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THE ORGANIZATION OF KNOWLEDGE[1]

IN an admirable introduction to Herbert Spencer's Synthetic Philosophy, by Alfred W. Tillet, occurs the suggestive observation that "one volume after another might be glanced at or even carefully read and no idea whatever obtained as to Spencer's *aim*." Even the *Study of Sociology*, in the words of this author, "does not give any definite idea of the aim of Spencer's work" but no one "even superficially familiar with a moderate portion of Spencer's monumental contributions to knowledge can fail to be impressed by the fact that it is from end to end an organized system of scientific knowledge."

What after all is the real difference between scientific and general knowledge, or between organized and unorganized information? Is it not rather a difference in structure than in function, for, as said by Karl Pearson, "the classification of facts, the organization of their sequence, and relative significance, is the function of science," which must be the objective of every attempt to gather and classify the knowledge extant on any particular subject. The moment we desire to apply a given train of thought to some practical purpose we are confronted by the necessity of understanding facts in their relative significance.

Yet so difficult is the practical task of arriving at sound conclusions in the presence of some complex phenomenon that even civilized man reasons as a rule in disregard of scientific principles, indifferent to the value or necessity of organized knowledge as a substitute for disorganized or chaotic information. The cause of this anomaly is of course quite obvious; the former process requires painstaking care in the accumulation and classification of facts,

[1] Address of the vice-president and chairman of Section K—Social and Economic Science, Toronto, December, 1921.

while the latter is simply a convenient form of guesswork opinion, often aided by a good memory and a sound intuition. Unfortunately the truth is frequently unnecessary to the attainment of the objects of every-day existence, and there is much to be said for the view given expression to by M. Anatole France "that in the majority of cases truth is likely to fall a victim to the disdain or insults of mankind and to perish in obscurity." For unhappily, in the words of this brilliant Frenchman, "truth is inert, is not capable of modification, is not adapted to the machinations which would enable her to win her way into the hearts and minds of man" while "falsehood on the other hand possesses the most wonderful resources." Yet in the long run truth does prevail, at least in all large projects in the pursuit of knowledge or profitable trade or long range undertakings just as we build a different foundation for a pyramid than for a cowshed.

The science of forecasting has perhaps nowhere been more completely developed than in the vast businss of insurance, and of no branch of commercial enterprise can it be said with less fear of successful contradiction than of insurance that it rests its principles and policies upon the lasting and, in fact, indestructible basis of truth. Likewise, it might be said that the fame of Sir Francis Bacon rests largely upon his conception of applied science as a process of pure induction or the orderly method of arriving at trustworthy conclusions on the basis of experiment and observation or of natural laws having "the dual characteristic of universality and reality."

The inductive process of reasoning is essentially one of *fact gathering* and of classification and analysis. But systematic fact gathering as a science is of comparatively recent origin, while the urgency of organized knowledge as a prerequisite to true scientific endeavor is as yet, at least in the larger sense, only in a stage of embryonic development.

Fault has been found with Sir Francis Bacon for the barrenness of the results flowing from his laborious observations and classifications. This, as said by Church, is due to the fact that "he had a radically false and mechanical conception, though in words he earnestly disclaims it, of the way to deal with the facts of nature." The fault was one of the limitations of knowledge inherent in the age in which he lived rather than of Bacon's theory of the human understanding and of the primitive conception of the comparative value of collective phenomena or statistics, which even to this day is far indeed from having reached the status of a true science. Church is also of the curious opinion that the cause of Bacon's defect was a non-mathematical mind; that he took no notice of the invention of logarithms and that he was impatient of the subtleties of astronomical calculations. In very truth, however, the source of Bacon's transcending intellectual powers were conditioned by this very limitation of his knowledge, for as observed by Church in a subsequent passage "with all his mistakes and failures the principles on which his mode of attaining a knowledge of nature was based were the only true ones and they had never before been propounded so systematically, so fully, and so earnestly."

