THE SYSTEM OF THE SCIENCES

PRINCIPLES OF THE THEORY OF EDUCATION[1]

I

THE SYSTEM OF THE SCIENCES

AT the moment when the Rice Institute undertakes to begin its public work and to organize the wide and splendid educational activity for which it was intended, I do not know of any subject that could affect the development of its future more extensively and more deeply than the problem of the System of the Sciences. Judged by its present state, the problem appears more like a pastime for idle minds than a practical question of far-reaching importance. For at the present time there does not exist a single system of this kind, generally accepted and universally employed, and the numerous attempts of various investigators to establish such a system have not yet received the recognition which, on the one hand, would be a guarantee of its effectiveness, and, on the other hand, an indication that by the establishment of such a system one has discovered, in a measure at least, the correct and suitable thing. Nevertheless, such a system is a crying need, as is apparent at the present moment, when we are confronted by the problem of attaining a complete survey of all conceivable and possible sciences and similar activities of the human mind for the purpose of

[1] Two lectures prepared for the inauguration of the Rice Institute, by Privy Councilor Professor Wilhelm Ostwald, late Professor of Chemistry in the University of Leipsic, Nobel Laureate in Chemistry, 1909. Translated from the German by Professor Thomas Lindsey Blayney of the Rice Institute.

sketching a normal and rational plan for the realization of the fundamental aim of the Rice Institute. It may suffice at first, as has happened in the case of this institution, to select somewhat at random indubitable branches of science—*i.e.*, to let ourselves be guided by the demands and the attainments of our time—in order to be sure that at its organization at least a part of the entire range of science has been incorporated. But in measure as the present plans widen and it becomes necessary to envisage more accurately departments of this institution which are to be developed in the future, the need of a rational system that will include the functions of science as a whole will make itself felt more and more imperatively, and thus we shall be able only to postpone, but not to avoid, the question that confronts us here.

If we look about us to see how the problem has been solved by the universities which have been founded heretofore for the advancement of science, from an educational standpoint as well as for the purpose of scientific research and development, we shall find, generally speaking, the traditional four, sometimes five faculties. To the oldest faculty—the theological—law and medicine have been added, and all of the remaining sciences are united in the fourth—the philosophical faculty—which here and there, on account of its wealth of subject-matter, has already been divided into two parts, the one including the natural sciences and the other the so-called mental or historical sciences. If one raises the question as to the reason for this division, it will be seen that it is to be looked upon as a sort of fossil, as the fixation of a condition which belonged to the oldest period in the historical development of these institutions, and was in keeping with them, and which at the present time has completely lost its earlier significance. We know that all sciences in the early stages of their development formed one great whole, which, together with all other departments of human activity having to do with mental work and cogitation, was intrusted to the oversight of a single corporation —the priesthood. A division of labor came only in the course of higher development, when the sum of all knowledge belonging to the single disciplines continued to increase to such an extent that it could no longer be contained in the head of a single person. First of all, the sciences relating to the regulation of human affairs and those having to do with the healing of human diseases were isolated, and they attained to self-administration. This produced the law and medical faculties. This process continued to be repeated under most varied forms, and we may see down to the present day how new sciences have detached themselves from the joint association in which they and other sciences have been included, and demonstrated their independence by providing their own chairs, texts, and curricula. This formation of new sciences has recently become so common and so varied that for a long while the universities have not seen their way clear toward providing each and all of them with opportunities for development. Hence there has come about a sort of division of labor between the different institutions in such a way that this or that special discipline is cultivated predominantly and with particular zeal in one institution, and other new disciplines in another. This does not depend in general upon systematic causes, but rather upon purely personal reasons. Whenever there is a gifted representative of a new discipline who is an excellent teacher and at the same time scientifically productive, he will be able sooner or later to acquire the means and influence to develop this new discipline into a recognized science. By surrounding himself with a circle of students suited to his purpose he sees to it that the local influence which he exercises in his home university spreads within a few years over the entire civilized world, from which he draws his students and to which they return again after having imbibed the new ideas and new methods.

However gratifying the process may be in a given case, it is impossible to look upon it as the ideal solution of the problem in the general development of sciences. For by the side of the fortunate ones who at the place where they were accidentally situated succeeded in acquiring the necessary means for developing their new ideas and rendering them effective, there are many with whom things do not go so well. Those of us who are more intimately acquainted with institutions of higher learning, be it in Germany, England, France, or the United States, will recall those personalities who upon closer acquaintance revealed an astonishing store of new ideas and far-reaching plans, but who had not succeeded in gaining sympathy at the hands of the proper authorities for these ideas and plans, and who therefore were forced to exhaust themselves in unfruitful attempts to develop them and make their value felt. At all events, our institutions everywhere lack at present an arrangement for organization by means of which progress of this kind in all departments of science may be wisely encouraged and developed. As a result of this lack of organization science does not progress like a group of well-regulated workmen, cultivating a wilderness with new expedients and methods, putting it into proper condition for the proposed work of civilization, but advances rather like the bold individuals who moved toward the West in the early history of the United States, one settling here, another there, wherever accident or inclination led them, and where the character of the region or climate appealed to each one, leading a highly individual and peculiar life in the midst of manifold difficulties and dangers, paying little heed to what had been their connection with their homeland and its civilization, for the extension of which they had undertaken their daring expeditions. In other words, we must give up the accidental development of science hitherto existing, which depended upon where and how, as occasion offered, the new disciplines came to light and found suitable soil for their growth, and substitute for it an entirely reasonable, systematic, and carefully considered type by means of which we may render the new soil productive for science. Thus we may organize our progress so regularly and systematically that it will march steadily forward and bring about a gradual improvement that is in keeping with the present condition of existing knowledge and adapted to the most pressing and immediate needs of future knowledge.

For this purpose it is absolutely necessary, in the first place, that we recognize exactly and clearly the legitimate relations which exist between the individual sciences, so that we may no longer be dependent upon accident for their advancement, but rather that by means of this conformability to certain laws we can indicate, and will have to do so with more or less precision, not only in which direction science must be extended, but also what, approximately, will be the character of the anticipated extensions.

If one were to inquire in what manner the problems arising here could be solved, the reply at hand would be that we must take from the previous historic development of science those determining facts which would serve as a criterion for the future development of science. In fact, we shall be convinced farther on that the fundamental ideas for the development of science at which we shall arrive are to be noted in the history of the formation of the various branches of knowledge. But an historical phenomenon is such a varied and complicated affair, however, that while those portions of it which conform to existing laws may be recognized when the light of systematic knowledge is projected upon their differences, yet without such a guide recognition of what is authoritative by the mere observation of things heretofore existing appears rather hopeless. For, to begin with, one must of course convince himself that a number of accidental factors have encroached upon the development of science, particularly that all the sciences have sprung from the necessities of the hour and therefore have not been determined at their origin so much by systematic or general points of view as by the more or less urgent nature of the necessity and of the possibility of meeting it immediately or in the future—a possibility depending, to be sure, upon a variety of unforeseen circumstances.

If we examine in this sense the four traditional faculties, we recognize in the first three applied sciences. The first faculty—the theological—has to do with the content and form of religious tradition and of religious education, and is to this extent essentially an historical science which, however, cannot free itself to a certain extent from development in a modern sense. Thus law is an applied science, since its object is the regulation of legal relationships between people; and its functions are essentially historical, since the legal works of the later Roman Empire are still looked upon as the most important and in many ways the final source of law. The medical faculty represents, again, an applied science—viz., the technique of healing, and more recently the technique of avoiding human disease. Finally, in the philosophical faculty all is included that does not find a place in the three "higher" faculties, and in it pure or abstract sciences are found, such as mathematics and history, as well as applied sciences, such as dentistry and pharmacy. Thus we see that the historical and traditional division of the sciences as practised in the universities is totally devoid of system, and that the original purpose of the universities to serve as training places for the future clergy still makes itself outwardly felt as a standard for classification and administration at a time when the theological aim has long since been relegated to the background.

The irregularities and inconsistencies, however, do not end with these matters; for, in addition to the three applied disciplines first mentioned, other large fields have been newly formed in the meantime—I mention only the technical fields for which a place has been provided in the universities only in a very incomplete and meager fashion. In Germany, therefore, the technical schools have developed independently of the universities, and have as a primal object the culture of modern technical applied sciences. By the side of these, quite recently, numerous other institutions have arisen, such as commercial academies, schools for administrative officials, and the like, which emphasizes the fact that universities, even with the inclusion of polytechnic schools, are at the present day no longer satisfying all the demands for the scientific treatment of important questions of life which our many-sided, prolific age has evolved. At the same time it is an expression of the fact that experience has proved the old system of science in the universities to be totally inadequate. Hence, from the purely practical reason that each nation must necessarily and primarily look to an organization of its educational system that will be as complete as possible and sufficient for the future, the need arises for utmost clearness in systematizing science.

From such an organization we may expect a better employment of resources existing heretofore, not only from the point of view that necessary disciplines which through accidental, external circumstances have not yet been developed will be taken into immediate systematic cultivation and be made ready for their social functions, but also from the other point of view that certain fields which have been traditionally regarded as sciences and have been correspondingly supported by the government and have consumed the resources belonging to them will be shown by a systematic examination of the idea and meaning of science to be of very much less importance than has been admitted in the past. Thus we shall be able to free the present development of science from many narrow conceptions and trammels that have consumed the means, everywhere limited enough at best, for things whose social importance does not justify the employment of resources that have been raised for purposes of social betterment.

In a word, the problem is to replace the former disjointed and accidental development of sciences with an organized and systematized one. Like every other department of human activity, science also rose upon the basis of development purely individual. Those persons who felt a special inclination and special fitness for this kind of work endeavored to form their external circumstances so that they could carry on scientific work without coming too seriously into conflict with the requirements of life. And the general public, though it at first received the results of such disinterested work slowly and not without a certain amount of questioning, especially on the part of a church unfavorably disposed toward science, has more recently accepted them with increasing willingness and gratitude. We are now just beginning to emerge from this period of accidental scientific development. Numerous scientific institutions that were equipped hitherto chiefly for the purpose of instruction have begun very recently to develop exclusively with a view to the advancement of science, uninfluenced by any side interests, and thus in a most far-reaching way have assured the cultivation and dissemination of science in all civilized lands. Therefore in our day the question of national systematization of all science makes itself felt with special emphasis in order that its development may be organized—*i.e.*, may be subjected to thorough, wise, and judicious control.

For what is organization? What is the meaning of this process that has proved to be of fundamental importance in all departments of our present social life? The word relates to the existence of the characteristic desired in living beings, in organisms, and it is among them, in fact, that we find the principles in question put into practice and their existence long recognized. We know that a living creature is all the more perfect in proportion to its having been able to develop proper organs for the varied functions peculiar to its existence, and in proportion to its assuring more completely the common and organized co-operation of these organs by means of a central nervous system. In connection with all organization there come into question two related yet distinct operations: on the one hand, a division of functions and their apportionment to special organs for the purpose of having each single function all the more perfectly carried out by the particular organ formed for it, and secondly, a co-ordination of these single distributed functions in the interest of their common service in such a way that each single organ carries out its activities, in point of space as well as of time, so that it thereby produces the greatest gain for the whole organism. Therefore the distribution of functions and the combination of functions are the very essence of organization, and so we shall not be able to organize science otherwise than by separating its functions and then by reuniting them in collective efficiency.

A suitable division of functions implies, moreover, a knowledge of the separate functions—*i.e.*, it presupposes a general survey of the total range of the sciences, and demands therefore a system of them, and this is shown to be the great practical problem that must be solved if we are to organize scientific progress logically.

One occasionally hears the objection raised that an organization of the sciences is not to be thought of, for the reason that science is the highest manifestation of spontaneous mental activity, and therefore is to be gratefully received, but should not be consciously and systematically directed toward definite problems and fields of work. Such an objection is not justified, for the reason that all human progress in all departments rests upon the fact that those things which have occurred heretofore unexpectedly and by chance are transformed into a systematized harvest in the field of human activity through our recognition of relationships established by law. Such an objection in the face of science has still less justification for the reason that science in its very essence rests, as we well know, upon the systematic, logical, and rational ordering of single facts. Therefore, only a very undeveloped condition of science as a whole is indicated if it has not yet learned to apply to itself this process of ordering of which it has always made use as a fundamental principle in connection with its own subjects of study. Thus we see that the ordering of facts and their relationships in each individual science is the first and most important function in its development. A discoverer of new facts may not content himself with simply imparting these facts to the world at large, but only after having recognized and fixed them does there then arise for him the new, great, essentially scientific duty of demonstrating the relationship borne by these new facts to the existing condition of knowledge in a particular field, and of thus rendering them real, organic component parts of the entire science in question.

An ordering process of this kind in each particular science has always been the principle of all progress, and the fact that great fields of possible knowledge have already been mastered by man and brought into natural relationship postulates the possibility (contemporaneously with the need felt for it) of our beginning to attempt the solution of the greatest problem of this kind. We are therefore confronted by the task of subjecting the whole range of science to the same organizing and systematizing process which has been carried out so successfully in single sciences, to the advantage of society as a whole.

Let us now, with the help of historic facts, endeavor to come to a clear understanding of the leading features of scientific development in order to arrive at certain fundamental ideas by means of which, independently of accidental happenings in the zigzag progress of historic development, we may extend the facts which have been discovered into an actual system of science. We recognize three chief phenomena in the history of science, which we shall discuss in their proper order, that we may derive from them those fundamental notions for our system which they enable us to reach. We have already called attention to the first of these facts, that all the sciences gradually separate from some central or general form of knowledge which at the dawn of history was everywhere in the hands of certain persons whom we usually term priests, but who are to be regarded more properly as the representatives of the entire knowledge of their time. Now that which above all else in the early course of historic development was concentrated in the hands of the priesthood was the guardianship of the supernatural relationship through which man imagines himself to be connected with the unseen powers, and the separation of it from those fields of knowledge which appear to him to be natural relationships. These latter are those things which are subject to the law of causality, in connection with which one is accordingly able to recognize the conditions which must be fulfilled in order that the phenomena may be produced, and may be able to control more or less the course of these phenomena. This process of development is going on continually, and is far from being completely terminated in our own day. We may say, however, that on general principles we do not recognize within the entire range of science any field of supernatural phenomena; that, on the contrary, we are convinced that every phenomenon that can form in any way the content of human experience may be comprehended in its logical relationship to other phenomena, and may be co-ordinated thereby in the total fund of human knowledge. In contradistinction to the earliest and rudest conceptions connected with the belief in spirits and ghosts, this idea of the existence of a field beyond the reach of science has disappeared more and more rapidly from our mental life; and it may now be said, without prejudice to any person's individual attitude regarding the religious views of our day, that all fields of human experience are subject to scientific treatment; that therefore the idea of natural law is everywhere applicable; and that, under like circumstances, like consistency in resultant phenomena may always be expected.

