “real world” can be described directly. What science actually does is to construct a system of symbols (e.g. words or algebraic signs) and to formulate statements in which these symbols occur. These statements are the “principles of science” from which one can obtain, by logical conclusions, observable facts. The checking of the facts by sense observations provides the body of experiences upon which science is based. [top of page: “5 Thomism, Materialism [?] and Pragmatism”]

If the facts derived from the principles of science are in agreement with our direct experience, we say that the constructed principles are conformed by science. Therefore, the new conception of science which we characterized by saying that “science is not a picture of the real world” can also be expressed by Henri Bergson’s assertion [formulation?] that “the laws of science are not discoveries but rather inventions.”

The concpetion of truth as a ‘picture’ or a ‘copy’ or even a ‘photo’ of the real world has dominated the philosophical interpretation of science through centuries. It has been the basis of philosophies which have in our present period the character of world-wide creeds: Thomism as the foundation of Catholic philosophy, and Dialectical Materialism as the basis of the Communist world-view. Both philosophies have been based upon “realism” and the “picture-theory” which made science an easy target of anti-scientific attitudes: it was easy to show that our [??] science does not furnish [??] actually a “true picture” of the real world.

IV. From the New Science to a New Philosophy

The ‘realistic’ or ‘picture philosophy’ has been replaced in two steps since the middle of the 19th century. The first step was the conception that science is the systematic description of ‘facts’ or, in other words, of our experience. This conception was formulated elaborately in the “Positive Philosophy” of August Compte, in the “Synthetic Philosophy” of Herbert Spencer, and the “system of Logic” of John Stuart Mill. It has been known under the name of positivism or empiricism.

To men like Comte or Spencer it was clear from the start that ther cannot be a description of mere facts; facts are only the raw material of science. The chief intention of science is to give a description of a great number of facts by a unifying idea. Mathematicians, physicists, and historians of science, in the second half of the 19th century, investigated the way in which this unifying idea is formed. They worked out a conception of science in which the emphasis was put upon the way in which the human mind has built up a framework or pattern in

order to describe the 'facts.' This new turn in positivism was given the name of "new posivitism" by the French historian of science, Abel Rey.

Positivism of men like A. Comte and H. Spencer had been connected with the conviction that Euclidean geometry and Newtonian mechanics were the final word in our knowledge of nature. The rise of non-Euclidean geometry and non-Newtonian physics had a profound influence upon the rise of new positivism. Its representatives like Ernst Mach, Henri Poincare, and Pierre Duhem emphasized more and more the rule of human creativity in the production of new scientific theories. They advocated the conception of science as a flexible, conceptual frame which is invented and constructed by the human mind in order to accomodate new facts.

In the same period, the end of the 19th century, in the U.S.A., a new conception of science originated which was, in many respects, similar to the New Positivism.

We refer here to the School of Pragmatism which is known best by the works of the psychologist, William James. However, Charles Sanders Peirce, a mathematician and logician was the first to introduce the word and concept of "pragmatism." He applied the pragmatic views to science. Since, for him, science was a background of action he strongly rejected the old picture theory with its attempt to make science a 'copy' of the real world.

In the 20th century, new physical theories emerged in which the role of human imagination and the formation of new languages became more and more conspicuous. The New Positivism, sometimes called neo-positivism, developed more and more towards a theory of language; the philosophical interpretation became linguistic analysis.

The history of science was now being studied as a history of factual discoveries accompanied and sometimes even guided by the invention of new languages. All advances in science are closely connected, according to the new view, with advances in language. This has to be kept in mind if we want to understand the philosophical groups into which the New Positivism branched out in the 20th century.

In this introduction I am only going to enumerate in a perfuctory way the philosophical groups which have participated in the overcoming of the 'realistic' or 'picture theory' of science. We note in the U.S.A., beginning from 1920, the "operationalism" of P.W. Bridgmann [sic?]. We note in Central Europe, at the same time, the opposition against the prevalent German idealistic and realistic philosophy. This opposition started in the first decade of the 20th century by [the] 'scientific world-conception' advanced by the Vienna Circle. From this group there developed what has been called in the U.S.A. "logical positivism" and "logical empiricism." In England, we note in the 20th century, the school of analytical philosophy which was based like the New Positivism on the analysis of language. The prevalent idea of this English philosophy was, above all, to study the language by which one expresses our everyday life experiences and which is briefly called 'natural [ordinary, crossed out] language.' In all these groups, one has regarded metaphysical problems as confusions which have arisen from the 'realistic' and 'picture theory' by neglecting the analysis of natural language.