But Bacon suffered much more from the shortcomings of his age and its follies than from defects in his method of scientific reasoning. What to-day is known as Economics, Sociology, and Statistics, was far from having been recognized as an urgent need of a Science of Progress in which the lessons of mankind's experience are relied upon at least in commerce if not in government as controlling the rational conduct of mankind. This conception, however vaguely perceived, rests upon the larger truth, as pointed out by Herbert Spencer, that "ultimately mankind will discover a constant order even among the most involved and obscure phenomena." It is with this process that the present discussion is concerned; the organization of knowledge as differentiated from the mere gathering and accumulation of facts regardless of their interrelation or interdependence for useful purposes as the case may be.

The organization of knowledge for the present purpose is meant to include all manner of descriptive data; all observations whether

objective or subjective, all that is cognizable and recorded in the realm of human experience or as a natural phenomenon; in brief, what is Fact and Evidence, useful in the endless struggle to perfect human relations individually or collectively in the pursuit of all that concerns a higher and more effective standard of life, labor, and social happiness.

The principle is laid down as incontrovertible that most of the ills from which mankind suffers are the result of chaos and confusion in the boundless domain of knowledge and the misunderstanding of the why and wherefore of life in the higher and larger sense. This applies as much to the earning of a livelihood or success in commerce and trade as to the affairs of nations and questions of peace and war. A League of Nations not based upon completely organized and unified knowledge is as foredoomed to failure as a merchant adventure in ignorance of the market to which it applies. Yet less progress has been made in the direction of organizing the data of human experience on the basis of a well-considered plan than has been made in the case of any other single branch of science or business enterprise. Of the collection of data there is no end, nor of the accumulation of books and the making of card indexes; but this is often not an aid but rather a hindrance to the organization of knowledge in the sense and for the purpose indicated. It is largely due to this defect in the Baconian philosophy that the practical results of Bacon's theories fall so far short of their theoretical possibilities. In the same sense it is a safe statement to make that the practical value of a public library at the present time is but a fraction of its possible utility were it properly conceived on the principles of organized knowledge.

It was the opinion of Herbert Spencer that "The sciences can not be arranged rationally in a serial order." Yet numerous have been the attempts to classify the sciences from Bacon and Spencer to modern workers, including the fragmentary observations of Mercier. Perhaps the most useful remarks on classification are those of Jevons in the second volume of his "Principles and Science," but in this as in all similar discussions the true objective, the organization of knowledge, is lost sight of. Nearer to the point are Spencer's data on Sociology but wholly impractical for everyday needs, being rather a classification of information than of knowledge or verifiable evidence.

Nor is the question much advanced by such a learned work as "The Organization of Thought" by Professor Whitehead, although it is properly observed that "first-hand knowledge is the ultimate basis of intellectual life," and the further and extremely interesting and practically valuable conclusion that "The second-handedness of the learned world is the secret of its mediocrity. It is tame because it has never been scared by facts," and finally that "The main import of Sir Francis Bacon's influence does not lie in any particular theory of inductive reasoning which he happened to express, but in the revolt against second-hand information in which he was the leader." (p. 43).

This is precisely the point raised in this protest against the apathy of the so-called scientific mind, which is often satisfied with doubtful or incomplete information because forsooth it is a task of colossal difficulty to collect and properly organize the information on almost any subject whatever. But the difficulty arises chiefly out of an unorganized or disorganized state of mind, habituated to a pretense of knowledge full well known to be imperfect and incomplete. The defects or deficiencies are therefore often made up by the use of mathematics, by every conceivable method of abstract reasoning as a substitution for the want of sufficient concrete evidence which more systematic and qualified research would bring forth.

Completely unified knowledge, from the viewpoint of Spencer, is unattainable in any field of human endeavor, but the approximately complete organization of the knowledge extant on any particular subject at the present time is not only feasible but an imperative *duty*. The use of mathematics is, under such circumstances, more of a hindrance and a pretense than a help. What is wanted is *more*

and better understood control of organized information.