The second point which an examination of historic development enables us to recognize is that the pure and abstract sciences grow by degrees out of the applied sciences. We have seen already that originally all mental activity was united in a totality of knowledge administered by the priesthood; or, more exactly, that in the hands of the priesthood only that kind of knowledge was formed which was not the common property of all adult citizens, and which was therefore used only on special occasions. On the other hand, the kind of knowledge necessary for the accomplishment of the tasks of daily life, of procuring booty, of combating enemies, of cultivating the soil and acquiring the necessary products for clothing, food, and shelter, could not be confined, of course, to the administration of a few persons, but was the common possession of all, and was apportioned from father to son with correspondingly slow increase, and from one member of the community to another. We know that just at this point a division of functions took place, just as we have seen in the case of the distinct kinds of knowledge which were administered by special classes of people. While in the original forms of social activity each person exercised all the functions necessary for life and maintenance, it subsequently came about, at first slowly but later in increasing measure, that the technique of division and combination of functions—in a word, the organization of management—caused certain functions demanding special skill—for example, blacksmithing—to separate and attain to their own degree of technical advancement, with their own traditions. With increasing cultural development, knowledge became here, too, increasingly diversified and richer, and the division of functions proceeded farther and farther.

All of these fields of knowledge, however, were only applied sciences, and quite an extensive special development inside the applied sciences was necessary before there were formed in certain advanced members of the human race new activities by which knowledge for its own sake, without any immediate reference to any application of it, came to be regarded as a vocation and aim in life.

European civilization began in this respect with an unusually rapid and brilliant development among the Greeks. There, owing to previous economic development and to the formation of a small group of well-to-do men whose wealth was based on an extensive slavery, there arose men with sufficient leisure to direct their vision beyond the mere necessities of the day to more general problems and discussions. So we see that the early beginnings of pure science took the form of philosophic systems—in the first place, that of the Ionian natural philosophers. It was no longer a question of how one might satisfy the needs of the day more easily and to better purpose, but rather, since the needs of the hour no longer occupied these men, problems were sought in more distant fields.

Thanks to a well-known peculiarity of the human mind, the range of problems envisaged by them soon became extended to the utmost limits. Questions relating to the origin of the world, the manner and means by which living beings might have come into the world, and, after these, questions concerning the purpose and aim of human life, were the ones that busied these first thinkers. At the same time we notice that the pleasure of making use of this new organ of human activity—the capacity for reflection—soon led to extensive exaggerations in its use. Instead of supplementing in proper sequence the answer to questions relating to immediate surroundings, both as regards time and space, with solving more distant problems from remoter times and space, they ventured upon the remotest imaginable confines of time and space. It was only natural that these first activities of the newly developed thinking faculty in man should soon go astray in these distant and uncertain regions. A hard and long training was necessary before mankind learned that the newly grown wings could not, after all, bear them beyond the atmosphere of the earth, and that the first bold and illogical flights into unbounded space could only lead to the miscarriage of such impossible undertakings.

So we see how Greek philosophy turns back more and more from the excesses and capricious ideas of its early days to the realities of life and to an analysis of the capabilities of the human mind. We have received, unfortunately, only a very incomplete and highly one-sided and biased account of those days. Nevertheless it can be seen from these few literary remains that the Greeks had already entered upon a course which approached quite nearly to the modern development of the sciences, but which for that very reason was in complete contrast with the older traditions. This was the school of the Sophists, which demonstrated by its activity the inadequacy and complete inaccuracy of the first endeavors of youthful thought, and which, very logically, was accustomed to emphasize experience as the only reliable source of all human knowledge. These first germinations of scientific activity among the Greeks were in large measure repressed and destroyed by the great political upheavals which began some two thousand years ago.

Only a very small part of this mental stimulus was assimilated by the Romans and rendered fruitful of good; only a slender thread of tradition leads from those days, by way of Arabian translators and commentators, to the beginning of modern times, when the peoples of central Europe who had in the meantime become accessible to culture began to take part independently in the cultivation of science and of the reflective qualities of the human mind. The restriction of all medieval development to imbibing and discussing the traditions of the Greek philosophers resulted in the fact that during this time no new important intellectual productions were brought to light. In the same manner, the destruction of technical culture by the incursions incident to the migrations made it necessary that the stores of applied knowledge that belonged to varied fields of daily and social life, and which were lost at this time, be slowly gained anew while a corresponding new technical culture on the part of these fresh peoples was slowly reformed. All these preliminary conditions were so far developed in the seventeenth century that at that time a phenomenon could take place similar to the one that had occurred among the Greeks a few centuries before the beginning of our era. For there arose again, on the basis of the general culture attained at that time, individuals whose thoughts were turned to science as such, and who, by systematically collecting what was known up to that time, put the human mind in possession of a disproportionately far-reaching power for overcoming terrestrial conditions. The historical appreciation of these events is rendered somewhat difficult, because at this time new sources of Greco-Roman tradition were opened, and especially because the artistic productions which had been found dating from the period brought before the eyes of modern artists new solutions of their problems that differed entirely from those which they had found previously in the course of their natural development.

This rehabilitation of Greco-Roman art in sculpture and architecture, as well as in poetry, is what one consistently terms renaissance. The learning, however, which developed in the province of mathematics and physics cannot be counted as a part of the renaissance movement. This development has in common with the former only the factor of time; it stood, however, in entirely conscious contradiction to rehabilitated tradition. While the artistic renaissance consisted in taking over the completed works of art of the past, as regards both content and form, and holding them up as unattainable ideals for the artistic movements of the day, the new sciences were in no wise developed as a rebirth of the sciences of antiquity, but rather in sharp and definite contrast to them. It is characteristic that the Greek traditions in mathematics, for example, as contained in Euclid's geometry, did not lead to any kind of special development in geometric science; that, on the other hand, a new discipline that could not be traced traditionally in any way to the Greeks—algebra, and afterwards differential calculus—opened very extensive and important new fields to mathematics, and so, for the first time since those days, caused new scientific ideas and methods to appear in history as the original product of the peoples of central Europe. We find in the same way that the fundamental progress in physics, as brought about in the province of mechanics and astronomy by Galileo and Copernicus, arose in conscious and sharp contrast to the traditions of antiquity. In the truly fundamental investigations of Galileo concerning the mechanics of bodies falling freely, special reference was made to the false and untenable view previously held by force of tradition, and which was based upon the observations of Aristotle concerning this problem; and thus in a thousand other particulars can be shown the position of conscious contrast which the new sciences were forced to occupy toward the many traditions of Greek science.

In the few centuries which have passed since these beginnings a development in science has been accomplished which is incomparably greater and more varied than that attained in its first flower among the Greeks. And, judging from the progress which this highest attainment of the human mind has made, one may prophesy with certainty that the extraordinary development which has taken place down to the present time will be only the small beginning of incomparably greater further development, and that this science which, in the two or three centuries that it has been under the control of mankind, has already accomplished so very much in the transformation and betterment of our life, will exhibit a much greater and more important range of activity still, both in the near and in the more distant future.

If we ask what this development means for us in respect to our chief problem—the system of the sciences—we cannot fail in general to recognize that an absolutely definite sequence can be shown in which the various scientific disciplines have appeared and have been developed into their first florescence. The first real science which we received from the Greeks was mathematics, especially geometry, and so we see also, on the occasion of the new flowering of science at the beginning of modern times, how mathematics stepped at once into the foreground of scientific interest. It reached at once such an unusual height of development with the discovery of differential calculus by Leibnitz and Newton, that all the performances of the past were left far behind, and our present mathematical knowledge still stands completely under its influence. This course of development is so characteristic that we can now say with certainty that the highest development of mathematical knowledge is already a matter of history. A wealth of unexpected, new results and prospects, such as the development of differential calculus and of its nearly related disciplines has brought with it, does not now exist in mathematics. Though year by year new progress may be noted in this oldest department of pure science, yet at the present time it is merely a question of extending and widening the fundamental ideas already existing, and we cannot mention a single mathematical discovery in the entire past nineteenth century that could have influenced the thought of the age in a way that even approached in importance and fruitfulness the discovery of differential calculus a century and a half before.

Following mathematics, astronomy—an applied science—

and physics were developed. This development began with mechanics, and was then extended to the fields of optics, heat, and electricity. We are not accustomed to recall the fact that the voltaic pile, for example, upon which the theory of the electric current is based, was not discovered until the year 1800, and that this entire field, therefore, which to-day, under the guise of electrotechnics, has so profoundly transformed our economic life, is scarcely more than a century old. Chemistry is even more recent than physics in its various disciplines, and began its scientific transformation only toward the end of the eighteenth century; in it, as in physics, we may experience from day to day the most astounding and unexpected extensions of our knowledge and views.

A whole series of other sciences—on the one hand, the biological; on the other hand, the so-called mental sciences, especially language, history, and finally sociology—was developed in the course of the nineteenth century and formed into sciences. This formative process is far from terminated, for sociology, as an example, is still occupied almost exclusively and above all things with inquiring upon what fundamental ideas its claims to being an independent science rest.

In this short review of the total development of science we can already see something like a system. We can say that mathematics and mechanics are about the simplest that we are able to discover in the whole variegated gathering of present knowledge, and that the sciences which appeared later, as of course was necessary psychologically, made their appearance later in proportion as their problems became increasingly more complicated. Unquestionably the problems of sociology, which has to do with the whole development of human culture, are disproportionately more complicated than, for example, the problems of chemistry, which have to do with the reactions of objects without life and under uniform conditions.

We may derive, then, from these observations the three following facts. First, that we shall renounce in any scientific system the consideration of all supernatural relationships, of whatever nature, and that, on the other hand, from the very nature of things we shall extend our scientific problems to each and every field of human experience; secondly, that we must differentiate carefully between applied and pure (or free or theoretical) sciences, and in doing so we shall find the accidents of life and of origin principally in the sphere of applied sciences, whereas we shall look for theoretical and methodological relationships wholly in the pure sciences; and, thirdly and finally, that the general historical development of science also places at our disposal a clue for the systematic envisagement of all science by reason of the fact that from among the individual scientific disciplines the simplest arose and were developed first, and that, in proportion as the reliability of the human mind in mental operations was developed, the more complicated and diversified fields of experience were gradually submitted to science. We shall have occasion to subject to careful examination this last thought, especially regarding the increasing multiplicity of scientific subjects, since in this field we may expect first of all to find the solution of the problem regarding the rational systematization of all the sciences.

In order to find this general principle that has been sought, we shall first have to meet and answer the question, What is the general characteristic, the real essence, of science? It is evident that for the division of all science, only that peculiarity of it can be serviceable and effective which occurs to the same degree in each science, and which, therefore, is common to all. We may discover this common constituent part all the more readily if we call to mind the origin of each individual science in such a way that we take into consideration not the special content of knowledge, but rather the manner and means of the formation of knowledge. Thus we now observe that every individual form of knowledge develops into a science after having been cultivated previously as a technique. The fact has already been emphasized that all sciences have had their origin in the needs and desires of life. From the fact that certain needs occurring frequently and regularly, such as those pertaining to food, the healing of the sick, administration, the building of homes, the making of clothing, etc., etc., have been met regularly from one generation to another, there have been accumulated a quantity of experiences which are handed down from father to son, from master to apprentice, and soon form a more or less important proportion of a particular science. This knowledge indicates in each case not only how things have previously come to pass in one way or another, but it points to what must be done in order to attain to any particular future results. Such a knowledge of the future is, for example, that in making bread one not only has to put the flour mixed with water in a hot oven, but that one must let the dough stand twenty-four hours or more beforehand, because otherwise the bread will not be sufficiently light. In the same way certain processes are worked out, for example, such as forging and hardening iron, and similar conditions may be found in every other field of knowledge. This means, in other words, that every branch of learning rests upon the knowledge of certain laws of nature, certain successions of phenomena, which are regularly repeated; and every technique is based upon the fact that one determines the hypotheses or preliminary conditions of every such succession of phenomena, so far as is desirable and suitable for the work in hand, in order to bring the phenomena to a normal issue.

Every technical branch—and along with it, to an even greater degree, every science—has as its object, therefore, the attainment of future happenings by means of suitable preparations. It means, therefore, in the first place, foreseeing the future, hence forming the future. Both possibilities have their limits. One can foresee the future only in part and for a relatively short duration of time, and one cannot prevent many approaching events, even when it may be desirable to do so, because the means for altering future occurrences are more circumscribed than those for foreseeing them. But, nevertheless, the number of things which may be foreseen and influenced is continually increasing in proportion as knowledge, and therefore in proportion as science, reaches farther.

All prognostications of this kind depend for their part upon the circumstance that certain groups of phenomena always occur conjointly. The groups may not be connected as regards time; in such cases it is a question of objects, or subjects, of our experience such as are included in the nouns "horse," "stone," "fire," "sky," etc. Each of these words indicates a definite accumulation of experiences, repeatedly gone through with, which have the special characteristic that as regards time they are always to be observed connectedly. These peculiarities that are observed coincidently are called the characteristics of that particular thing, and the technical as well as scientific knowledge of this thing is all the better and more developed in proportion as characteristics and relationships are better known. The most frequent and best known of these kinds of groups are given definite names, as we have just seen. Those which are less well known and which have been investigated only in the course of conscious endeavor are expressed more commonly through rules and natural laws. However, in both cases it is a question of the relationships of definite single happenings or single characteristics; and prognostication depends in any case upon the fact that, after taking cognizance of some few of these characteristics, one finds himself in a position to predict the others also. Thus the primitive huntsman, for example, contents himself with the optical picture of game well known to him in order to set out at once to pursue or kill it, though he has not been able to discover from experience that it can be killed and transformed into food. Since, however, this experience has been met with in connection with similar things on previous occasions, he dares prophesy that it will also be so in this case; and this prognostication, therefore, is sufficiently certain for him to expend trouble and labor upon the killing of the game. In a somewhat more advanced period of cultural development this ability to foresee events is even extended considerably further, in that man intrusts seeds to the earth with the foreknowledge that in proper time they will grow, that the resulting plants will bear fruit of like structure and in such quantity that the measure of grains used in sowing will be abundantly replaced.