If we actually want to describe the “real” world we soon becme aware that there is no adequate presentation [representation?] by natural language and one will use symbols which have no clear-cut connection with the natural language. Most of the British philosophers in our period hope that by analysis of this “natural” language the eternal metaphysical puzzles can be eliminated. If one “explicates” the meaning of metaphysical statements by using statements in the natural language they become a consistent system of statements that can be checked by “experience” in the ordinary sense of this word. British analytical philosophy has its origin in Bertrand Russell and G.E.Moore, and is no mainly based upon the teachings of the Austrian L. Wittgenstein who has been the link between the Vienna Circle and the British analytical philosophy.

Besides the branches of New Positivism, several schools have developed which have attempted, in a practical way, to achieve an actual improvement of the language which is used in philosophical, religious, and political discourse. In the U.S.A., the most important and successful group has been the school of “general semantics” which was founded by Korzybski. A similar group is the school of Significs in Holland. All these, more or less neo-positivistic groups have in common the opinion that by abandoning the “picture theory” one could dissolve the insurmountable difficulties which have tormented traditional philosophy.

Nowadays, we conceive science no longer as a “picture of reality,” but as a system of symbols that helps us to bridge the gap between the science [sic] and humanities, or, in other words, between facts and values. According to the new conception, science consists of an instrument and the directions which tell us how to use it. The instrument is a system of propositions which are, in turn, relations between symbols. In geometry, for instance, the system consists in the axioms of geometry. The symbols are ‘straight line,’ ‘point,’ etc., while the propositions are of the form ‘two points are coinciding with one straight line only.’ The directions which tell us how to use the system are the operational definitions, for instance, the statement—that a straight line should be realized by a light ray or the edge of a [straight?] rigid body. From the propositions, one can logically conclude statements about observable facts. Such statements are the basis for the production of technical devices. However, neither these observations nor the success in producing technical devices determine the general principles of science unambiguously. Since the earliest times of scientific and technical endeavor, the general principles have been used for the purpose to provide a general view of the universe and, in this way, guidance to human conduct. The Ptolemaic system was preferred to the Copernican one by some scientists, although everyone agreed that it was not the more practical instrument. But, the Ptolemaic system was in better agreement with the religious and philosophical traditions, and therefore, a better basis for making good citizens.

According to the new conception of science, we cannot simply say that a certain system of principles provides a “true picture of the real world” but only that it is useful from a technological viewpoint or useful from a moral or religious viewpoint.

From the start, the definite form of scientific principles is determined by their purpose. Technological goals as well as moral and political ones, have their influence upon the final shape of these principles. We can no longer say with certainty that science as a system of statements about the world is independent of the men whou make these statements. Since science is an invention of man, it is invented for a certain purpose. It is, therefore, dependent upon the purpose which has been selected.

If we speak rather perfunctorily we may say that the principles of science depend upon whether we want an instrument for technological purposes or an instrument for supporting a certain moral or political conduct. Anyway, the "fact finding" and the "evaluating" tasks of science cannot be completely separated from each other.

V. Humanities are Trailing Behind the Natural Sciences

One has often deplored a situation in which the advance of the 'humanities,' of philosophy, ethics and religion has lagged sadly behind the advance of science and technology. Such complaints have become fairly commonplace today. To find an instance, I merely pick at random today's issue of a Boston daily and read in the Letter to the Editor: "Science and technology have given us material benefits almost beyond imagination, but ethics and moral values have fallen far behind our rapid advancement in technological knowledge. It is the time—here and now—to close this gap." (Christian Science Monitor, Feb. 4, 1956)

However we meet the same complaints at the 'summit.' Professor I.I.Rabi, Nobel Prize-winning physicist of Columbia University addressed (on Feb. 1, 1956) the American Institute of Physics on the small effect of scientific advance upon the advance of general culture. He pointed out that the impact of scientific thought on the culture of the time "becomes less and less even as science advances to greater pinnacles of understanding and discovery. As the importance of science in this country increases, its dignity seems to be diminishing." The speaker obviously referred to the ratio of "technological importance" to "moral dignity." If one describes this situation not in moral terms but in a more sociological vocabulary, one would say: our society is technologically well advances, but the evolution of social institutions is lagging far behind the technological advancement.

