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groups of phenomena, the latter being accomplished mainly by experimentation. These characteristics are realized in the physical sciences, where the conservation and transformation of energy permit the use of exact units of measurement. Here the mathematical principles of substitution, continuous change, and deduction apply. So soon, however, as we come to the natural or biological sciences, the use of measurement is subject to a remarkable limitation. Transformation of energy has not been made out and no exact units of quantity have been determined. The fact of growth presents difficulties to the theory of change, because organic groupings seem to have inherent principles of development. So far as natural science has gone in being quantitative, it is mainly for purposes of classification. The difficulty is in part surmounted by the resort to the theory of probability, vital phenomena in many cases being treated as variations, and their laws of distribution, relative frequency, &c., investigated by the theory of ERRORS (q. v.). Cf. VARIATION (statistical treatment of).

This difficulty goes deeper also; it affects the results of experimentation. The analysis which it is the main utility of experiment to afford cannot be adequate or really explanatory without units of exact statement; that is, the analysis of a more complex group into a more simple group of phenomena must show that all the elements of the former are statable in certain units of the latter. But without vital units of measurement this cannot be done. No stage of subsequent growth is adequately stated in terms of earlier growth. The best that can be done is to get a series of curves of variation for the different stages (say the height of children of 8, 9, &c., years) and investigate the relation of these curves to one another. When that is done, the results are, or may be, laws of growth, but they do not state the analysis of the higher stages in terms of the lower, nor of either in terms of elementary units.

In view of these limitations of quantitative measurement and of experimental analysis, the biological sciences may be described as evolutionary or genetic. Genetic statements largely take the place of quantitative statements. The attempt to reduce vital changes to redistribution of matter in motion under mechanical principles has been made in a schematic but altogether hypothetical way. If it be ever done it will be an achievement of chemistry; but when we remember that not only the cycle of the individual life with its infinite chemical compositions and decompositions must be accounted for as occurring in a single system, but with it occur the combinations of systems in reproduction, and the projection of new vital systems in heredity—a sort of returning upon itself of life at birth-nodes—we find an undertaking before which even the investigation of the celestial system pales into insignificance. When we talk of a chemical or mechanical explanation of life, we forget that life is a system, and that to explain it we must have a principle by which we can not only account for all its minute phenomena, but predict them all as well. Cf. BIOLOGICAL SCIENCES.

In much the same sense PSYCHOLOGY (q. v.) and ETHICS (q. v.) are genetic; they present certain peculiar features which remove them even more widely from the quantitative sciences. Cf. MORAL SCIENCES. (J.M.B.)

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Scientific Method: Ger. *wissenschaftliche Methode*; Fr. *méthode scientifique*; Ital. *metodo scientifico*. The general method of successful scientific research. The following are some of its characteristics. Cf. SCIENCE.

(1) The student's first step is to form a perfectly definite and consistent idea of what the problem really is; then he ought to develop the mathematics of the subject in hand as far as possible; and to establish a mathematical method appropriate to the particular problem, if it be one which allows exact treatment. As examples and models of what is meant, may be mentioned Maxwell's researches on colour sensation in the *Philos. Trans.* for 1860, Flinders Petrie's book *Inductive Metrology*, the last chapters of Pearson's *Grammar of Science*. Of course, as the student's understanding of the matter advances, he will return to this first task, and continually improve upon his first essays.

The second step will be to consider the logic and methodeutic of the research in hand, unless it is itself a question of pure mathematics, where the logic is inseparable from the mathematics. He will do well to study the manner in which questions somewhat analogous to his own have been successfully resolved in widely different fields; for the greatest advantage has accrued from the extension of methods from one subject to a widely different one, especially from simple to intricate matters.

The third step should be to reform his metaphysics, if the question is a broad one. Perhaps he thinks he has no metaphysics, and does not wish to have any. That will be a sure sign that he is badly handicapped with metaphysics of the crudest quality. The only way to disburden himself of it is to direct his attention to it. But he cannot reduce himself to anything like absolute scepticism in metaphysics without arresting his work. [This is especially true and important for psychologists.—J.M.B.]