In this manner one can work at will through the whole range of human activities and knowledge, and the general fact will always be encountered that all conscious performance rests upon a knowledge of the regular temporal relationship between different experiences which recur in the same way. Thus all knowledge consists in group-memories by means of which certain definite amounts of experiences, happening simultaneously or in sequence, are included from time to time. Through the general psychophysical nature of all living beings, repeated experiences affect the individual experiencing them otherwise than do single or varying ones. They become possessed of a special characteristic which, in connection with conscious living beings, we term remembrance or acquaintance. Upon this recollection of regularly recurring associations, or our acquaintance with them, depends our power, at first more instinctive, later more conscious, of foreseeing and anticipating future events. Such associations we may comprehend under the general term of concepts, in connection with which it is well to repeat emphatically that natural laws are also to be classed under concepts; for they represent relationships, just as the ideas "horse" and "stone" represent associations of definite occurrences that may be experienced, or characteristics connected with the object in question.

Such a formation of ideas has a purely technical character at the beginning—*i.e.*, only concepts impress themselves in the consciousness of primitive man by repetition and a corresponding awakening of interest as relates to experiences which are important to him for his existence. He could form for himself, for example, ideas or experiences concerning the many thousand plants which he has the opportunity of observing daily. He confines himself, however, to those plants from which he derives a special advantage or harm, and avoids the forming of ideas concerning less urgent objects, for the reason that they have no known importance to him, and because for that reason he shuns the efforts (and evidently they must have been very great in the case of primitive man) necessary for such a formation of ideas. One may observe this condition of mind in all possible gradations among races which are but slightly developed, whose characteristics and psyche have become well known to us in recent time, thanks to the many anthropological investigations. We may thus observe all the stages, from the most circumscribed formation of ideas, which extend only to the most urgent necessities of life, up to the very highest development in this sphere, such as may be found in the mind of the modern investigator, discoverer, or organizer.

These considerations now lead us to establish the essential difference between technique and science, or, as one may more properly express it, between applied and pure science. Technical knowledge, from its very origin, gravitates around certain necessary or desired things, and all knowledge is created and collected in respect to the accomplishment of the task that underlies this relationship. Whenever a technique is followed, however, for a considerable length of time, and is developed to even greater completeness, it always happens that new circumstances arise from time to time which cannot be controlled by existing knowledge, but which demand rather the acquisition of new knowledge. The more varied the knowledge as regards the events which occur more infrequently is, the more experienced, the better informed, the wiser the person in question is. The necessity of being prepared for unforeseen cases causes finally a certain inclination of mind in accordance with which, even without any thought of a particular task's lying just before one, a condition of preparedness for all possible problems appears to be a desirable state. Accordingly, one will strive not only to become acquainted with the material employed by the technique in question with reference to its immediate application, but one will endeavor to investigate it from so many sides and so variously that the future occurrences in that technique may, in so far as is possible, offer no further surprises of any kind. It should not be stated that this train of thoughts is the only one which has led from technique to science. But, so far as we can historically see from the statements of those who have created a science out of technique, this general impulse to know more than the needs of the hour require, and to be prepared for all eventualities, has been, after all, a prime motive power everywhere for the carrying out of research work.

Since the necessities of life are always transformed, according to the well-known laws of natural selection, into activities which promote happiness, because the beings that gladly and readily perform the necessary thing are, in the struggle for existence, especially preferred as compared with others, it is also to be expected that the necessity for logically controlling phenomena becomes by degrees a passion for knowledge. This passion for knowledge is a variation of the racial type, the origin of which is therefore to be expected only in a very few extraordinary individuals. And so history teaches us that the investigator, the man who, independently of any technical application, though possibly incited by it, feels the general impulse to extend his knowledge and to shape it into greater effectiveness by a process of rational comprehension, was originally a sporadic phenomenon. It is to so small a degree a question of professional investigation, that in the case of the first investigators in each special department we cannot help observing just about the opposite. Those who content themselves with handing down existing knowledge look upon every extension and renovation of intellectual materials as a wrong done their efforts, and take a most energetic stand in opposition to any possible change in pre-existing functions. So these greatest and most decisive benefactors of mankind, the men who have endeavored to transform the short-sighted technique of their day into a correspondingly more far-sighted science, have almost always been persecuted and oppressed. And though investigative activity in our day is no longer fraught with danger to life as it was three or four centuries ago, and though in our scientific institutions attention is generously and readily given to carrying out investigations, we see, nevertheless, that even in the twentieth century the profession of the investigator as such is found only sporadically as yet. Professional appointments of this type exist in the form of research professors in the American universities and members of the research institutes of Germany, and certain professoriates in the old English universities, Cambridge and Oxford, as well as a number of professoriates in the Sorbonne in Paris. All the other positions in which research work is now being carried on permit this work only as a species of minor office, the men in question being appointed either as professors for the instruction of students or for some other regular activity which, to be sure, has some factitive relationship to their research work, but is quite secondary to it so far as their outward position is concerned. To find means new and universally applicable by which research work may be regularly overseen and encouraged by society, whether by the government or by narrower groups within the government, is a great task for the twentieth century and for this institution now in process of formation; the question of a logical separation of instruction and research will also be of vital import, if the Institute is to attain to the high aim which its founders have set for it. In other words, the relationship between research and teaching must be organized. Each of the functions must be developed to the highest possible point of efficiency. And since along with a division of functions the co-ordination of functions is also important to all true organization, care must be taken that a member of the Institute who is occupied chiefly with research work shall have an influence upon its entire intellectual activities which is proportionate to the extent of his ability and his tasks.

We have seen how the Greeks, immediately after the discovery of the enormous power that comes with the development of ideas and laws, in the freshness of their youth soon greatly exaggerated their view of the effectiveness and productiveness of this new intellectual instrument. Instead of allowing the formation of concepts to depend exclusively upon experience, as the very nature of the matter demands, the Greeks, as soon as they had experienced the workings of abstract intellectual activity, attempted to increase it to the very furthermost limits. Instead of forming for themselves conceptions about the nature of the earth, about the laws governing the growth of plants and the propagation of animals, about weather and clouds, in keeping with actual conditions, they soon extended their speculations to the most universal and unattainable problems, such as the beginning and end of existence, the nature of the entire visible and invisible world, and thus took as a subject for their meditations those ultimate characteristics of bodies physically perceptible which are far beyond the confines of perceptibility. Such intoxication in the use of this newly discovered intellectual power is readily explicable, but we must always keep before our minds the fact that it is only a species of intoxication and exaggeration of a means newly won with which we have to do, and we must not consider the intellectual accomplishments in the sphere of speculation that date from that youthful period in man's development as unassailable and unsurpassable master-accomplishments of ripe intellectuality.

Greek speculation is an expression of childlike pleasure at the new intellectual acquisitions. Just as a child, after having overcome the first difficulties of speech formation, cannot repeat and vary the art just learned enough, so, too, in connection with the Greeks we see the theoretical or abstract thinking—*i.e.*, that which has only its very earliest origin in common with the necessities of life—developing in a great variety of forms, but leading only in rare cases to a lasting and really fundamental result. So in geometry Greek thought created a theoretical or pure science (probably in close conjunction with the empiricism of the Egyptian surveyors), which found its classic expression in Euclid and in this form influenced most profoundly the later development of the science. Since the Euclidean form, however, is only the product of a very long and thorough study of this science, and, therefore, does not consciously contain the slightest trace of its genesis, this presentation of geometry is anything but suited to introducing the formative mind to the way in which science has its origin. It is only typical of the manner in which science, which has already developed prosperously to a considerably advanced stage of completeness, may be logically co-ordinated in accordance with known principles.

An insight into this relationship is essential to all the questions pertaining to instruction and education. The conception which has been current for centuries, that the geometry of Euclid is an especially good means of training for the human mind, is incorrect in so far as one places any important degree of weight at all upon the development of the capacity for discovering new relationships and principles, for forming new concepts out of the chaos of varied experiences for the advantage of mankind. For this there is not the slightest introduction in Euclid.

So we see, then, that after the overthrow of medieval barbarism, through which there ran only a slender thread of earlier cultural traditions, the entire science of the time was occupied with the task of developing this tradition as completely as possible. The real key to it was the knowledge of ancient languages. For a long time men contented themselves with Latin writings, until finally, owing to a series of accidents at the beginning of the sixteenth century, the Greek language and Greek tradition became known in central Europe and gave impetus to great movements which were called the Renaissance of art and letters. This Renaissance had to do primarily with art; secondarily, under the name of humanism, with literature, which, by way of the long circuitous route through Arabian translations, became known to the peoples of central Europe, who were once more struggling upward. Independently of these, modern mathematics, then physics and chemistry, arose, as we have already seen from what has been said.

The fact that, owing to the Renaissance, the predominant occupation of the time was on the language side of classic tradition was brought about because the ancient works in the course of their transmission had undergone extensive disfigurement and harmful changes, so that the reconstruction of the original, genuine text was an important preliminary condition for attaining their real content. As is almost unavoidable in such cases, the means was gradually made the end, and the treatment of the corrupt and disfigured texts by means of the apparatus of linguistic criticism became, without any consideration for the content that might possibly be arrived at thereby, the subject-matter of zealous and devoted labors, whereby the results stood completely out of proportion to the efforts expended. Through this circumstance a thread of pseudo-science developed by the side of that thread of real or empirical science which has been described above.

In our universities there may yet be found a great number of men occupied with the same tasks with which culture, just beginning to emerge out of barbarism, was compelled to busy itself at the beginning of modern times, in order to disclose the only fountains of culture existing at that time—the traditions of classical writings. At the present time, in all sciences without exception, we have far surpassed the stage reached by the Greeks and Romans. An objective, therefore, for expurgating the traditions from those days, by means of the apparatus of philological criticism, no longer exists; owing, however, to the law of the conservation of form, this work is still being continued down to the present day. And a goodly portion of the respect that was paid to this activity, and with some degree of justice, three or four hundred years ago has been maintained down to our time, when work of this nature has completely lost its former importance and has not in the meantime attained to any new significance. I know full well that with such notions I am placing myself in contradiction to the majority of my contemporaries who are studying the problem of the sciences. But at this important opportunity I cannot refrain from calling attention, with all possible emphasis, to the conclusions at which I have arrived on this question. The whole province of the so-called mental sciences,—above all, classical philology, and in connection therewith many other historical disciplines, are nothing but passing phenomena which do not proceed from the continual ascent in the development of civilization, but rather from transitory waves in this great stream. In their own place, in so far as it is a question of the proof of certain stages of culture and their peculiarities, this knowledge has still a certain value; but it stands upon the same plane of importance, for example, as the knowledge of the development of the ancient Mexican civilization, or that of China or any other, and it is out of the question to attribute indefinitely this predominant importance to the history of the development and content of Greek civilization which by force of tradition we still concede to it.

And in measure as the general laws of the development of culture become better known (we shall return later in proper connection to this problem), in the same proportion also the knowledge of a particular case will lose in importance. For when the general law is known all the individual cases are known along with it, and there is no need of studying a special case more thoroughly than is absolutely necessary for the clear and definite ends in view.

To whomsoever this judgment may appear severe or unjust, I would beg him to call to mind the fundamental definition of science at which we arrived in our study of its historical development. Science exists for the purpose of prophecy; a science, however, which confines itself to gathering information in the most exact possible way concerning the minutiæ of some past epoch in the development of a certain people—as, for example, Greek archæology does—foregoes from the very start all claim to the character of a science and confines itself to representing a branch of knowledge that possibly at some later time (when it becomes impregnated with more general interests in the wider field of mental activities) may serve as material for a science, but in itself is in no wise a science in the general modern sense. The same thing is true of the relatively modern discipline of comparative philology, which also has limited itself in its functions up to the present exclusively to determining what has existed, or at least still exists, with respect to the various exceedingly diverse and therefore accidental forms for the signs—but slightly subject to intelligible laws—which different groups of humanity have co-ordinated with the ideas they have formed. However well one may know the past and present of these formations, one has not attained in the slightest degree to anything in the nature of true science. Such a thing could occur only if one employed the knowledge of the past and present for the prevision of the future, and, whenever possible, for preshaping it. This leads us to the true task of linguistics, namely, to the task of setting in place of (or at first by the side of) the more and more impossible multiplicity of national languages, which have originated within narrow circles, a new general language, free from all the imperfections and shortcomings possessed without exception by all those formations that have risen by accident, and uniting all the advantages and special auxiliary means that it is possible to observe in the individual languages for the fulfilment of the purpose of attaining an exchange of thoughts as rational, simple, and unequivocal as is possible. In the same way, chemistry was an exceedingly incomplete science,—indeed, it was only the beginning of one so long as it confined itself to the analysis of the materials at hand and to the determination of their characteristics. Chemistry became an all-transforming science only after it had learned, on the basis of the knowledge so obtained, to form limitless quantities of new materials with new characteristics,—in fact, to seek consciously and to gain synthetically materials with definite characteristics, concerning the existence of which nothing was known up to that time, but whose manner of production and whose presumable characteristics could be foreseen on the basis of the scientific knowledge already attained. In precisely the same way we must employ our present knowledge concerning the formation and transformation of language in order to construct a really complete and universally available language which may serve for the general intercourse of mankind, at first by the side of, and perhaps at a very remote date exclusively in the place of, the national languages which have arisen by accident.

These considerations, which in an analogous way we may extend to history (whose present scientific representatives for the greater part also still refuse to employ their knowledge of what has transpired in the past for a logical predetermination of the future), teach us that the group of so-called mental sciences at present correspond much less to the real substance of science than do the natural sciences. Nevertheless, we observe how the natural sciences, ascending from the simpler to the more complex, become more and more imbued with scientific method and with the true idea of science, which looks toward prediction, and the approach nearer and nearer to the ideal thus characterized. So physics and chemistry in large measure have already reached this stage, while biology is most zealously engaged in endeavoring to attain to it. And in very recent times we have seen a group of sciences adopting the same methods, and with their assistance making great strides in the direction of human progress and culture. I refer to the cultural sciences comprised at present under the name of sociology. The mental sciences, of which we have just spoken as being undeveloped, are gradually being taken over by sociology, and are being fructified and rejuvenated by the application of general scientific methods. And so in our own day a renaissance of science is beginning to be felt, which, however, unlike that of the artistic Renaissance, does not confine itself to a relatively short space of time, but rather began three hundred years ago, after the rebirth of the sciences in central Europe; and it has experienced, and must still experience, especially at present, great and important changes in the entire thought of the time (as example I mention only the transformation of our conception of the nature of legal relationship due to the irresistible socialization of jurisprudence in our day).