While religious minded groups have deplored the lagging of moral advance behind technological progress, the advocates of a materialistic conception of history have similarly deplored the fact that our present social structure is no longer fitting to the highly developed state of today's technology. K.Marx and F.Engels, the founders of revolutionary socialism, saw in this incongruency the very root of future social revolutions. This lagging of mral and cultural progress behind scientific and technological advance can also be formulated by claiming that the advance in science has not contributed much to the advance of our knowledge about 'social' improvement, or, generally, about human values. In other words, the study of science has been completely isolated from the study of the humanities. Aldous Huxley, in his book, Science, Liberty

and Peace, New York, 1946, related this shortcoming of science to the fact that "some scientists, many technicians and most consumers of gadgets have lacked the time and the inclination to examine the philosophical foundations and background of science." However, according to Huxley, "…The scientific picture of the world is inadequate for the simple reason that science does not even profess to deal with experience as a whole but only with certain aspects of it in certain contexts." Huxley thinks that the scientific world view, which is often referred to as "positivism" leads practically to the totalitarian forms of government with their regimentation of human life. "As theory," he writes, "pure science is concerned with the reduction of diversity to identity." The most familiar example is the "mechanistic world view" by which all the various qualities appearing in our sense experience are reduced to the positions and velocities of material particles. Another example is the "electromagnetic world view" by which all qualities are reduced to electric and magnetic forces. The term "reduces" is certainly misleading because it has disparaging connotations; it would hint that mechanical and electromagnetic forces are regarded by science as "more real" than human qualities or values. Actually, according to the practice of science, these mechanical or electromagnetic quantities are a system of symbols from which statements about our human experience can be derived. Nobody would doubt that this system should be as simple as possible, provided it allows us to derive the world of our experience. Exactly speaking, science is not a "reduction of diversity to identity" but a method to derive the immense diversity of human experience from a simple conceptual scheme. Huxley claims that "as a praxis, scientific research proceeds by simplification. These habits of scientific thought and action have, to a certain degree, been carried over into the theory and practice of contemporary politics." According to Huxley, the restriction of individual liberty in authoritarian counties has been justified by the methods of science. "Philosophically," he writes" this ironing out of individual idiosyncrasies is held to be respectable, because it is analogous to what is done by scientists when they arbitrarily simplify an all to[o] complex reality." He points out that "a highly regimented society…is felt by the planners and even by the planner to be more 'scientific'…than a society of freely cooperating individuals." This view is not an individual view of A.Huxley, but has been repeated again and again by contemporary authors. However it has its roots in an obsolete "philosophy of science."

VI. The "Special Sciences" Don't Exhaust "Science"

When modern science was born in the 17th century and grew up in the 18th and 19th centuries, the central idea has been to build up "special sciences" like astronomy, physics, biology, etc. Each of these special sciences was based upon a conceptual scheme which contained a few number of symbols. This specialization and simplification was certainly very successful and resulted in the construction of marvelous buildings like modern physics, chemistry, etc. But one must not forget that no concrete problem which is put to us by nature, or, in other words, by life, can be solved by applying one of the special sciences. Let us

consider the “simple” problem: What will be the potato crop of this fall? Or, more exactly, how many bushels of potatoes will we reap on a certain plot? To solve this problems “scientifically,” we have, of course, to apply botany. Since insects may influence the crop, we have to use zoology, and since the structure of the soil will be relevant also mineralogy and geology. Because of the influence of rain and storm, we need the results of meteorology or cosmic physics. But all these “special sciences” don’t allow us to predict the crop actually. There may be labor unrest which we can only predict from economics and sociology; there may be even a war which we can only predict by knowledge of foreign affairs. There may be epidemic diseases which can prevent us from digging potatoes, and if we believe in traditional religion, the crop depends upon the favor of the gods which we can only predict from theology or maybe from astrology. The prediction of all these doctrines are interwoven in their application to the reap9ing of an individual potato crop. We note that we have not only to do with “science” in the ordinary sense of this word, like physics, chemistry, botany, but also with doctrines which one would usually call “humanities” or “social sciences,” like theology, history, foreign affairs, sociology, etc. Generally speaking, the marvelous buildings like “physics,” “biology,” etc. are beautiful and impressive in their proud isolation. But in order to solve an actual problem, even asking for a potato crop, we have to make use of these “special sciences” as building stones for a big building “science.” If each of the special sciences contained peculiar symbols and concepts which would not occur in other special sciences, they could never form a combination of botany, history and religion in order to derive statements about the potato crop. In order to draw such conclusions, botany, economics and theology must have a great deal of concepts in common. Ultimately, all observable facts can be described in terms of our everyday language. If these terms did not occur in all the special sciences, from mechanics to theology, we could not derive from science statements about observable facts, e.g., about potato crops.