The fourth step will be to study the laws of the phenomena dealt with, so far as they can be made out at this stage. The general order of discovery in the nomological sciences is first to pick up the phenomena by excursions in those fields in which they are to be found, with alertness of observation, with those clear ideas that makes the new fact instantly recognizable as new, and with the energy that seizes upon the faint trace and follows it up. Witness the manner in which all the new phenomena of radiation have been brought to light during the last generation: cathode rays, X rays, Becquerel rays, etc. After making some acquaintance with the phenomena, the next discovery is of their laws (nomological). In the light of one's metaphysics and general conception of the department of truth dealt with, one considers what different hypotheses have any claims to investigation. The leading considerations here will be those of the 'economics' of research. If, for example, a hypothesis would necessitate an experimental result that can be cheaply refuted if it is not true, or would be greatly at variance with preconceived ideas, that hypothesis has a strong claim to early examination. But one must not give up a hypothesis too readily. Many a discovery has been missed by that fault. Gravitation would have been known a decade earlier if Newton had not hastily thought it refuted, and so set back all the subsequent history of physics by something like that amount of time lost. It is likely that thousands of persons more will die of consumption—as remote as that may seem—than would have died if he had not made that error. The testing of the hypothesis proceeds by deducing from it experimental consequences almost incredible, and finding that they really happen, or that some modification of the theory is required, or else that it must be entirely abandoned. The law of the phenomena once made out, it only remains to measure with precision the values of the coefficients in the equation which expresses it.

The problem under investigation may not be of a nomological kind. Not that the phenomena are not conceivably subject to law, so that the subject may ultimately be received into the nomological sciences,—as chemistry, for example, promises some day to mature into a nomological science; but in the present state of knowledge the question, we will suppose, cannot be so studied. Still, a certain amount of nomological study is a necessary preliminary to engaging with the problem itself. Biology calls for aid from physiology. The student who is studying the growth of languages must avail himself of all the knowledge that there is about the physics of speech sounds. In case, then, the question has not yet reached the nomological stage, the sixth step in the work will be of a classificatory nature. Such order, of a more or less imperfect kind, as can be traced in the phenomena must be made out. Students of the classificatory sciences like to call such regularities laws. The tendency is a symptom of health; because it shows that law is their ideal, and that they are striving to bring their sciences to the nomological stage. But such orderlinesses as 'Grimm's Law' (see GENDER) and 'Mendeléef's Law' are not laws in the sense in which the association of ideas and the three laws of motion are laws. They are not satisfactory for a minute. They are nothing that can blend with our metaphysics; they are not of a universal kind; and they are not precise. You may imagine that there might be a chain of more and more universal, precise, and reasonable regularities leading from these to those. But there is, in fact, a great gap, which has to be acknowledged. A hypothesis may be made about the cause of the three laws of motion; but we can have no present hopes of satisfactorily proving the truth of such a thing; while we at once set to work with great hopes of making considerable steps towards explaining Mendeléef's Law and Grimm's Law. But the most important distinction between true laws and such regularities lies in the very different way in which we proceed to the discovery of the one and of the other. The whole attitude of mind is so different that it is difficult to believe that the same man would have great success in the two tasks. We have seen in our day the establishment of a grand example of each kind, the Law of the CONSERVATION OF ENERGY (q. v.) and the Periodic Law. The one dealt with a small number of observations. Exactitude was the main thing. The hypothesis itself sprang almost immediately from the natural light of reason. In the other case, it was necessary with a positive effort to put ideas of exactitude aside and to find order in a great tangle of facts.