The organization of knowledge involves as a first consideration the synthetic collection of facts, and a fact in the present sense is construed as defined by Webster, as "Anything that is done or happens, as an act or deed, anything actually existing, and anything strictly true." But aside from this narrow definition of facts in the more restricted sense the organization of knowledge involves as a secondary consideration the collection and classification of information, which may or may not be strictly true but of relative value sufficient for the purpose. Information is defined as "knowledge acquired or derived, or as timely specified knowledge, sufficient for the ordinary needs of life and the basis of the large majority of judgments upon which human conduct is regulated." To these preliminary definitions must be added the term knowledge itself or "the clear and certain apprehension of the truth or assured rational conviction." This is not knowledge in the ordinary sense of the term, for we *know* much of what is not clearly apprehended at all. As said by Webster, "Knowledge is *all* that the mind knows, from whatever source derived or obtained or by whatever process; the aggregate of facts, truths, or principles acquired or retained by the mind, including alike the intuition native to the mind and all that has been learned respecting phenomena, causes, laws, principles, literature, etc."

With these principles clear in mind the task of the organization of knowledge is less difficult. It is immaterial what subject is selected; the Seal Fisheries of Alaska or the Climatic Conditions of the Falkland Islands; The Development of the Export Trade in the Basin of the Amazon River or The Theory, Practice, and Results of Insurance. The process of organizing the facts of any branch of knowledge is the same however much the nature of the data may vary, or their extent in time and place. Facts must first be looked upon as information—as mere knowledge irrespective of intrinsic worth; they are the raw material which, subjected to qualified critical and impartial consideration, forms the ground work of science inductively conceived. Science has been defined as "Knowledge gained and verified by exact observation and correct thinking," and also as the sum of universal knowledge, or in other words "an exact and systematic statement of knowledge concerning some subject or group of subjects." Now a systematic statement of knowledge is organized knowledge, and in this sense much of what is called scientific falls far short of the required essentials of a true science. Webster's definition is admirable but of itself incomplete. For it would seem of the first importance to emphasize the need of organized knowledge as a conception of science in the more restricted sense of the word.

This must have been recognized by Webster, who goes on to qualify his definition of science as follows: "Knowledge of a single fact not known as related to any other, or of many facts not known as having any mutual relation, or as comprehended under any general law, does not reach the meaning of science," for, he adds, "science is knowledge reduced to law and embodied in a system." This process is primarily one of organizing the data of science and of subsequent classification and analysis, out of which the principles of science are logically evolved by a process of pure induction. It is held that this process of organization aiming at complete unification of the knowledge of any particular subject or group of subjects is as yet but very imperfectly realized in the manner most conducive to practical results.

In other words, the objective of organizing knowledge is the accessibility of facts useful for the purpose of selection for particular and practical purposes. In the words of M. Poincare, "Scientists believe that there is a hierarchy of facts and that a judicious selection can be made," and furthermore that "The most interesting facts are those which can be used several times, those which have a chance of recurring." He then asks the question "Which then are the facts that have a chance of recurring?" and he replies that in the first place simple facts "although facts which appear

simple even if they are not so in reality will be more easily brought about again by chance."

It is upon this conception that a practical science of organized knowledge on any subject must rest. Simple facts are the ground work of sound reason or the common sense of every-day questions; facts which are known to recur with regularity, particularly such as are in the form of statistics "systematized numerical facts collectively" considered and which form the basis of judgments concerned with forecasting the future more or less in conformity to the principle of or the law of probability. This has been defined as "the ratio of chances favoring an event to the total number of chances for and against it." Obviously no sound judgment involving the future can be arrived at without a knowledge of what has taken place in the past, and yet an immense number of opinions are rendered in total disregard of the lessons of past experience. But as M. Poincaré observes, "although it is with regular facts that thought ought to begin, as soon as the rule is well established, as soon as it is no longer in doubt, the facts which are in complete conformity with it lose their interest, since they can teach us nothing new." Thus, while on the one hand the lessons of experience are only too often ignored or set aside, there is on the other frequent failure to recognize the limitations of experience and to scorn the "exception which becomes important."