These observations lead us now with absolute certainty to the chief point of our problem,—to the question, According to what principles are all the sciences to be divided? We have seen that the element common to all the sciences is the formation of ideas and the investigation of the relationships between the ideas thus formed. And we shall have to seek, therefore, a basis of division for all the sciences in the nature of the ideas with which the various sciences are busied. We see at once that such a division cannot be employed in connection with the applied sciences, which are a product of the physiological and psychic requirements of the human race and of the accidental climatic and local conditions incident to its development, but that a system of this kind can be found only in connection with the pure sciences, which are independent of such sources and motives, and which are directed merely toward the solution of relationships belonging in the field of concepts. Just here an exceedingly simple and perspicuous system presents itself, which provides us with the frame within which all human knowledge may be logically and methodically included, both in the form in which it exists at present and in whatever form it may assume in time to come.

When we consider, therefore, the various ideas which humanity has formed, and which have been brought into order by science, we find in them the following fundamental difference. There are certain ideas which are the fairly immediate results of experience, and which have retained in consequence a relatively large proportion of the inexhaustible diversity which every experience brings with it. Such concepts, for example, are "man," or "tree," or "government," etc. Since, however, the entire content of a single experience does not serve each time for the formation of ideas, but only those common portions of each experience that occur in a great number of them, therefore every idea is poorer than the single experience which can be associated with the idea. In every single horse one is able to show more individual differences than are contained in the general idea "horse." Hence we must take no note of a certain part of every experience, or, technically speaking, we must abstract from it, in order to arrive at the general idea in question. Now this deduction may be carried more or less far,—it may be carried so far, for example, that the idea "horse" is still retained; it may, however, be carried, if we include "horse," "dog," and "butterfly," as far as the much wider term "animal," whereby we abstract from the special peculiarities of particular animals, and take account only of certain common peculiarities, such as assimilation, oxidation, locomotion, reproduction, etc. One can imagine this process of abstraction extended until we shall finally arrive at notions which are applicable to practically all experiences, but which on that account have sacrificed most of the peculiarities of each single experience. In fact, they can retain only such peculiarities as occur in all experiences, and which, therefore, are of the most general character possible.

Thus there will always exist a reciprocal relationship between the diversity of the single characteristics, or parts, included within an idea, and the number of experiences or things in general which can be brought within this idea. The richer an idea is as regards content, the smaller it is as regards its range, as regards the number of individuals that come under this idea, and *vice versa.* This is a relationship which is universal and which therefore represents the principle sought for in the division of ideas and thus in that of the sciences. We begin with a science having reference to ideas of the widest range and least content, which accordingly predicate something about each and every experience, but can make only circumscribed and very general predications about these experiences. We can then ascend to concepts which have a richer content, but which on that account also refer to a narrower range of experience, and we can thereafter continue this process step by step. Since every idea must have a definite wealth of content and a definite range, which must fall between the furthermost limits of the most general and far-reaching ideas, on the one hand, and of the richest and narrowest concepts on the other, so we see that according to this principle we can actually dispose of all ideas, each in its own place, and that a systematic arrangement of all conceivable and possible sciences, in the order of narrowing range and increasing content of the ideas, gives us the certainty of logically encompassing all human thought and hence all the human sciences possible.

Before we undertake to carry out this general idea, there are perhaps a few words to be said about the real task of science in connection with the study of concepts. In accordance with what has been said, in order to have the totality of science, it should suffice to enregister all existing ideas in accordance with this principle of content and range, and to group similar ideas. Such a notion is, of course, entirely incorrect, and the error arises from the fact that we have tacitly considered the materials of our ideas as being complete and correct. Actually, however, no single idea represents an enduring and unchangeable image; rather is it constantly subject to new treatment, owing to the development of special knowledge and to the increase of our experience. This development, on the one hand, takes the direction of causing us to discover new elements of the idea which previously had not been known. For example, every investigation of the action of any substance in chemistry produces new facts of this kind, which contribute to a more exact characterization of the idea of the particular substance—*i.e.*, to a more extensive differentiation of its content. Moreover, the ideas as first formed by man have not in many cases been grouped and delimited most adequately; and there is a second kind of concept-making going on continuously in all science, which consists in our so altering the range and content of the idea as it was originally determined, and so analyzing it or grouping it with others, that a more logical —*i.e.*, a more distinct—division and arrangement of the ideas are rendered possible in a way calculated to bring out more clearly the existing relationship. It is thus that we gradually approach the solution of the standing problem of science, namely, by rendering as innocuous as possible the effects which the process of abstraction, in necessarily limiting experience, produces in every concept; by endeavoring to emphasize as completely and as diversely as possible the elements of the idea which remain after this process of abstraction, and to determine from every point of view their present relationship within the range of the idea.

Furthermore, there exist relationships between the various ideas which had not been recognized at the time the concept was formed. To discover these relationships is yet another exceedingly complicated and varied problem of science. It forms the so-called deductive part of it, while the determination of the ideas and their content is usually called the inductive process of science. Our results are not very satisfactory when we attempt to represent these two kinds of activities as opposed to and independent of each other, for real scientific work results from the uninterrupted employment of both methods. But few sciences have developed to such an extent that the deductive part has gained ground, as is the case, for example, with geometry and already to a certain extent with thermodynamics.

So we have now made the necessary preparations in order to undertake in detail the formulation of the pure or abstract sciences. For this purpose we shall next endeavor to find the very widest general idea with which any experience or object one pleases may be co-ordinated, which therefore possesses the greatest compass of all conceivable ideas, and in addition, of course, the least imaginable content. This concept has no definite name, for its establishment is necessary only for the purposes of pure science. In every-day life a concept so comprehensive and so poor in content finds no suitable application. We shall therefore experience a certain amount of difficulty in designating adequately this concept with the help of language. Whether we speak of a thing or an experience, of an object, or of anything else which approaches this concept, we run the risk of ascribing too great profuseness to its content, hence too much narrowness to its compass. We shall, therefore, content ourselves with the description that this most general idea—to which, in order to be able to speak of it, we shall ascribe the name "thing"—has no other characteristic than that it represents an experience which can be differentiated from others. So long, indeed, as all experience is felt to be a regular, invariable sequence of situation, there can evidently be no question of any conceptual activity. Only when the different portions of our experience react differently upon us, and those which are similar and coincident are included to the exclusion of the others, do the first traces of conceptive activity appear. Thus there occurs automatically and unconsciously the differentiation of our experiences and the arrangement of the corresponding parts, owing to that general characteristic of living beings which has been called by Hering, in the widest sense, memory—the basis for all concept-building in general. In this sense a thing is everything of which we are aware and which we can feel to be different from other things—a thought just as well as a house, a sensation of pain as well as the Milky Way, etc., etc.

A science of this thing alone, without further content, is impossible; for all that can be predicated about it is limited by our definition to the fact that we can differentiate it from others and recognize it again on the occasion of its reappearance in our experience. In order that a science be possible, we must therefore be able to bring somewhat more content into the idea. This content consists, in the first place, in our not limiting consciousness to a single thing, but in combining a number of things which appear as belonging in any way together into an association or group. As soon as we do that we get at once a whole number of possibilities of testing certain experiences in connection with such groups, and of setting up certain laws of nature which express these experiences. If, for example, we have, on the one hand, a group of children, and, on the other hand, a number of apples, we may give each child an apple and we are quite certain that one of the following cases will arise. Either each child receives an apple, or, after giving out the last apple, some children are left over, or there are apples left over after the last child has received an apple. There can be no other situation—*i.e.,* in other words, we have never experienced the occurrence of other possibilities when we co-ordinate the members of one group singly with the members of another group, as has just been described.

The usual way of expressing this law—that, of two things, one is either like or greater or smaller than the other—is somewhat too narrow, because the idea of number is included, which we arrive at only in connection with a later development of the considerations we have suggested here. In the same way, the philosophical law regarding the excluded middle, which is recognized as one of the fundamentals of logic, is only a special case of the general law of co-ordination, whose relation to the general law I need not explain further. At all events, we see that even in the case of an exceedingly general operation, as in the case of inclusion of things into groups and of the co-ordination of these groups with one another, very definite peculiarities conformable to law soon appear, which we find again in every single case, whatever may be the content of the group in other respects. They have, therefore, no distinguishing mark other than that one can merely distinguish one from the others. We may sum this all up in the statement that, of two groups, the one must either be similar to or richer or poorer than the other; other cases than these three never occur, and are therefore, as far as experience goes, impossible. These experiences are so very frequent and so common that we cannot imagine a world in which these simple laws of co-ordination do not hold. Accordingly we have not considered these laws as empirical laws, which they really are, but as *a priori* laws which inhere in the human mind before any experience, but which do not come into its consciousness until after it has encountered them through individual experience. We have no reason to hold longer this artificial construction, which has no real basis, but whose source is to be traced back to the half-forgotten religious conceptions regarding the act of creation and the endowment of man with certain characteristics on the occasion of that act.

With these considerations others may be connected by means of which one arrives at the idea of number by the comparison of groups and by the systematic construction of them out of single numbers. We see, then, that if we confine our observations to enumerable things, we arrive at a corresponding science—arithmetic, or science of number. Some one may perhaps ask whether there really are any things at all which cannot be counted. Without doubt, an affirmative answer must be given to this question; for in our experience we have a number of parts which are variable without our being able to set the various single parts over and against each other. When, for example, we look at the sky at sunset, it has on the horizon the color of gold and gleams; as one looks toward the zenith, this gleaming phase of the sky passes by degrees through greenish tones over into the pure blue of the sky. In this case we are quite certain that the color of the sky at the horizon and at the zenith is different. We are not able, however, to designate numerically the number of the different colors of which the total variety consists, because a line of demarcation can nowhere be drawn between the ending of one color and the beginning of the next. Therefore all the continuous diversities that we experience elude enumeration, although they do not escape co-ordination; for, to retain this illustration, every special color in the whole wealth of color in this sky has its own special place, and we should easily notice it if we were to undertake to transfer the color as it appears at a height of thirty degrees, as a spot, to a height of sixty or seventy degrees above the horizon. There it would be completely different from its surroundings and would not merge continuously with them. Thus the succession of colors from the horizon to the zenith represents an ordered variety, not a multiplicity consisting of members which can be counted, but which, on the other hand, are connected from beginning to end by a constant relationship. This, of course, is not the place to enter upon a discussion of the systematic construction of this whole theory of multiplicity. From what has been said one gets a sufficiently clear picture of how, by the inclusion of one idea after another, more and more elements come into connection, through whose alternate union and mutual effect an increasing variety of relationships or special conditions arise, the determination of which is the mission of science. In the relatively simple case of geometry it has already been shown by recent investigations that at least sixteen different and entirely independent concepts are united to render the multiplicity of geometric phenomena. And the theory of combinations shows us at once an immense number of combinations of second, third, fourth, up to the sixteenth order, between these ideas; and what a variety, therefore, must be produced by the whole of a science so simple as geometry! And if we include in addition the idea of time, we pass from geometry to kinematics, the theory of motion, which proves to be considerably more varied than geometry.

All these sciences may be included under the idea of order, and hence may be termed in an inclusive manner the sciences of order. As regards their relations to the science groups previously formed, the most important thing to be said is that the most general theory of order is identical with the discipline which, ever since Aristotle, has received the name of logic. Aristotelian logic, to be sure, is only a very small part of the theory of order—that part, namely, having to do with the inclusion and exclusion of groups corresponding to certain definitions. Modern symbolic logic, or logistic (*Logistik*), as it has also been called, represents a more scientific and universal conception of the problems before us, but it has not yet arrived at the most elementary analysis of their concepts. This is due to the fact that symbolic logic has been developed from the side of mathematics, which is a still more complicated science, in that one thing after another has been thought out from the elements of mathematical concepts as presuppositions. This process of abstraction has already been carried quite far, and we now have a corresponding science which has been developed in recent years to an encouraging degree in a variety of directions. But the ultimate deductions have not been systematically completed, so that an accurate working out of the thoughts just outlined here is still lacking, and this first-principle foundation for all other sciences, which from the very nature of the case is all-important, is yet to be constructed. Thus much, however, is already known: that logic still passes as a postulate for all other sciences. For, as we know, there is no single science that does not consider as at least one of its aims the bringing of all its thought material into logical relationship—*i.e.*, the subjection of it to the laws of logic, or to the general theory of order.

The disciplines called arithmetic, or theory of numbers, and algebra, or theory of quantities, are still more special cases. For the general hypothesis which is made in algebra, that things belonging thereto can be added to or subtracted from one another, and furthermore that as quantities they can be subjected to measurement, is itself a limitation, since, as we have seen, there are also things which cannot be added or measured, and hence cannot be subjected to the other algebraical operations.

In connection with this description of the most general of all the sciences, we are at once confronted with a fact which is absolutely fundamental for the entire superstructure of the sciences, and with which we must, therefore, become as thoroughly acquainted as possible. We have seen that the most general concept of a thing may be defined by saying that that thing may be differentiated from all other things. This characteristic of differentiability is evidently a characteristic which is presupposed in any scientific problem. Whether we are examining chemical substances or searching for the natural laws having to do with agriculture, we must always be able to differentiate the objects with which we are busying ourselves in order to be able to talk at all sensibly about them and to determine their natural laws. In other words, this means that those elements of an idea which we have found occurring as the *most general* ones we also encounter anew, owing to this very characteristic of universality, in connection with all the special ideas which we meet in any way or place in the more *special* departments of science. The most general sciences, therefore, will inform us concerning relationships which are not confined to these sciences themselves, but are found in all other sciences which arise through specialization from the more general applied ideas,—which treat ideas, therefore, that contain more constituent parts and more diversified ones than the ideas of the more general sciences.

The fact has already been emphasized that logic, for example, is a criterion for all the other sciences, and that its laws must be fulfilled before there can be any question of special laws in the other sciences. We also find that the quantity characteristics and the intensive variations parallel thereto that have no quantity characteristics occur in all the other sciences. Whether we have under consideration sociological or physical problems, we endeavor in each and every case to apply number and measure to them, and we think that we have made unusual progress in these sciences if we have succeeded in applying more general principles and methods of this kind. In the same way we apply to geometry the ideas which we have developed in arithmetic and algebra, and kinematics in its turn presupposes again all the ideas and relationships of geometry in order to be able to express thereupon its special laws.