VII. Semantic components of Science

As a matter of fact, the opinion that science deals with an impoverished world which is deprived of all human elements, is based on an obsolete conception of science and ignores the contemporary attempts to build up a science which reflects the whole of our experience of the world.

The new conception of science and its relation to man has been referred to often as the concept of “Unified Science”; it has been advocated and elaborated by the Encyclopedia of Unified Science. The traditional scientific approach to the physical world consisted in reducing this world which was rich in qualities to a mathematical skeleton. This “dessicated world” was described and presented itself by a “science” which an impoverished picture of the genuine rich world. Science was based upon a scheme that consisted of two components, “reality” and “picture,” a “dyadic scheme.

Towards the end of the 19th century, it had turned out that it would be much more expedient to base the presentation of science upon a richer scheme

that considers three factors: I) [objects?] directly observed by the scientists at physical phenomena. II) The scientist as a person. III) The signs invented and used by the scientist. C.S. Peirce spoke of a 'triadic' scheme and we find these three factors in the workd of all the great philosophers of science who worked about the turn of the century (1900), in particular, in the workd of the great French scientists, Henri Poincare and Pierre Duhem. This scheme can be illustrated by a triangle. [hand drawn in top margin]

Objects --- - experience -------**man**

? + logic pragmatics

signs

In the Encyclopedia of Unified Science, this triadic scheme was elaborated and clearly defined by the leaders of the "Unity of Science" movement, e.g., by Rudolf Carnap and Charles Morris. To give examples of this scheme, we may choose a very new and a very old one. The contemporary one may be taken from the explosion of the atomic bomb. The first factor, physical object, consists in the famous mushroom-shaped cloud, the pressure exerted upon buildings or men, the injuries produced by burning, etc. The second factors are the nuclear scientists who have attempted to understand these phenomena. The third factor of the scheme that we call "nuclear physics" consists in the symbols that have been introduced by these scientists, e.g., the concept of electron, nucleus, neutron, cross section, isotope, etc. What is now the work which the scientist "actually" does? Firstly [hand-written insertion (indecipherable, p. 16) mentioning the first of the three factors], Secondly, he studies the correlation of the physical facts to the scientific symbols and signs. He studies, e.g., how the mushroom-cloud can be understood as a swarm of electrons, of radiations, of neutrons, etc. He invents the symbols, electrons, neutrons, etc., by which these physicla phenomena can be understood in a simple and comprehensible way, or in other way [?], he studies the 'physical meaning" or "operational meaning" of symbols like nucleus, electron, neutron, etc. These studies are often referred to as "semantics." There is however a third kind of investigation. One can investigate by what factors the scientist is driven towards inventing certain signs or symbols.

VII. Pragmatic Component of Science

These influences come, of course, from the scientist's environment, or, in other words, from his social background. This background manifests itself by the predilections of the scientists and of their public for certain symbols. These predilections are obviously determined by the role which these symbols have played in human life. This means that these predilections or "values" can only be determined by arguments that are taken from the "behavioral" sciences, like psychology, sociology, etc. Hence, by the "traidic scheme" of science, a large

field of humanistic and social studies is introduced even in the most "inhuman" sciences like mathematics, physics, etc.