The foregoing brief exposition of certain principles of science applied to the systematic collection of facts in the accepted sense will serve the purpose of emphasizing that in its final analysis all fact gathering, fact arrangement, and fact comparison has for its primary objective the approximate certainty of the truth in its application to the needs of every-day life. At least in this sense my own efforts have been construed not upon a well-defined theory but in coincident adaptation to my needs, strongly influenced by the profound conviction that only the broadest understanding of any given subject is likely to prove trustworthy, that all collateral or related facts must be taken into account, that the knowledge must be sufficient in quantity as well as extended in point of time while absolutely free in its gathering from any bias or prejudice.

The procedure of fact gathering is much more arduous than is assumed by amateurs satisfied with the collection of mere information and the mechanical indexing of data divorced from practical use. In my judgment it is of the very first importance that the fact gatherer should be the fact user, or, in other words, the one to apply the results of his research to the solution of the problems of every-day life. Nothing is more likely to be harmful than when the fact gathering is done mechanically or without a definite objective.

The organization of knowledge, in its final analysis, is concerned with the task of assembling the facts of human experience in a form conveniently available and adaptable to every-day needs. In brief, the very purpose of organization and classification is to bring order out of chaos, and yet, in the words of Boutroux, "In the reality of things, the right eternal, mathematical order which science considers from its own point of view serves to obscure an order that is invisible, subtle, supple and untrammeled and therefore all the more beautiful." But mankind can not do without the latter any more than the former and it is therefore of the utmost importance that the knowledge organized or arranged and classified shall be as nearly as possible complete or inclusive of all the experience that has been had in a given matter. For as further observed by Boutroux, "It is beyond dispute that our reasonings are susceptible to being in harmony with facts," for "when they are out of harmony we do not consider that reasoning is a conscious instrument but rather that we have insufficient data, that our field of opportunity is too limited." Hence the supreme need of a clear grasp of the methods of inductive reasoning as opposed to those of deductive logic, since the former is based on experience while the latter is not.

The practical ideal of good judgment in matters of our every-day living needs is expressed by Spedding, the biographer of Bacon, in the words "I doubt whether there was ever any man whose evidence upon matters of fact may be

more absolutely trusted," yet it is equally true, as observed by Cowley, quoted by Robinson, that "Bacon missed success in detail because he was striving to encompass nearly the whole field of nature in a life which was engrossed with work enough of other kinds to keep a strong man busy." But Bacon suffered even more from the absence of a clear recognition on the part of the age in which he lived of the truth fundamental to his aims, that information and belief are not a substitute for a knowledge of facts and a recognition of their relative importance. The purpose of the Baconian philosophy is contained in the prediction that "Men's power over nature would be increased a thousand fold when they learned to interpret her with the humility of truth seekers casting aside all prepossessions," a prediction realized in no small measure in modern life freed from a vast amount of the credulity, deliberate falsehood, and class bias, which mar the greatest achievements of Bacon's time.

But mankind is still a long distance from having recognized that truth alone can make us truly free. There is, no doubt, a considerable degree of practical utility in common errors. Since all of our human relations are based on relative conceptions of truth the margin of error may be large or small as circumstances permit, but only for short range efforts. It matters little whether the distance I am to walk is a mile, or nine-tenths, or even less in my estimation, but it makes a world of difference whether the calculated position at sea is correct within a small fraction of the longitude and latitude determined by the sextant. And just as surely as small errors repeated and accumulated lead to disaster at sea, so more serious errors in conduct, individual or social, may defeat a course laid out in ignorance of the truth.

The clearest recognition of this principle of right action is the statement by Mill in his discourse on "Fallacies of Observation," in connection with which it is said that "A fallacy of misobservation may be either negative or positive; either non-observation or mal- observation." This important distinction is explained in part that "It is non-observation when all the error consists in overlooking or neglecting facts or particulars which ought to have been observed. It is mal-observation when something is simply unseen or seen wrong; when the fact or phenomenon instead of being recognized for what it is in reality is mistaken for something else."