Here, then, we have a natural law for the formation of all the sciences. *The more general ideas and laws enter as regular component parts into all higher or more special sciences,* and there is no possibility at all of making any sort of scientific assertion in these more special or higher departments if the hypotheses are not fulfilled which the laws of the lower or more general sciences demand. We shall, therefore, be able to say that every higher science is divided into as many separate divisions as there are lower sciences to be found below it. The most complicated and highest of the sciences that we have considered—kinematics—will, therefore, have its algebraical and arithmetical and finally its logical side, for all the laws of the sciences just mentioned are already presupposed before one is able to set up the special kinematical laws. Hence, to express the matter in a purely scientific and technical manner, the variety of science, or the number of headings into which it falls, must become greater and greater the higher we ascend the pyramid of the sciences. This point of view will be of decisive importance to us, especially in connection with the later, more complicated sciences, in dividing and reviewing them.

We turn now to the second group of pure sciences, which treats of ideas that are lesser in range, but, on the other hand, are more diversified in content, than the ideas that have been richest in content heretofore, and which have been employed in the field of the sciences of order which we have just completed. These more diversified concepts are *space* and *time,* and it will be well, perhaps, to convince ourselves that both ideas are already of a very complex nature. We are accustomed to think of space in the following manner: we know that it has three dimensions, each independent of the other; that it therefore represents a threefold manifoldness; that it is in other ways continuous and without direction—*i.e.,* that it is alike in all directions. It is to a less degree a matter of common knowledge that time represents a complex of quite a number of ideas. One can soon convince himself, however, that it certainly is not of an elementary nature, for it shares with space the characteristic of continuity; it is not, however, of three dimensions, but of one dimension—*i.e.,* in other words, one can pass from one point of time to another only in one way, and not, as in the case of space, in a threefold infinitude of different optional ways. Moreover, there belongs to time a characteristic which we do not encounter in connection with space, namely, the lack of symmetry. We differentiate the past from the future with absolute certainty, while in space it is entirely arbitrary what direction we call forward and back, or up and down, so long as we leave out of consideration other relationships not having to do with space. Moreover, time has the characteristic that, in spite of its one-dimensional nature, it never overlaps itself, there is never a point of time that belongs at the same time to an earlier or later time. These are all characteristics which can be expressed only with the help of simpler ideas, and which, therefore, make one realize how very composite and complex an idea is, taken in such a form from our experience.

In this connection we can only mention in a few words the fact that by means of the latest developments in physics, especially through certain optical experiments, science has been able to subject the ideas of space and time to a revision which has led to a peculiar synthesis. According to these developments, the details of which cannot be elaborated here, space and time are not to be thought of at all independently of each other; but, on the contrary, terrestrial occurrences are represented by a four-dimensional multiplicity, three dimensions of which belong to what has heretofore been called space and one to time. These dimensions, however, are not mutually independent, for the definition of time in various places and that of space at various times condition each other in a special way. This points to a weighty general point of view, with which we shall soon be intimately confronted. We may ask ourselves whether the simple ideas upon which we gradually build up our system of ideas are of such a nature that each newly added idea comes as an additional degree of *higher* order to those which have been treated and employed previously. In that case there would exist among the various simple ideas a definite hierarchy, according to which, in the first place, are employed for the construction of a scientific system those general conceptions which have the most universal character, and then, of the other ideas, those which follow each other in this hierarchy should by degrees be sought out and employed for the construction. Up to the present this question has not been subjected to a close examination, and the possible answers thereto can therefore only be touched upon. It appears from what one has been able to see heretofore that a double relationship obtains. Single conceptions actually are built up one above the other in this hierarchical manner. This we see from the fact that after examining the question from all sides, there is indeed but one single definite sequence of sciences that permits of arrangement one above the other according to these principles. From this we must conclude that the new conceptions appearing in connection with the higher or more special sciences are of such a nature that they can appear only at this point, and, on the other hand, can play no rôle in the sphere of more general concept-building. On the contrary, we observe (and the relationship of space and time just described affords us an example of this) that when we arrive at a certain stratum of science formation it is not one single newly added conception which determines the new science, but several. In this case, then, it would be the ideas of space and time which, since they are not independent of each other, cannot occur as steps one after the other independently of each other, but determine simultaneously the new stratum of thought and science.

In the observations which we shall now have to make regarding the sciences next in rank—the energetical—we shall find a similar case. The various types of energy appear as absolutely parallel conceptions which have no natural gradation as regards each other,—at least, none has been recognized and proved beyond possible question,—and which may be used, therefore, beside one another in whatever sequence one pleases. By their application to the classification of the sciences there result a number of special sciences, which are to be arranged one beside the other, but not one over another. With these hints, I must let the matter rest here, and only state in general that investigations like the above have not as yet been carried out in science from sufficiently general standpoints, so that it is frequently new territory, not yet investigated or worked, which must be entered. The uncertainty naturally belonging to such soil is lessened owing to the fact that we have already come to an understanding concerning the more general principles according to which the investigation is to be carried on. Therefore each single case that has not yet been more thoroughly examined may be clearly and definitely determined, thanks to these principles.

We now turn to the second great stratum of the sciences. The first we called the sciences of order, after their all-important, determining central idea, and the second we shall call the *energetical sciences,* because in this case the idea of energy is shown to be as general and determining as was order in the sciences mentioned heretofore. The sciences which we shall discuss here are also called the physical or inorganic sciences; according to traditional division, they consist of mechanics, physics, and chemistry, and have to do with far more complex ideas than those with which the sciences of order had to deal. Within the sciences of order a cube is determined, so far as geometry is concerned, by the length of an edge; for the geometer there are not two or more different cubes, the measurement of whose sides is one centimeter. In physics, on the other hand, such a cube may turn out in a great variety of states: it may be different in density, in color, in temperature, in electric activity, etc., etc. Still greater variety occurs in connection with this idea in chemistry, where the cube may be formed not only out of more than a hundred thousand different chemical substances, but also out of an infinity of solutions and compounds made from them, and therefore it appears to the chemist each time as a different object.

We have already designated energy as the central idea within this sphere. This means that one can express all the variations of which we have just spoken within the whole sphere of physical sciences by certain statements regarding their ratio of energy. Since it is here a question of a relatively new thought formation which stood in a certain antithesis to those hitherto encountered, a few words concerning this matter are necessary. The field of the phenomena which have just been characterized is more commonly termed at present the field of material phenomena, or of phenomena occurring in matter, in which connection we understand matter to be the foundation, or what is permanent in the diversity, of physical phenomena. A general characteristic of concept formation has made itself felt in this connection, which we can also show, even if not quite as clearly, in the ideas of the sciences of order, but which is especially familiar to us in the field of which we are at present to treat. This is the idea of substance. We have already seen that our mental attainment is characterized essentially by the ability to remember, through the circumstance that the recurrence of an event affects us differently from its first occurrence. Owing to the function of memory, those which are repeated are endowed with the characteristic of familiarity, and thus, when we encounter new experiences of so well known character, we are placed in a position to feel at home or at ease with them; that is, the different component parts of the experiences are expected and presupposed by us, because we have impressed their connection upon our minds by the function of memory. Things which always recur together as regards space, such as are represented by the ideas of "apple" or "stone" or "tree," we are accustomed to consider as belonging together, and to call with special emphasis "objects" or "substances." Here it is a question of such formations as show a quality of stability; and therefore each time that we come in contact with them, a school of philosophy which denies so-called reality,—*i.e.*, the existence of things independent of ourselves,—owing to the circumstance that we can experience such things only in our consciousness, thinks itself justified in drawing the conclusion that these things exist only in our consciousness. I shall not occupy myself with a refutation of this opinion, but merely call attention to the fact that no one of the philosophers who share this opinion arranges his practical life correspondingly. Each of them, like the rest of mankind, actually demeans himself as a realist as regards the facts of life—*i.e.*, he recognizes in his practical attitude toward them that they have an independent existence in no wise influenced by his consciousness, and confines this spiritualistic theory of existence to his books and lectures. And there, too, we may leave them, because it is my intention to deal only with realities—*i.e.*, with such things as have practical results, and especially with such as enable us to foretell the future with certainty.

The ideas of such substances are formed, as we have seen, automatically from our experiences through the function of memory. Our whole language, in its nouns, is full of the names of such substances, in which, however, the characteristic of stability changes within various limits. We encounter every possible and imaginable degree of stability, from things which exist only for a moment, but recur often with the same characteristics,—for example, lightning,—to things in which, within the memory of man, no lasting changeableness has ever been shown,—for example, sun and moon,—and therefore we always guard ourselves very carefully from connecting with the idea of a substance, or of a real thing, any kind of postulate concerning its "absolute" permanence. We can, of course, say to ourselves that substances in connection with which there can be shown a very high, or, so far as our memory serves us, even an absolute degree of invariability, will evidently play a predominantly important rôle in the formation of concepts. So we see that in the entire province of physical sciences mankind has continually sought for ideas by which such substances may be represented. And the whole thought of the period of scientific development which terminated with the middle of the last century rests essentially upon the fact that a concept of substance which had been developed up to that time—that of matter—was considered the most general and lasting. This idea of matter was formed quite rationally in the eighteenth century, men having co-ordinated with each related group of physical phenomena, determined by their similarity, a form of "matter" appertaining thereto. So there was, by the side of the heavy, massive matter of ponderable substances, also matter in the form of warmth, of light, of electricity, of magnetism; and each of these terms serves to designate the existence of a definite kind of essence, or substance, to which a certain measure of durability and constancy has been attributed experimentally. Then, however, a certain degree of hesitancy regarding the completely ideal durability of many of these substances began to make itself felt. One can produce electric matter by rubbing glass and rosin; magnetic matter may be increased arbitrarily by rubbing unmagnetic steel rods; and in the same way one sees matter in the form of warmth arise in fire and disappear by absorption. We are confronted here by a twofold possibility: either one may extend the idea of matter in such a way that we may also include in it this process of appearance and disappearance, or we may limit the idea of matter to those things that we have experienced in which we are unable to show appearance or disappearance. Science has chosen the second route, and all imponderable forms of matter in which a process of appearing and disappearing can everywhere be shown have been eliminated from science. During the whole of the nineteenth century, since the time when Lavoisier proved—or, rather, since the publication of the postulate first promulgated by Lavoisier—that the sum of weighable substance remains constant under all circumstances, the idea of matter has been confined merely to these ponderable substances. By this process every other form of matter came into a false position, so that one did not know how to classify these entities, which, however, had not given up their rôle in either pure or technical science. One finally got around the difficulty by deciding to consider them hypothetically as motions. This, however, has not been carried out consistently. Until toward the end of the nineteenth century one read not infrequently of electric "fluidum," even though the expression electric "fluid" was avoided on account of a sort of linguistic feeling of embarrassment.

This un-coördinated and, so far as system is concerned, insufficient character of science has been fundamentally obviated by the discovery of the law of the conservation of energy. In his fundamental work, Julius Robert Mayer, the first discoverer of this law, undertook the single, definite task of finding by the side of weighable matter (whose constancy in all transformations, so far as weight and mass are concerned, had been fully confirmed by the physical and chemical investigations that had been made in the meantime) still another similar substance or matter which would include the imponderable part of natural realities. Mayer called these things *forces,* and hence sought, as he expressed it, to find a law which permitted of attributing to these forces that kind of uncreatability and indestructibility that had been noted in matter. His investigations at first led him into error. After he discovered that by the employment of mechanical action warmth was created, and, on the other hand, that in heat machines mechanical action can be attained through the employment of heat, he sought long in a wrong direction for the mechanical expression which could be proved equivalent to heat. Only after having endeavored in vain to provide the mechanical quantities, as he encountered them in text-books of physics as the measure of force, with this characteristic of uncreatability and indestructibility, did he finally arrive at the conclusion that the desired characteristic of mechanical *work* is due to the product of force and distance. With this discovery he revived an idea already expressed with utmost assurance and definiteness by Leibnitz upon a basis of purely mechanical considerations. Leibnitz had already shown that in the course of the manifold changes of mechanical agencies into each other there always remains finally, in like constellation, in the ideal limiting-case, that which he called living force, the quantity which we now term *kinetic* or *motive energy*. Mayer's addition is the clear recognition of that which had found only short and rather hypothetical mention at the hands of Leibnitz, that in all cases where this law of conservation does not hold, another form of *force* (as Mayer called it), *energy* (as we call it), has taken the place of mechanical work or natural power, and this other form is, in general, *heat*. In the meantime Mayer extended this idea to all other forms of energy known at that time. We are indebted to him for the view that in addition to ponderable matter there was another sort of substance, an unweighable substance, which he called power, and which, like weighable matter, possesses the property of remaining quantitatively unchanged, whatever be the qualitative changes that it undergoes.

It is a well-known fact that this idea was arrived at independently by Joule, Helmholtz, and a few other investigators, and was further developed by them, and that down to the present it has led to the most definite and far-reaching theory concerning all physical phenomena that science has ever possessed. We now know that all physical phenomena, inclusive of chemistry, may be quite sufficiently and accurately defined and characterized as transformations of energy; so that, given the kind and amounts of the forms of energy that disappear and those that arise, every physical event is sufficiently characterized.

We thus see that the idea of substance, which was decisive for the origin of conceptions within the sphere of physical phenomena, assumed its most accurate and all-important form in the idea of energy. And it only remains to call attention in a few words to the fact that in this regard energy has a more real meaning than ponderable matter, which had been looked upon from a physical point of view as the essential part of all phenomena. For the most recent development of physics has brought us to the point of view that mass can no longer be considered as something that is unchangeable under all circumstances, and that under present conditions we can no longer consider as absolutely correct either the fundamental mechanical law concerning the conservation of mass, or the law, regarded as equally fundamental, concerning the conservation of the quantity of motion or of the center of gravity. It is true of the greatest part of the phenomena of which we know. In a certain number of phenomena, on the other hand,—those, namely, in which radiation occurs as an energetical element,—further and more general formulation is necessary, and with its development science is now engaged. The history of this matter comes to a focus, however, in the fact that energy, as a matter of course, must be recognized in general and in particular as a substance. For, although in this last-mentioned great change in physics all other laws of conservation, and hence all other previous ideas of substance, have experienced upheavals and interruptions, no one has yet dared, even in the course of the most far-reaching speculations, to doubt the law of the conservation of energy. This is not due to any sentimental reasons; for the law regarding the conservation of energy is not much over half a century old, and therefore has by no means become such an almost ineradicable element of our mentality as had formerly been the case with the fundamental laws of mechanics at the hands of scientific people. The cause is, rather, that while those other substances, especially weight, mass, and the similar quantities that we have mentioned, extend their significance over quite a considerable proportion of science,—but not, however, over the whole range of phenomena coming here into consideration,—energy, on the other hand, is the absolutely universal idea which finds its application in *every* physical phenomenon,—yes, as we have seen, in connection with every occurrence in general. To question the accuracy of the law of the conservation of energy would mean in fact to bring about a much more far-reaching upheaval in our previous methods of thought than to discuss the changeability of quantity (shown according to newest theories to be dependent on its rapidity) and other more circumscribed questions.