These studies of the relations between the person of the scientist and the symbols of science have been called "pragmatic" in contrast to "semantic." We have to be aware that there is also a very important study of the relation between the symbols themselves and this study is referred to as "syntax" or "logic." Altogether the triadic scheme of science implies three fields of study: observation, semantics, and pragmatics [? Was: "semantics, logic, and pragmatics"] One says often that "science" treats only a very poor skeleton of the world, because human personality and human values are eliminted by a far reaching process of abstraction. But this is only true if we restrict ourselves to logic and semantics neglecting the pragmatic component. The pragmatic studies of science includes the influence of social, philosophical and religious factors upon the invention of scientific symbolism. In order to understand this point well, we have only to remember the passages in Plato's Republic where the author stresses the value of astronomy for supporting Greek religion and good citizenship. In the same category belongs the insistence of the Roman Church that Galileo's presentation of the Copernican System in which our earth is freely moving in the world space, is harmful to traditional Christian religion. A similar result can be drawn fromt he attitude of the present Soviet philosophy to Einstein's Theory of Relativity. The symbolosm by which this theory had been presented seemed to be a help to philosophical systems (like Agnosticism, idealism, etc.) which were regarded as harmful to the political philosophy of the present government. By using the pragmatic approach to scientific theories of a certain period, we are impelled to study the human values of this period. For this reason a chief topic of the present book will be the pragmatic approach to present day science including the line of descendance from which our present science has originated. If we want to study this approach, we have to study the symbols of science not only from the scientific angle. We have not only to study the actual meaning of symbols for the purpose of predicting future facts or for producing gadgets; we have also to study the meaning of these symbols as expressions of human aspirations. Thus, the variety of meanings which have been attributed to scientific symbols is a main topic in the present book. Scientists and technologists have always attempted to interpret these symbols in such a way that they would serve "practical" purposes in the technological sense of this world. However, at the same time, philosophers, educators, ministers and politicians have attempted to give these symbols "moral" interpretations by which the statements of science would become helpful in the support of human aspirations and goals. Every new term in science was accompanied by a lively discussion about the possibility to employ this new symbol for improving human conduct in a line whouch would have a desirable religious, moral or political effect. This was the casw ehen Galilean and Newtonian science replaced medieval scholasticism but was equally the case when 20th century physics (relativity and quantum theory) replaced the Newtonian concepts of strict determinism by the [of the?] initial position and speed of particles.

We shall discuss in the present book the role which the symbols of scientific discourse have played in the struggle for moral and political goals. In this way, the humanities and social sciences are tied almost inseparably to the physical and biological sciences.

IX. Philosophical Schools Woo the Support of Science [indecipherable comments in top margin]

As far back as any recorded history of science and philosophy goes there have been attempts to build up symbolic systems which would embrace all "adventures of the mind," all efforts to master nature by effective prescriptions and to master human conduct by establishing systems of values. These structures of concepts have been mostly referred to as "philosophical" systems. They ahve been advocated by "philosophical schools" which have become actually social groups and have occasionally cooperated with religious and political parties. We have seen the coopeartion of Thomistic philosophy with Catholic religious and political organizations [crossed out: which called themselves Christian Democrats ro[sic] Christian Socialists]. The philosophical schools of British Empiricism, American Pragmatism, Western and Central European Positivism have intensively cooperated with democratic and liberal groups of the Anglo-American and political type. The most instructive example of our period is perhaps the close cooperation between the Communist Party in the Soviet Union and the philosophical groups which have advocated "Dialectical Materialism." All these philosophies have looked for the support of science; again and again new achievements of science like Newton's mechanics and Einstein's relativity have been interpreted as supporting or refuting philosophical schools.

We shall discuss, in the present book, the ways in which these philosophical gropus attempt to trace their "geneology," back to scientific theories. Very frequently, one and the same scientific theory, e.g., theory of relativity, is claimed to be the support of antagonistic philosophical schools. This comes obviously from the fact that no philosophical school can claim to be actually derived from science. The shoe is on the other foot; the primary fact is the wish to justify the philosophical approach which supports our favored politial or moral ideals. We shall learn in the book that when one knows which philosophical approach should be supported, one will find a way to get this support out of several [crossed out: any...] physical or biological theories.

Scientific theories play a double role. On the one hand, they are statements about observable physical facts that can be logically derived from those theories. But they have also been interpreted as statements about the nature of the universe. In order to do so, one had to interpret terms like "matter," "energy," "force" "determinsim," not by the "operational meaning" by which they have been defined in science, but by some analogy in common sense language. If the scientists speak of "mass" they denote by it the results of physical operations by which they assign to the word a certain number of pouns, the "quantity" of mass. If they speak of "kinetic energy" or "radiating energy" they

refor to the results of other physical operations by which they assign to these terms “quantities of energy” which are [??given as] “ergs” or “watts,” etc. In this context “mass” and “energy” have the same status. However, when one speaks of “mass” and “energy” in a metaphysical context, one does not replace “mass” and “energy” by the operational definitions of physics. One attempts rather to embed or to integrate expressions like “mass” and “energy” directly into the language in which one describes the facts of our everyday life.