Both errors are of such common occurrence in every-day life that they are the rule rather than the exception among those whose judgments are relied upon as a matter of course in the conduct of affairs of the first importance. Mill recognized this limitation of the average understanding, pointing out in his discussion of Fallacies that "In the conduct of life—in the practical business of mankind—wrong inference, incorrect interpretation of experience, unless after much culture of the thinking faculty are absolutely inevitable; and with most people after the highest degree of culture they ever attain, such erroneous inferences, producing corresponding errors in conduct, are lamentably frequent." Yet as clearly as this is stated and admitted as a fact of every-day experience, generation after generation grows up in ignorance of the inherent limitations of the human understanding, the serious danger of unorganized knowledge, and the menace of a continuous stream of mere information much of which is only guesswork, possibly grossly false in matters of detail, while all of it, by itself, may be totally unrelated to the practical needs of every-day life.

There is an imperative demand for accuracy in public utterance which falls lamentably short of the ideal. Statesmen utter weighty opinions on matters of verifiable knowledge obtuse to the implication of wilful ignorance, if not wilful deception. Even in high places the most vague distinctions prevail between what is mere opinion and what is fact and truth. Almost half a century ago George Cornwall Lewis in a very readable treatise on the "Influence of Authority in Matters of Opinion" called attention to the need of a clear grasp of this distinction, holding that "a large proportion of the general opinions of mankind are derived merely from authority and are entertained without any distinct understand-

ing of the evidence on which they rest." Authority in this sense means "the principle of adopting the beliefs of others on a matter of opinion without reference to the particular grounds on which that belief may rest." The profound error implied in the blind or unreasoning acceptance of the views of others is the most serious menace to present-day civilization, and the growing habit of accepting as conclusive the views of men possibly as ill-informed as they may be influenced by wrongful motives, simply because they audaciously emphasize and reemphasize mere opinions as statements of fact, involves the very integrity of the intellectual life of the age.

The half-educated, but possibly well informed, do not realize the truth that "the formation of opinion by authority can never (except by indirect means) produce any increase or improvement of knowledge or bring about the discovery of new truths," or, in other words, progress for its attainment depends upon intellectual virility, independence of thought, and judgments impartially arrived at. In the large majority of matters men must rely upon the opinions of others, but here again, in the words of Lewis, "It is of paramount importance that truth and not error shall be accredited; that men when they are led by opinion should be led by safe guides." Hence the importance of an intellectual standard which shall insist upon fact gathering, reflective analysis, and verifiable knowledge in all matters fairly within the compass of a mind of average intelligence. It was the weakness of the German educational system, so largely copied or adopted in this country, that it made respect for authority its cornerstone to the infinite harm of the countless many who fell victims to the soul-deadening policy of the Super-State.

Essentially progress and discovery depend, in the words of Karl Pearson, upon a disciplined imagination and while "the man with no imagination may collect facts" it is equally true that "he cannot make great discoveries." As perhaps the most illustrious examples, he cites Farraday and Darwin, who were both fact gatherers but at the same time gifted with a brilliant imagination. But the imagination will fail unless it is a disciplined one, and all discipline leads, unconsciously perhaps, to the development of the critical faculty. Yet this faculty is to-day the least regarded—looked upon as mere fault-finding, when in very truth, in the words of Pearson, "Criticism is the essence of the scientific use of the imagination, in fact the very life blood of science."