Now this is the reason why we in general term the great new field of science, which has been opened by specializing the previous more general ideas, the field of the *energetical sciences*. In regard to energy we know that it is a quantity taking part in all the phenomena of the entire field, and which, as regards all these phenomena, is subject to the law that to disappearing amounts of any forms of energy there always correspond like amounts of other forms of energy which arise simultaneously, so that the sum of all forms of energy remains constant. The question, then, how can one measure these various forms of energy so that their sum may be arrived at, may be answered by saying that it has been agreed upon to regard as equal those amounts of energy which arise from an amount of definite form of energy taken as unit (*motor energy* has been chosen for this purpose), or which change into this unit. This looks very much like a *petitio principii,* for if we call the amounts arising from the transformation alike, then the sum of the amounts of energy so measured must naturally be constant under all transformations. However, it is here a question not only of a formal determination of this kind, but of an actual natural law which arises from the following consideration. Given three forms of energy, *A*, *B*, and *C*, assume that we next change the unit amount of *A* into *B* and define the amount obtained thereby as the unit of energy *B*. We then transform this unit into the third form *C*, and again define the amount thus got as the unit of the form of energy *C*. We can, in the third place, however, transform the unit amount from *A*, instead of passing by way of *B*, directly into the unit amount *C*, and the empirical law which thus comes to light reads that one gets in this direct way exactly the same amount of the energy *C* as one would have got through both steps from *A* to *B* and from *B* to *C*. If one adds still a fourth form of energy, *D*, there are not merely two different ways, but six of them, in which one may transform the unit amount *A* into the amount *D*; and experience also shows in this case that one always gets the same amount *D* from the unit *A* in whatsoever way the transformation may be undertaken. Hence can be formulated the general natural law that the amounts of any kind of energy that are got from any other kind are not only determined by this first and last form, but show themselves to be in no wise dependent on the intermediate forms nor on the multiplicity of ways in which the transformation results. This is the real content of the law of conservation of energy, and this content finds its shortest expression when one attributes to each form of energy its value in the way described in reference to the unit of an amount of energy taken as normal, and calculates with this value as with real quantities which can be added and divided without losing any part of their value on account of the manner of their arrangement or origin.

It is not necessary for the general observations which we have undertaken here to consider the different forms of energy which exist. It will be well, perhaps, only to say that the old division of physics into mechanics, acoustics, optics, electricity, and heat can no longer be considered as logical. In the first place, acoustics is a part of mechanics, as has long been known, even though, of course, thermic phenomena do not play an unimportant rôle in it; then, on the other hand, optical phenomena have been recognized as a part of electromagnetic effects at a distance, and the most recent developments of this science even make mechanics appear as a part of electromagnetism, while at the same time a new electric theory of chemical action, at least in its initial phase, has been noticed. It would, therefore, appear at present as if we should be able to trace all other forms of energy back to electric—or, more exactly expressed, to electromagnetic—energy. However, development in this sense is only just in its most elementary stage, and therefore it cannot yet be stated with a sufficient degree of certainty whether the way that has just been pointed out, that would also conduce to the inward unity of the various forms of energy, can really be followed to the end. It is not impossible that the position of the electric theory of all physical phenomena in the course of half a century or so will be similar to that of the mechanical theory of all physical phenomena at present, namely, that it will demonstrate itself ultimately as unfeasible.

Finally, we should not fail to mention just here that the various forms of energy are not to be looked upon as ideas placed in a higher order, but rather as collateral, new, complex ideas in this field. For this can be assigned only the partial reason that the forms of energy that have been traditionally taken together in physics show a closer relationship to each other than to chemical energy, which, owing to the excessive variety of its phenomena, has for several centuries developed as a special science as compared with physical phenomena, and shows also certain fundamental new variations. Whereas, for example, it is a matter of indifference in electrostatics whether a conductor of any definite form—for instance, in the form of a ball which is a meter in diameter—be made of tin or gold, of iron or lead (for electrostatic capacity depends only upon the form and environment of the conductor, not upon its special nature), for the chemist the various balls just mentioned are absolutely different objects, and in his eyes are endowed with the characteristics of mutual untransformability and lasting difference. For as regards chemistry before the present time, the law of the conservation of elements has been as valid as the law of the conservation of volume is for mechanics. But the same investigations that cause the law regarding the conservation of volume to be viewed only from what must be admitted frequently as a complicated special case of a general law, have also led us to view the law of the conservation of elements as a very general law whose conditions, so far as the occurrences known down to a decade ago were concerned, had always been fulfilled, while the facts which have been observed recently in connection with radioactive substances lead to the establishment of exceptions to this law. We are, therefore, led to conclude that there are some more general laws, as special cases of which these particular laws of conservation appear, which, however, under certain conditions and hypotheses, also permit a non-conservation, possibly a mutual transformation, of such quasi-substantial qualities.

If we now undertake to prove the proposition just laid down, that the laws of the more general sciences everywhere and in every detail must be true of the laws of the higher and more special sciences, we are able to convince ourselves readily that it must be so throughout. That we cannot treat of all the physical and energetical sciences without logic is a statement which is so trivial that one almost hesitates to express it; however, it must be mentioned here for the sake of completeness, and also for the reason that the position of logic as the most general of all sciences—more general, in fact, than mathematics—is by no means commonly known and recognized, although for a decade I have pleaded for this point of view, which is so fundamental as far as method is concerned. It is also just as much a matter of common knowledge with us that we have to apply mathematics and geometry, and finally kinematics, to all the phenomena of energetical happenings. It is well known to every one acquainted with the history of these sciences, that especially the introduction of mathematical and geometrical methods into the treatment of physical phenomena has brought with it enormous progress in our comprehension and treatment of them. Does not quite an appreciable proportion of our highly developed technical knowledge of to-day rest upon the fact that we have learned to apply number and measure to the various physical phenomena, and hence to foresee the results of certain constructions and combinations, so that they may be exactly determined, not only in respect to kind, but also as regards amount? The construction of all modern machinery rests in fact, as we have seen, upon a knowledge of mechanics and thermodynamics. Electrotechnics, too, which has begun to transform our outward life so successfully, and whose influence upon this transformation is by no means terminated as yet, has been completely developed upon a mathematical-geometrical basis laid so successfully and deeply by the geniuses of electrical theory, from Ohm through Faraday and Maxwell to Hertz and the investigators of to-day. In this very department of the physical sciences, more clearly than in any other province of knowledge, is shown the extraordinary assistance that the systematic introduction of the earlier and more general sciences has brought with it into the investigation of the higher and more special sciences. As a most impressive example of recent times physical chemistry may be mentioned, which also rests upon this kind of application of the more general mathematical and physical concept formations to the phenomena of chemistry, through the operation of which problems have been solved in a few years which the usual method of investigation in vogue up to that time, that clung more to the immediate phenomenon and took no consideration of any further means of assistance, could not have touched in a hundred years.

We have now noted what is most essential regarding this second stratum of the sciences, and we have yet to call attention to the fact that the variety in this field may easily be surveyed synthetically by means of conjoining the various kinds of energy. Within the range of all the physical sciences the legitimacy of each single kind of energy must first be established. Then each one of these kinds of energy must be combined binarily with each of the others, whereby new localities result from their reciprocal action. Thus, for example, the characteristics of vapors have been investigated, on the one hand, by the theory of heat; and, on the other hand, one could apply to them the mechanical laws studied in gases. By means of the combination of the laws of mechanics and heat thermodynamics arose, the science which has taught us the nature of the agent so important to steam-engines, upon which the whole enormous development of the corresponding technical science of the present rests. To the binary combinations of two forms of energy the ternary must be added, and so forth, until all the combinations possible have been exhaustively worked over. By means of this seemingly outward manipulation, but one which is in fact fundamentally scientific, not only a complete diagram of all the possible and conceivable disciplines of physical science can be constructed, but one may even predict to a considerable extent what forms the special laws will assume in the various columns of this table. Moreover, a diagram of this kind makes possible the immediate drawing of conclusions in case a form of energy is discovered which has not been previously observed. One has to bring this new kind of energy, *X*, as a new member into the whole calculation or combination with the pre-existing kinds of energy, and to form again as a consequence, after having determined their laws by the combination of *X* with the energies *A*, *B*, *C*, etc., a group of binary, and later, as has been described, a group of ternary and of more highly complicated fields, by working through which one may be certain of exhausting methodically all the physical disciplines that permit of survey down to that moment. Such a situation is so highly desirable and valuable that under all circumstances we should do everything possible lying within the range of science to attain to it.

An especially instructive example of this scientific process of extension by means of the inclusion of the ideas already derived from the earlier and more general sciences is presented by the most recent development of chemistry in respect also to the application of the ideas of time and space to special chemical problems. The incorporation of the time idea in chemical phenomena led to the great field of *chemical kinetics*, which has borne fruits so abundant, and in which, in spite of the short duration of its previous scientific existence, progress so noteworthy has been made, both from a theoretical and from a technical standpoint. It need only be mentioned that it was in this field alone that the phenomenon of catalysis, which had been known for a century, was able to attain a logical explanation. As to the application of the idea of space to chemical phenomena, we need only mention stereochemistry, which at the present time also represents a science that has arisen only in the last decade, but which already has a wide range of application, and in which the idea of the multiplicity of space has been successfully applied for clearing up chemical diversities, especially isometrical relationships. Here, too, it has been possible, by carrying out logically the basic idea, to make a great number of chemical prophecies which later experimental investigation has confirmed down to the smallest details.

We now turn to the last group of sciences, whose ideas are the most complicated and therefore the smallest in scope but richest in content. This group arises from the fact that to the ideas that we have thus far arrived at in the field of order and energy, that of life is added. By phenomena of life we understand very definite transformations of energy by virtue of which the objects in question—the living beings—accomplish a continuous transformation of free energy, consumed either in the form of chemical food, as in the case of animals, or in the form of the radioactive energy of the sun, as in the case of plants. Over and above this continuous or stationary transformation of energy they are distinguished, moreover, by the capacity for reproduction—*i.e.*, the production of new similar types, by means of which individual mortality of single members has been transformed through time and space into a disproportionately longer continuation of the *species*, the totality of similar individuals. Thus in connection with the scientific examination of life we have to presuppose for its ideological comprehension and definition the totality of the sciences of order and the entirety of the physicochemical or energetical sciences. In so far, therefore, we shall have to say that every living being is an energetical type, and that all the laws that we have found for such a being must find their legitimate application to living beings. We shall have to say, furthermore, that a new conception has appeared here,—that of life,—which is characterized by stationary transformation of energy as well as by the capacity of reproduction, and concerning which we cannot maintain that it can be completely defined by general physicochemical laws. For we are quite in a position to differentiate experimentally living beings from those without life, and this fact alone suffices to prove that new relationships have appeared in connection with this narrow group of things, the ideological comprehension of which gives the scientific definition of life. Hence we shall have to consider every living being as a physicochemical object, in so far as nothing can occur in this object that does not take place within the compass of the energetical laws. But we shall have to consider animals as formations of a special kind in so far as certain peculiarities belong to them which are by no means present in all energetical objects, and which, therefore, render necessary special treatment and scientific discussion of them.

The science of living beings we term in general *biology,* and we divide this whole discipline into single groups according to the special kind of life activity, and, at the same time, according to the increasing intricacy of the entire organization of the living being. The most general characteristics and relationships which occur in all living beings, and take on a one-sided and specific development only in the case of certain ones, according to special forms and purposes, we treat in the form of a whole science bearing the name of *physiology.* In the very first place, it is a question here of physicochemical conformity to law. The special characteristic of physicochemical happening in the living being must be shown here in detail and explained experimentally; and, inversely, the physicochemical hypotheses must be found regarding the activity of all specific happenings in living beings, their single functions. Thus the principles of division which were determining for the energetical sciences make themselves felt also as secondary reasons for division in physiology, and the corresponding groups have also been formed already in this science, such as electrophysiology, mechanical physiology, chemical physiology, etc.

A special apparatus in connection with which new kinds of phenomena arise, which have led, therefore, to new formations of concepts, is not found in all living beings, but only in those in which a division of functions has taken place, and hence in which the necessity exists for uniting these divided functions for the purpose of harmonious and suitable working. This is the nervous system, which in the case of the more highly developed animals is grouped about a central organ which, as we ascend the scale, is formed in a more and more complicated and abundant way, until it reaches its highest development in man. The special relations that occur in the function of this central organ are what form the subject of this higher and more special science of life, which, from the name for the totality of this function in man, we call *psychology*. Here, also, we shall have the same things to say about general biology, namely, that for the investigation of psychological relationships in lower and in higher living beings, finally in man, the knowledge and efficacy of physicochemical as well as of general biological laws must in all cases be presupposed, and that here it is only a question of specializing the mode of operation of these laws according to the special conditions under which, in the first place, nervous phenomena—in a narrower sense, psychic phenomena—occur. Since these psychic phenomena also presuppose energetical happenings, even occurrences in connection with ponderable substances which are endowed with chemical energy, we must consider them of course as energetical occurrences, and the old problem of the connection between mind and matter attains a satisfying systematic solution in the light of the general system of science here described. Psychic phenomena, in the next place, must be considered as resting upon a definite energetical basis. Within this limit, however, they are specialized by peculiarities connected with the function of the nerve tracks and central organs.

Finally, an uppermost layer of this pyramid of sciences is formed by those facts and relationships which have developed in *man,* in contradistinction to all other animals, and which form that which we specifically call human *civilization.* This science is usually designated by the improper name of *sociology.* The name is due to the fact that man, even in the very early stages of his development, has unquestionably been a social being, so that, for much the greater part, specifically human culture has shown itself to be the culture of groups of people living together socially and busying themselves in common. This special nature of human culture, however, is relatively a secondary phenomenon; and it is, moreover, not entirely general, for certain cultural performances have been, and can in the future be, accomplished by a single individual. Thus, socializing mankind is an important phenomenon in this field; indeed, it is one of the most important, but not the characteristic and universal one. I proposed, therefore, a long while ago to call the field in question the science of civilization, or culturology (*Kulturologie*). And though it is not my opinion that anything of very great importance for science depends upon the acceptance or refusal of this proposal, I think, nevertheless, that in the present indefinite situation in which the science of civilization, or sociology, finds itself as regards its general principles and its place within the field of the other sciences as compared with the generality of them, a sharper emphasis of this kind on the essential feature of this new science might be of some benefit.