In this language, “mass” is something clumsy and inert, but “energy” is something much more subtle and active. To a very high degree, the “Philosophical Schools” have made use of these metaphysical interpretations of science. A main point of their intellectual argument has consisted in an atttempt to prove that a certain school has the blessing of science. Scientists have often braded this type of philosophy as “school philosophy” in order to stress the fact that the driving force behind these philosophies has not been the search for solution of scientific problems but the urge to serve an ethical, political or religious purpose, by joining a social group that is known as a philosophical “school.” The term “School Philosophy” has been used with a sligntly derogatory connotation. The Scholastic philosophy of the Middle Ages has been referred to as the “Philosophy of the Schoolmen” because this particular “School” has, for centuries, been regarded as “the School.” Its central work was, perfunctorily speaking, the adjustment of Aristotelian and Platonic philosophy from pagan to Christian faith. Hence, in the 18th and 19th centuries “School Philosophy” had the connotation of a philosophy which was not adjusted to the results of modern science. In the present book not all philosophical schools are going to be discussed. We shall only examine those schools which are near to the political and religious creeds of the 20th century and at the same time look for an adjustment to modern science.

X. Philosophical Schools and Political Creeds

According to J.B. Haldane, the British biologist, an advocate of Marxist philosophy, there are three schools in our 20th century which are considered from these viewpoints. They are: Scholastic Philosophy, Modern Science, and Marxist Philosophy. By regarding “modern science” as a philosophical school, the author refers, of course, to the group that has attempted to “purge” modern science of any metaphysical interpretation and which has been known under the name of “positivism.” As a matter of fact, the attempts to avoid all such interpretation have led to new types of interpretations and the formation of new “schools” with all the characteristics of social organizations which work for shaping human behavior. Such groups have been the American Pragmatism, the French Positivism, and more recently, General Semantics in the U.S.A. and Logical Empiricism in Central Europe. There have certainly been other philosophical schools in our century which have played a great role in organizing our picture of the universe as a support of a certain way of life. We may mention the School of “Kantianism” which has played, in the German countries, almost the role of a national religion, diluted by “positivism, it has been called the School of Neo-

Kantianism. The school of "existentialism" appeared in the 20th century by a certain interaction between German and French philosohy. It has regarded the world of science as an "impoverished" or "dehydrated" reality (Section I), and did not look much for the support of science.

However, my present goal is not a history of philosophical schools but rather a discussion of the social phenomena one calls "Philosophical Schools." We shall restrict ourselves to some typical examples and shall select those which are the nearest to the big political and religious currents of our time. We shall present as examples first the Thomistic interpretation of science, as a support of Christian or exactly speaking Catholic way of life. Secondly, we shall present the positivistic interpretation of science in the widest sense of this word, which includes the pragmatist interpretation. As the third example, we shall present the materialistic interpretation of science, in particular the doctrine of Dialectical Materialism which has been the official philosophy of the Soviet Union andits affiliated states. This Philosophy has been regarded as a support for the mway of life which is advocated by Marxism. All these "philosophical" schools have ardently claimed that they are in agreement with "science" and moreover that each of these is the genuine philosophy that fits to science. We have heard from quite a few scientists utterances which would claim that a certain philosophy like Thomism or Dialectical Materialism are 'anti-scientific.' There have even been authors who have maintained that positivism is anti-scientific because it denied the "reality" of the physical world, upon which, allegedly the belief of science is based.

As a matter of fact, none of these philosophical schools will ever admit to be contradictory to science, because to speak in a rather flippant way, no government of whatever ideology could survive without an atomic bomb. This means that no ideology can afford to alter the technological [possibilities? priorities] of the sciences. [T]he slightest deviation from the recognized laws of science could frustrate the production of nuclear weapons.

XI. Principles of Science and Human "Values"

As a matter of fact, the results of science have never actually depended upon the ideology professed by a certain government. Materialist, Christian or Buddhist bombs have the same effects. This is all true if we regard science only as an instrument to produce technological rules which, in turn, are helpful in predicting observable phenomena and constructing gadgets that serve man's pleasure including his victory in battles with other men. However, science has never restricted itself to the role as an instrument for the production of technological rules.