An excellent practical illustration is E. Ray Lankester's essay on the "History and Scope of Zoology," originally contributed to the Ninth Edition of the Encyclopædia Britannica. (Reprinted in his "Advancement of Science," London, 1890). The author observes that "The possibility of verification established verification as a habit; and the collection of things (or facts) instead of the accumulating of reports (or mere information) developed a new faculty of minute observation." But it did much more. It developed at the same time the judgment qualified to draw correct conclusions both as to the nature of things and causation. To-day there is the most serious danger that the ever-increasing amount of mere information on countless questions as wide apart as the universe, made accessible anywhere to those who can read—through books, newspapers, and motion pictures, will, in the absence of a clear recognition of the fundamental principles of the limitations of the human understanding, lead to hopeless confusion in matters essential to every-day living. There was never a greater fallacy uttered than "Knowledge is Power," for it is by no means mere knowledge or information that gives support to creative intelligence, but the understanding alone aids the disciplined imagination ever on the search for new truths or the larger and better use of the truths or facts already known.

Sir E. Ray Lankester refers to the immense influence of the Royal Society in the seventeenth century when "It laid down definite rules for its guidance, designed to ensure the collection of solid facts and the testing of statements embodying novel or remarkable conclusions." Nothing would give more substantial furtherance to the cause of truth than

if this practice were adapted to-day by all scientific bodies as a first essential to conserve the precious intellectual heritage of the past against the menace of falsification and error and ridicule. To-day, unfortunately, there is not the serious jealousy against the inroads of the imposter and amateur now into one branch of science, now into another. Conversely, there is need of a broader scientific spirit, of a more hearty encouragement of all seekers after truth, in place of the narrow-minded attitude so often displayed by men who could be of the greatest aid to those who are doing pioneer work outside of the recognized field of the scientist of the academies. Sir E. Ray Lankester illustrates this point by calling attention to the fact that "The delay in the establishment of the doctrine of organic evolution was due not to the ignorant and unobservant but to the leaders of zoological and botanical science," an attitude of hostility which has by no means passed away.

I can not do better than draw one further observation from Sir E. Ray Lankester's essay: "Outside the scientific world an immense mass of observations and experiments had grown up in relation to this subject (genetics). From the earliest times the shepherd, the farmer, the horticulturalist, and the 'fancier' had for practical reasons made themselves acquainted with a number of biological laws and successfully applied them without exciting more than an occasional notice from the academic students of biology." But, he adds, "It was one of Darwin's great merits to have made use of these observations and to have formulated their results to a large extent as the laws of variation and heredity."

Over-specialization is developing a type of scientific mind as much to be guarded against as the credulous and ignorant. The limitations further emphasize the necessity of a broad scientific spirit anxious to give furtherance to the seeker after truth in whatever direction and by whatever methods useful results may be obtained. For, in its final analysis, every discovery rests primarily upon the power of observation or fact gathering, and discrimination and aptitude in fact classification and analysis, which may or may not require the aid of modern instruments of precision. Modern man is only too apt to forget the vast achievements of the ancients. The four greatest inventions of an earlier period were all made without the modern aids to scientific discovery, but by men gifted with a disciplined imagination. Printing, Gunpowder, Steam, and the Compass did more to change the face of the world and the fortunes of mankind than Electricity, Wireless Telegraphy, Motion Pictures, and the Graphophone.

The foregoing observations have been included in the present discussion to further emphasize the view that a true organization of knowledge is essential to the future of scientific discovery, as well as to the needs of the more complex life of to-day and of the years to come. But more than this would I try to make clear the conclusion that science in the more restricted technical sense should do more to encourage the development of science in the larger or more universal sense, and therefore enlist the aid of any and all means available in place of a narrow spirit of aloofness unworthy of the aims and ideals of the sincere seeker after truth.

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(To be concluded.)

THE FIFTH YEAR OF THE TROPICAL RESEARCH STATION

THE Fifth Expedition of the New York Zoological Society to the Tropical Research Station at British Guiana, sailed on the "Maraval" on February first, with nine members under Director William Beebe. As in previous years, the chief assistant is Mr. John Tee-Van. Mr. Paul Howes, who was a member of the first expedition, will work on the field staff. The artist is Miss Mabel Cooper who is completing her remarkable series of drawings from the life of living reptiles, amphibians and fishes. The party will continue tropical research at Kartabo until after the long rainy