To culturology, or the science of civilization, numerous sciences belong which we are accustomed to include under the name of *mental sciences,* the retrocedent nature of which, to express it in terms of method, we have already discussed and explained above. Law and language, administration and agriculture, industry and science, religion and art, are all merely different forms of activity proper to the general cultural work of humanity. Any investigation of them must, therefore, take the direction of applying the laws of the corresponding occurrences from what the historical knowledge of earlier phases and the anthropological examination of contemporaneous phases of less developed peoples and of other groups of human culture has placed at our disposal, in order to determine thereby the present *niveau* of a given field of culture and its prospective development. What we call politics in its wider sense, not only the relations of one state to another, but the general technique of the administration of common possessions and the education of coming generations for the corresponding activities of the community,—this wider kind of politics, including the politics of civilization, shows itself under this aspect to be the field of application for scientific culturology or sociology; and, speaking ideally, through the development of this latter science in the future politics should be formed and conducted with the same certainty and precision with which we build at present an iron bridge or a station and understand how to direct an electrical or steam plant of so many thousand horsepower and keep it going.

Culturology, appearing thus as the topmost course of the pyramid of the sciences, shows itself from the point of view of method also to be the most diverse and many-sided of the sciences. For all of the more general sciences, logic, mathematics, geometry, and kinematics, as well as all the energetical sciences, and finally general physiology and psychology, have each its influence upon the formation of culturological ideas. A sure mastery of at least the fundamental principles of all the sciences that I have just mentioned is therefore a necessary presupposition for the scientific mastery of culturological problems. If one considers that science of the twentieth century, even, is far from enjoying a sufficient development of them, especially of the biological sciences, and that the application of the sciences of order to cultural science has already made some progress (especially in the sphere of political economy and in its technical application—statistics), one realizes that the application of the energetical sciences to the science of culture has almost been mapped out provisorily in its fundamentals. Still less can there be any question of a rational general application of biological theories to the science of culture, in spite of the fact that tentative efforts in that direction have already been made.

Thus one sees with what an enormous problem we are confronted, one that is scarcely to be compassed with our present resources; and it is quite comprehensible if the workings of previous mental sciences, which have not been able to await the systematic development of concept formation in the lower sciences that are so necessary for any rational treatment, leave so very much to be desired at the present time on the side of scientific method. In the field of culturology it is still almost universally a question of the technical period of science, for nearly all of the special culturological sciences are at present only in the stage of their own development determined by practical necessity. In this connection, I need only remind you of the present condition of jurisprudence, which shows precisely the characteristic forms of development which have been outlined here. Mankind has not been able to wait until the twenty-first or twenty-second century, at which time it will perhaps be in possession of a pure or methodic culturology, to bring its affairs to such order that it might keep the body politic alive and capable of functioning. In the very same way, mankind has not been able to await the development of physiological chemistry in order to procure and prepare the food inevitably demanded day by day in order to preserve life. Thus, jurisprudence of the present is nothing but a most unsystematic sum of all previous attempts made by especially endowed empiricists to preserve the social and scientific order of a community of persons. The idea is very far from the mind of the jurists of the present, that all the problems relating to jurisprudence must first be illuminated with the fundamental principles of the physical or energetical sciences in order to place it upon an exact basis. If, however, one considers, for example, how exceedingly irrational our present criminal laws and penological procedure are, based almost entirely upon imprisonment, how by this process society is neither freed permanently from the evil-doer, nor is the latter placed under conditions in which he gives up as far as possible his anti-social habits and replaces them with social ones, one realizes what an enormous amount of work yet remains to be done in this field before we shall be able to speak of a real, scientific theory of law.

The same thing can be said of *language,* which represents the most important social means of communication, and whose duty it is to render the mental concepts of individual persons accessible to other members of society, and then, by means of written characters, to insure their effectiveness for posterity over and beyond the life of their creator. This conception of language as a means of communication, and the criticism of language resulting therefrom, according to the standpoint of its *technical* adaptability to the exact, unequivocal, and sufficiently complete expression of the ideas formed by each individual, as well as to the transference of ideas from one individual to others,—this conception of language, I say, does not yet play the slightest rôle in the science of language. Instead of properly envisaging what is essential in phenomena of this kind,—the ideas, their co-ordination and system,—and making them the subject of scientific work, linguistics had heretofore limited itself almost exclusively to the most unimportant and least necessary of the whole phenomenon, namely, to the forms, in sounds and characters, which have been co-ordinated with the preconceived ideas. The extraordinary diversity of the various languages certainly shows clearly how very unimportant the special forms employed by single groups of people are for what is essential in language—social intercourse. Nevertheless, what has heretofore been called linguistic science confines itself almost entirely to the investigation of the nature, or at most to the investigation of the slow changes which these accidentally co-ordinated characters have undergone; while practically no attention at all has been given to an investigation of concept formation, to a system of the ideas themselves, to the question as to what classes of ideas there are, in what way simple and compound concepts react upon one another when combined—in a word, to the problem of the science of concept formation. So we need not be surprised that the fact is known to but few people that at the present time the technical problem of an artificial language which is more complete than any natural one has already been solved. It is of special interest to note that the possibility of such a thing is most emphatically denied by the representatives of previous pseudolinguistic science, the philologists, though facts for years have proved the contrary.

If we glance back over the observations thus far made, we become aware that all of the sciences, taken together, represent an absolutely coherent complex, ascending from the simplest to the most involved, but exhibiting at every point the same course and the same character of progress, and consequently give no occasion at all for any delimitation of the frontiers of opposing fields as regards one another. It is therefore absolutely incorrect to separate, as is often done, the entire field of human sciences into two groups which have little or nothing to do with each other, and whose functions are fundamentally different. Regarding the group of the natural sciences there is complete agreement. Other sciences, however, which were formerly termed mental sciences, were set over against them. Afterward one necessarily became convinced that the natural sciences, too,—for example, psychology,—had to do with mind, and that mind, therefore, was no special distinctive mark of this other department of knowledge. Then it was thought that the science of civilization must be placed in contrast with natural science, but it soon became evident that cultural phenomena form a group (and indeed the highest) of natural phenomena. It is unreasonable and impracticable to consider the activity of man in his surroundings as "unnatural," as compared with the activity of animals and plants. Finally, the sciences of this special group were called *sciences of volition,* because they rest upon the activity of the human will. This difference is not practicable, either, for without the corresponding impulses of the will, which have been prompted by the exigencies of existence, no one would have busied himself either with the theoretical or with the applied sciences.

So there remains in fact no possibility of making an essential distinction, and only the historical difference exists that the treatment of the higher sciences heretofore has been largely carried on with inadequate means and without any information as to the real aim of all sciences, namely, the ability to predict. It is true that from this situation a contradiction has arisen which is destined, however, to disappear and will disappear all the more rapidly and all the more surely in proportion as the scientists in all the various fields become aware of the unalterable unity of all science. This unity of science leads us also to a great central problem, for the solution of which the representatives and incumbents of all the various sciences must co-operate.

This problem is to establish *a systematic inventory of all human ideas* upon the basis of the fundamental relations of increasing multiplicity and complexity that have just been explained in proportion to decrease in compass. Our preceding analysis of all knowledge has led us to see that some of these ideas, like those of order, of energy, and of life, stand out with especial clearness from the entire range of thought. But these ideas are all of a complex nature, and it is an inevitable necessity for the sure handling of the entire scheme of all the sciences that one should separate these very important collective ideas into their elements and arrange these elements in corresponding natural groups according to similarity and reciprocal efficiency.

This is a work the necessity of which was clearly recognized even by Leibnitz. We have from his pen numerous discussions of the extraordinary advantages which the human mind could derive from such an inventory of all its material for thought. But I am not aware that Leibnitz ever made the attempt to draw up a table of elementary concepts and to sketch, even schematically, the laws of their mutual effect in the formation of new ideas. I myself have been working on this problem for ten years, without, however, having made up to the present moment so extensive progress that I could give a consistent presentation of the entire matter.

In the course of these labors, however, certain points have been brought out as well as could be wished. There is, in the first place, the process of differentiating simple concepts from more complex ones. We recall the fundamental relationship between the content and the compass of the various ideas, and are enabled to establish upon it a means of defining the elementary notions. When we consider any idea and vary it, seeking out some nearly related one, the scope of this related idea will show itself to be either greater or smaller than that of the original idea. If it has become smaller, then the related idea is of a more complex nature than the original idea, and we have undertaken a synthesis instead of an analysis. If, on the other hand, its scope has become greater, we have simplified the idea, it has become more elementary. We can apply the same process to this simplified idea. If we finally reach an idea which cannot increase any more in scope by any form of change, we have arrived at an idea which may be regarded, at least provisionally, as elementary. Since it resists further analysis, it is entitled to a place in the table of elementary concepts.

This process, as one sees, is extraordinarily similar to the process of chemical analysis. In it, too, one proceeds by first subjecting a substance whose nature, whether it be elementary or compound, has not yet been established, to chemical influences—*i.e.*, one endeavors to transform it into another substance with other characteristics. If a single second substance with increased weight arises from the substance submitted to us, and if, under all the conditions under which it is subjected to chemical transformations, some other sort of substance always arises whose weight is greater than that of the original substance, then we know that we have to do with an elementary substance. If, however, the substance can be transformed into others, each of which weighs less, or only one of which weighs less than the original substance, then we know that we have to do with a compound substance. If we subject the product of less weight thus arrived at to similar transforming influences, we can establish in its case also whether it is of an elementary or compound nature. In other words, under the supposition that a substance is compound, we treat it from every possible side with the agents by which chemical transformation is brought about, and observe whether it increases or decreases in weight, and if we have a substance which under all circumstances only increases in weight or keeps its weight unchanged, we have proved its elementary nature sufficiently well.

In this way the scientists who have chosen as their field of labor the investigation of the total problem of science will have to begin by examining all concepts as to their simple or compound nature, without any reference to any other relationships. From these results is, then, to be arranged a preliminary table of simple ideas which have been found thus purely empirically. These elementary ideas are to be pronounced elementary until their complexity is established, just as is the case with the elements in chemistry. According to the generally accepted definition, an element is really not an unanalyzable substance, but a substance which has not yet been reduced. In the same way we can say that an elementary idea is not an unanalyzable one, but an idea which has not yet been analyzed.

My previous work on the arrangement of a table of concept elements like this has shown me that these elements may be divided into two large groups of which passing mention was made earlier in our discussion. On the one hand we have the group of *substances* or *objects* or *things*, or whatever else we wish to call them, the group of those concepts which represent entities existing in themselves, which we always find recurring in the same way in the range of our experience, and which have, as regards time, an unchangeable or at least only slightly changeable nature. By the side of this group still another group of quite essential ideas is found, which we term ideas of *correlation* or of *relation* or of *reciprocal action*. They, too, represent quite definite experiences, but they refer regularly to two or more ideas of the first kind, and are the material by means of which the connection between isolated substances or things is brought about.

We realize at once that the psychophysical function of memory leads first to ideas of the first kind. Those elements of experience (since we are speaking here of elementary ideas) which always affect us in the same manner take on, then, the form of these substances or objects in our consciousness, and independently of ourselves assume this character of real existence which we ascribe to our external world. So long as mental functions are confined to the formation of such concepts of objects or substances, real thinking is impossible, since each of these concepts leads its own isolated existence and can in no wise come into connection with the others. Just here the experimental fact is added, that we never experience such concept elements in isolated form, but in coherent complexes which even as such are felt to be units whose division into elementary component parts follows only by a considerable effort of the mind, for which a high degree of maturity and independence of judgment is necessary. This results from the fact of reciprocal connection, of the *relation* of substances to one another.

Thus these mental relations in the form of space or of time, or, to express it in general terms, of function, between the different concept elements of substantial nature, form quite an essential part of our total experience. The determination of such relationships between substances on the conceptual side has at least as much importance for our entire mental activity as the formation of the idea of the substance itself. The *association of ideas* which has been characterized and studied for a long time by psychologists is only a relatively narrow expression for this general function of relationship which is stamped upon our mind by the nature of its experiences. It represents, however, the best-known part of general ideas of relationship and permits us also to see the circumstances through which these relative ideas have been formed alongside of the ideas of substance. Such ideas of relationship, for example, are "by the side of" or "above" one another in space, "earlier" and "later" in time, and a number of others, all of which may be recognized by the fact that they never refer to a single object, but invariably bring two or more objects of different kinds into mutual relationship.

We recall from our preliminary description of all science that the idea of group, namely, the relation or connection between objects of like nature, appeared at the very beginning of our formation of ideas, and proved even then to be that process by means of which a mutual relationship arose from ideas of objects that until then had been disconnected, and with it also came the possibility of establishing natural laws. The unconscious work of language, too, has clearly differentiated these two kinds of ideas: the object-ideas are characterized chiefly by nouns, but also by adjectives and other words, while the ideas of relationship are expressed chiefly by verbs. But since language, as has been mentioned, has arisen unconsciously—*i.e.,* without a clear consciousness of purpose or aim—the two great classes just referred to are by no means sharply distinguished from each other. For surely freedom in usage has given us on almost all occasions the possibility of making a verb of a noun, and, inversely, of considering in a formal way every verb as a substance-idea—*i.e.,* as a noun. But in such matters it is only a question of formal resemblance to the other group, whereas upon real analysis of the content of the idea connected with the words in question, their character as objects or as relationships can almost always be determined without difficulty.