When the Epicurean school, in antiquity, claimed that the celestial bodies are made of the same material as the terrestrial ones, it proclaimed a radical change in man's interpretation of the physical universe. The new physical theory made it more difficult to believe that there are spiritual beings besides or above human beings. Plato chastises this physical theory as a subversive voew about human society because it endangered the traditional religion upon which good

citizenship seemed to be based. We see a similarl phenomenon in the attitude of authorities to the Copernican theory. It would be a mistake to think that this hostility was a special backwardness of the Catholic Church. Also "liberals" like Francis Bacon or John Milton recommended, at least, caution in accepting such changes because these would reflect on our beliefs on human society. It would be equally wrong to believe that this interference by authorities with natural science was a characteristic of the "dark ages." The attitude of the Soviet Government towards Einstein's Theory of Relativity and Mendel's Genetics is well known. Since we would hardly believe that an immensely practical government like the Soviet Power would risk a backwardness in nuclear technology or agriculture, we must assume that these attitudes had other reasons. They were all based upon the fact that every fundamental change in theory about the physical universe was employed to support some change in man's view about the desireable type of human society. We note a clear example of this connection in the interpretation of the new formulations and causality that have been given in the 20th century by atomic and nuclear physics. The view was abandoned that all particles, independent of their size, follow the same laws, Newton's Laws of Motion. The laws by which the motions of very small particles was [were?] determined would be actualy statistical laws. If these statistical laws were the ultimate laws of nature, one would say that there is no "determinism" in the physical universe. "Indeterminism" would be the characteristic of our world. However, there are also scientists who surmise that one could perhaps regard these statistical laws as merely superficial laws behind which the actual laws are hidden but as yet unknown. If these laws could be found our physical universe would be governed again by Determinism. It seems as if science cannot, by itself, come to a decision whether "Determinism" or "Indeterminism" is ruling our world. Many authors have maintained that the belief in Indeterminism supports the belief in the freedom of will while the belief in Determinism may lead to a belief in an iron causality which is oncompatible with human freedom and moral responsibility. The American Philosopher of Law, Justice Jerome Frank says in his book Faith and Freedom that the belief in an iron causality if applied to human society is incompatible with the belief in the free choice of every citizen which is, in turn, essential for the belief in the "American way of life." According to J. Frank, the belief in "Indeterminism" is much more favorable to the belief in the American way of life than the belief in Determinism. Since science cannot provide a clear-cut dexision between these beliefs, on should, according to J. Frank, choose the theory which is more favorable to the American way of life---and this belief is Indeterminism. We see that in our own country, as in the times of Plato and Galileo, scientific theories are preferred according to their fitness in supporting a way of life, or in other words, according to their ability to encourage a certain human behavior.

All these considerations show that ultimately the acceptance of General Principles of a science, say physics, has never been decided by this "special science" alone; there have always been arguments of social science which had an influence. One can visualize this situation by looking back to the "hierarchy of the sciences," the "pyramid of the sciences." This idea has played at all times a

role in the attempts to overcome the isolationist view that the whole of our knowledge consists merely of an aggregate of "special sciences." When Auguste Comte, in 1830, attempted to build up, under the name of "Positive Philosophy" a synthesis of all the special sciences, he established a certain hierarchy among them. He started from the sequence: Mathematics, Astronomy, Physics, Chemistry, Biology, Sociology. The main point was that every science presupposes the sciences which were prior in this series, but no the posterior ones. "Astronomy," e.g., needs "mathematics," but not biology, while "biology" needs "physics" and "chemistry" but not "sociology" as its presuppositions.

From this order, it follows, in particular, that none of the natural sciences like astronomy, physics or chemistry needs sociology as its basic [sic]. However, we have learned and we shall learn more and more that the most general principles of natural science, for instance, of astronomy and physics cannot be unambiguously derived without considering the social predilections of a certain period. We can learn, for instance, from Plato's Republic why the astro-physical statement that the sun is made of the same material as the earth is not compatible with Plato's moral and religious value system. In the same way, the Copernican system was not regarded as compatible with the value system of the middle ages.

Hence, we have to admit that the principles of astronomy and physics are not independent of social evaluation as it should be according to Comte's scheme of the sciences. As a matter of fact, an immediate disciple of Auguste Comte, E. Littré, proposed an imporant alteration of the scheme. The order of the sciences should not be represented by a linear scheme but by a circulare one. One could perhaps, in a rather perfunctory way, propose a scheme of the sciences by a circular (closed) curve in which they follow in the order--- mathematics, astronomy, physics, chemistry, biology, sociology and then again mathematics, astronomy, etc. This circular scheme may help us to visualize the pragmatic component of science.