Labors of this kind, which presuppose and demand quite a thorough knowledge of concept formation in all the sciences, represent now what I consider as the real rational task for a future philosophy, and one which will be useful—yes, indispensable—to mankind. According to this view, philosophy would be the science which is occupied with the sciences as a whole in reference to their mutual relations, their structure, and their circumstances. It has the practical mission, on the one hand, of predicting those fields of knowledge which have not been subjected as yet to any systematic treatment or to treatment of any kind, and, on the other hand, of rendering the existing fields of knowledge capable of easier advancement and better arrangement through the proof of systematic and methodical relationships to other sciences. By the cultivation of this new philosophy it will then be possible to organize and improve all functions of science which at present are so imperfect. The present procedure reminds one of the growth of a primeval forest, where every single tree develops on its own account and by its own strength, as well as it can, and so far as it finds light and air. Under such circumstances splendid individual giants may grow, but only at the expense of numerous other trees which under other circumstances could have developed luxuriantly and beautifully, but which suffocate here under the shadow of the giant. Future science is more to be likened, therefore, to a logically cultivated forest in which every tree stands in its own place, and each, in proportion to its value, receives generous attention. To employ another figure, we still stand in our present attitude toward science as men stood toward the problem of economics when men were only huntsmen, and when the acquisition of prey, and hence of food, was essentially a matter of accident and of special personal skill. In our treatment of the sciences we wish to pass out of this primitive condition into a condition which may be compared to that of men occupied with agriculture, by cultivating regularly scientific progress. Owing to the fact that we prepare the ground suitably and arrange the conditions of development as favorably as possible, we shall gain, in the place of the accidental discoveries, which were at times quite abundant, but frequently extraordinarily scanty and insufficient, a steady harvest which, to be sure, is not entirely independent of the contingencies of external climatic conditions,—in the present case, of the multiplicity of political and economical conditions among men,—but which produces nevertheless, with slight variations, year in and year out, a regular, recurrent harvest and assures therefore a rational and careful collective science of humanity in this greatest and most important field of its entire mental activity.

An attentive reader has perhaps missed two things in this examination of all the sciences. First, a thorough consideration of the applied sciences which are the mother earth out of which the general sciences have sprung. Furthermore, one may have noted the complete non-consideration of a discipline which is claiming at present an extraordinarily important place in our highest educational institutions, the universities, and the importance of which is being emphasized in a very lively way on many sides—namely, *history*.

As far as the first matter is concerned, it can be disposed of quickly and easily. One readily sees *that every applied discipline has its center of gravity in one of the general sciences*. Thus there is, for example, an exceedingly extensive and important applied science—astronomy. This had its center of gravity until half a century ago wholly in mechanics, for all astronomical phenomena which were then observed and which were essentially confined to the determination of the positions of moving stars, and of the energy of gravitation by which they are held together in single groups, like the solar system, for example. With the exact recognition of the nature of these two kinds of energy, begun by the investigations of the sixteenth century and terminated fundamentally by Newton, this astronomy of position became an essentially completed science, in the case of which, to be sure, there was refinement and inner development, but no further extension on the side of ideas. In the last half-century, however, a new and extraordinarily far-reaching auxiliary means has been introduced into astronomy through the discovery of spectrum analysis, by means of which other fields of the energetical sciences, especially chemistry, have taken up their rôle in the development of astronomy. In this connection the natural relation makes itself felt, that geometromechanical astronomy is a necessary presupposition for the investigation of astrophysics and astrochemistry. One must, of course, be sufficiently informed as to the general questions of position and motion before one can attack these more intricate problems.

Thus, from this example we see how at first an external thing by its striking character and its technical importance (that of astronomy lies in its application for getting our bearings upon the surface of the earth, especially on the sea and in the desert) takes first those sciences into its service whose development has proceeded sufficiently far for the study and explanation of fundamental phenomena. In its further development it makes use of all the other sciences that can be applied to the existing relationships, and leaves out of consideration those sciences for which there are no possibilities of relationship. The whole development through which astronomy has passed rests upon the fact that the only news that comes to us from the stars is transmitted by light. Only the relatively few celestial bodies—namely, the planets, moons, and the sun—whose demonstrable field of gravity reaches to the earth and influences its movements, show in addition the influence of the energy of gravitation. The entire sphere of the fixed stars, of cosmic nebulæ, and of other formations in the universe is so distant from the earth that any effect of its fields of gravitation is in no way demonstrable; in the case of these there remains only radiance, therefore, by which any energetical communication whatever takes place with the earth and its inhabitants. From this fact it may be concluded on general principles that only that which light can tell us can be known by us about the stars, and that since no other form of energy travels from the stars to the earth, it is absolutely impossible to learn anything about other energetical conditions of the stars. Thus, for example, we are thrown entirely upon conjecture as to how biological processes may take place on Mars or Jupiter, for instance, the confirmation or non-confirmation of which is absolutely without importance to the inhabitants of the earth in so far as there simply does not exist any energetical relationship between the eventual characteristics of the neighboring planets and those of the earth. According to general principles, one may imagine that the use of optical information from the planets may be developed so far that details of biological problems might also be studied, but obviously even in that case the possibility will be considered that other forms of energy, hitherto unknown to us, may be transmitted from star to star, and that we shall be able, if we become acquainted with such forms of energy, to deduce from them corresponding information, just as we now derive all the information that we receive from the stars from the energy of light.

Somewhat different from astronomy as an applied science are the technical sciences proper. Now, while astronomy is busied with the study of existing objects and makes use of their characteristics as basis for their application without being able to influence and change them in any way, in the sphere of technical sciences we have to do with objects and processes upon whose ordering in time and space and upon whose reciprocal action we are enabled to exercise considerable influence. We use this influence, then, to direct natural processes in such a way as may seem at all advantageous or desirable to us. Man's mastery of nature means nothing more than that he takes possession in an increasing measure of natural energies and learns with increasing skill to exploit them for his interests. At first we see how in regular succession the energies best known to man and most familiar to him—namely, other men's capacity for work—are put to use. This has found expression especially in slavery, which was general in antiquity and at present is being relegated more and more to those regions that are still in a stage of barbarism. Then the more difficult problem was solved—the employment of the capacity for work in animals for *human* needs. The more recent phase of this general advancement consists finally in the fact that for not much more than a hundred years—but then, however, in rapidly increasing measure—*inorganic energies* have been placed in the service of mankind. This has been achieved down to the present day chiefly by means of fossil coal. But in most recent times it has become possible through the development of electrical engineering to harness the natural powers of water and to place them in the service of human labor, so that they are beginning to supplant the chemical energy of coal in an increasing measure. For fossil coal is not a possession that is being produced continuously and formed anew each year on the earth in proportion as it is consumed by mankind, but it is like an unexpected and unforeseen inheritance which has fallen into the hands of mankind, and which will also be exhausted at a date not remote. All the improvements of technical science which are directed toward a saving in the consumption of coal, or which render possible the exploitation of coal regions which were inaccessible to technical science in the past, can, after all, only postpone but not prevent the complete consumption of the coal supply. And if this accidental inheritance is exhausted, mankind will be forced to put to use that portion of the regular supply of energy—namely, the ever present solar radiation—which it needs for the furtherance of its civilization. Natural water-power represents an energy of this type for raising water by the influence of the sun's rays, and the condensation of vapor on the highest points of the earth represents a continuous process which will not change essentially so long as the conditions of life on the earth remain adapted to the human race.

The fact must, of course, be taken into consideration, that through this very process of running ice and water down from the highest peaks of the earth there results a gradual wearing away of these summits and a diminution of their height, so that upon closer analysis this form of energy is also one which is slowly diminishing. We shall, therefore, have to consider as an ideal solution of the problem some form or other of mechanical contrivance by means of which the rays of the sun may be caught up directly and transformed into other kinds of energy. Technical science, for example, which a few years ago, when the question came into prominence of there being a possible lack of latent nitrogen for producing food for mankind, at once put an end to this deficiency by developing theoretical and sweeping methods for binding the nitrogen of the air until it was rendered serviceable, also envisages such a task with the quiet assurance that it will not merely be solved when, owing to the consumption of the last piece of coal, mankind finds itself face to face with the bitter necessity of a solution, but that the solution will have been reached long before the last treasures of coal have been subjected to exploitation.

As may be seen at once, the problems here in question in connection with procuring primary energy for human purposes are grouped around the energetical sciences. Physics, especially the theory of heat and of mechanics on the one hand, and chemistry in the form of the theory of chemical energy on the other hand, are the basic sciences the theoretical or general mastery of which is a prerequisite for successful technical development. Other technical sciences have other theoretical sciences as a nucleus. For medicine, for example, it is physiology, especially that of man. In more recent times psychology has also been coming increasingly into prominence, and advances in it are rendering possible a much more sure and successful treatment of mental disorders, anomalies, and defects. The future activities of both sciences will place within our reach in time to come the attainment of a healthier, stronger, and more capable progeny. Thus we can find for each technical science the sphere in which its theoretical foundations are laid and are being developed without reference to immediate application.

The science of civilization is especially fertile in that kind of applied disciplines (indeed, up to the present it has largely consisted of them) in which the theory of law, the theory of the state, education, and finally the whole organization of science, belong as technical branches. Since all the other sciences converge in the science of civilization, we see how extremely diversified this discipline must be in a theoretical as well as in an applied sense, and we see, for example, that certain disciplines, even, which according to previous belief stood outside of science, like ethics, must form a necessary and regular constituent part of sociology. For, from this point of view, ethics also is shown to be an applied science. It is the theory of the way in which and the content to which the individual must limit and direct the activities of his will in order to mold his own life in keeping with his own volition as far as possible, but yet with the greatest consideration for the volition of his fellow-men.

So in these considerations a fundamental fact is expressed, namely, that there does not exist a single class in the mighty diversity of our experiences and activities that could not be subjected to scientific examination,—in which, in other words, one could not work out the recurrent regularities and use them for the prediction and, where one may exercise any influence, for the pre-formation of the future. So on this side, too, science shows its specifically human and social character in a way that would be impossible for either applied or theoretical science of any importance so long as the human individual has to depend upon the narrow compass of his own powers and upon the short duration of his personal life. Only by means of the process of socialization, by means of the possibility of communicating one's own experiences and the generalizations derived therefrom to posterity, and indeed, by means of writing, to communicate them for any desired length of time to posterity, independently of any personal factor, has the enormous development of science become possible, of which we are the surprised witnesses as we contemplate the history of recent and more recent times.

These observations, finally, define our position as regards history. Owing to the circumstance that the civilization of central Europe has been erected upon the half-lost traditions of ancient Greco-Roman civilization, the means for attaining a knowledge of that old civilization, which appears so inaccessibly lofty to those striving after it, have enjoyed quite special prominence. And since from the nature of the case it was only a question of phenomena of the past, the means for investigating the conditions of the past and for bringing them to the knowledge of the present age came into correspondingly high repute and have undergone very extensive development. This explains the great respect which all historical disciplines have enjoyed. To begin with, historical disciplines which had to do with scientific, artistic, and religious traditions were, as a matter of course, appreciated to an extraordinary degree. Then this valuation was extended involuntarily and automatically to the investigation of all possible forms of culture of a higher and of a lower degree which were being rendered accessible by means of the same instruments of historical investigation. As almost always happens in human affairs, the means finally became confused with the end, and became in themselves the object of endeavor, in such a way that the present intellectual tendency of a great number of scientific persons has led them to the point of looking upon a merely exact knowledge of the past alone as an important task of science and worthy of any sacrifice. In reply to this it must be said that historical investigation in itself cannot be considered by any means as a science in its own right. History must rather be looked upon as a scientific technique, as an auxiliary means for the development of science, which, in an especial way, finds application to every individual field of all science. What is now called history was until recently almost exclusively history of rulers, states, and wars, and had reference, therefore, to an exceedingly insignificant part of actual events. Slowly and with considerable resistance on the part of those concerned, the idea has been making headway that the history of technical science and of civilization is a far more important discipline than the history of wars and countries. But as a natural result, again, of accidental historical development, the history of civilization is understood to be rather a history of art, of belles-lettres, and the history of the disciplines connected with them as a history of techniques; whereas every unprejudiced survey of the development of peoples and states teaches us that this development is preeminently determined by the technical agencies and capabilities at the disposal of peoples and states, while the artistic-literary side has played relatively only a secondary rôle therein.

Hence a logical history of civilization would be above everything else a history of technical science, and the history of the other intellectual possessions, of religious ideas, of art, and of science would have to be incorporated only as special headings in this general history of human progress written from a technical point of view.

Accordingly we see that an investigation of history would presuppose a still more varied preparation than that demanded above for the philosopher of the future; that is to say, in addition to a wide and fundamental knowledge of all the theoretical or general sciences, it would presuppose a much more detailed knowledge of all the *applied* disciplines, from astronomy to chemical technology and to the theory of natural selection. It is evident that the only attitude mankind in its present stage of culture can take toward these questions is *that the technical science of historical investigation is connected as a scientific method with the pursuit of every single discipline.* And heretofore, moreover, things have so shaped themselves in many places involuntarily. For example, we have historians of mathematics, namely, mathematicians who by means of historical investigation and with philological knowledge and the methods of literary criticism have thrown light upon the history of this particular discipline. In the same way the history of chemistry down to the present time has been written exclusively by chemists and not by specialists in history, for the simple reason that the professional historians have not the necessary knowledge.

What has been brought about automatically in this matter under pressure of actual conditions should now be cultivated farther in a conscious and scientific manner. In each individual discipline, in every pure science as well as in every applied science, the historical part should be submitted to careful scientific study. But it must be particularly noted that this should be done only from the universal point of view of scientific work in general, namely, for the purpose of utilizing logically and methodically the knowledge of the past for discovering general laws and at the same time for predicting the future. The definition given by the celebrated German historian, Leopold Ranke, which exercised upon a whole generation of historians an exceedingly narrowing and enervating influence—namely, that the only important thing for the historian to know is how things have come to pass—must be rejected for fundamental reasons. We have not the slightest interest, in and for itself, in knowing what has occurred in the past, for we have not the least influence on this past, and even the most accurate knowledge of it does not enable us to change it in any way desired by us. Only *in so far as the past* has *future value*—that is, only in so far as one is able from a knowledge of the past to deduce universal laws for shaping in general the field in question, and can apply them for predicting and, wherever possible, shaping the future in the general interest of mankind—have historical studies meaning or a right to existence. If one surveys the present pursuit of many disciplines from this point of view, one will become convinced that even in the twentieth century we still suffer in various ways from unproductive scholasticism, from pseudo-science, which has arisen everywhere from the fact that the means have been confounded with the end, and the correct bearings have been lost as to what is and what is not worth knowing. The past is infinitely too rich in events ever to be exhaustively reproduced even by the most careful and most complete study. For, at the very time we are devoting all our intellectual powers to such study, there actually happens in a moment so enormously much that to try to reconstruct in all its details any part of the past seems like drawing water into the vessel of the Danaides,—the mighty sea of new occurrences at once covers up all islands of this kind, islands that have been won with difficulty. So the essential impossibility of such a task in itself demonstrates its essential impracticability. On the other hand, the question of what relationships, what uniformities, what general formations of concepts can be deduced from the knowledge of any past events whatsoever affords us a safe guide that teaches us to judge what fields in the past and what problems of historical investigation are really worthy of study, because there finally results, not the science of the past, but the only science that deserves the name—*the science of the future.*