Perhaps the problem in hand relates to one of those sciences basely called descriptive, that is, sciences which study, not classes of facts, but individual facts, such as history, descriptive astronomy, geography. No science is merely descriptive. These sciences are investigations of causes. The historian's facts of observation are not those contained in his text, but those mentioned in the foot-notes—the documents and monuments. It is the supposed causes of these which make the text. Nor is he contented with a mere chronicle of striking public events; he endeavours to show what the hidden causes of them were. So the astronomer's real business is to prove the NEBULAR HYPOTHESIS (q. v.) or whatever ought to replace it. The geologist does not merely make a geological map, but shows how the existing state of things must have come to pass. To do this the historian has to be a profound psychologist, the geologist a master of physics and dynamics. Just as the classificatory sciences tend to become nomological, so the descriptive, or explanatory, sciences tend to become classificatory. The astronomer finds so many examples of systems in formation, that he can formulate the cycle of events through which they generally pass; as the historian formulates cycles through which communities usually pass, and the geologist formulates cycles through which continents commonly pass. These are analogous to the cyclical laws of the classificatory sciences.

But perhaps the problem before the student is not one of theoretical physics or of theoretical psychics, but a practical problem. He wishes to invent. In that case he ought to have a great knowledge both of facts about men's minds and of facts about matter; for he has to adapt the one to the other. He ought to know more than any pure scientist can be expected to know. Of course, as the world goes, he does not.

(2) The most vital factors in the method of modern science have not been the following of this or that logical prescription—although these have had their value too—but they have been the moral factors. First of these has been the genuine love of truth and conviction that nothing else could long endure. Given that men strive after the truth, and, in the nature of things, they will get it in a measure. The greatest difference between the scientific state of the modern scientific era from Copernicus and the middle ages, is that now the whole concern of students is to find out the truth; while then it was to put into a rational light the faith of which they were already possessed. The chief obstacle to the advance of science among students of science in the modern era has been that they were teachers, and feared the effect of this or that theory. But the salvation from this danger has been the fact that there was no vast institution which anybody for a moment hoped could withstand the mighty tide of fact. The next most vital factor of the method of modern science is that it has been made social. On the one hand, what a scientific man recognizes as a fact of science must be something open to anybody to observe, provided he fulfils the necessary conditions, external and internal. As long as only one man has been able to see a marking upon the planet Venus, it is not an established fact. Ghost stories and all that cannot become the subject of genuine science until they can in some way be welded to ordinary experience. On the other hand, the method of modern science is social in respect to the solidarity of its efforts. The scientific world is like a colony of insects, in that the individual strives to produce that which he himself cannot hope to enjoy. One generation collects premises in order that a distant generation may discover what they mean. When a problem comes before the scientific world, a hundred men immediately set all their energies to work upon it. One contributes this, another that. Another company, standing upon the shoulders of the first, strike a little higher, until at last the parapet is attained. Still another moral factor of the method of science, perhaps even more vital than the last, is the self-confidence of it. In order to appreciate this, it is to be remembered that the entire fabric of science has to

be built up out of surmises at truth. All that experiment can do is to tell us when we have surmised wrong. The right surmise is left for us to produce. The ancient world under these circumstances, with the exception of a few men born out of their time, looked upon physics as something about which only vague surmises could be made, and upon which close study would be thrown away. So, venturing nothing, they naturally could gain nothing. But modern science has never faltered in its confidence that it would ultimately find out the truth concerning any question in which it could apply the check of experiment.

These are some of the more vital factors of the method of modern science. For the purely logical elements the reader should consult special topics, e.g. REASONING, PROBABLE INFERENCE, PSYCHOPHYSICAL METHODS, ERRORS OF OBSERVATION, EMPIRICAL LOGIC, VARIATION, &c. (C.S.P., J.M.B.)

Sclerosis [Gr. σκληρός, hard]: Ger. *Sklerose*; Fr. *sclérose*; Ital. *sclerosi*. Induration of the substance of the central nervous tissue, usually by the increase of fibrillary connective tissue.

The medullary sheaths are destroyed, but the axis cylinder often persists for a long time thereafter. The blood-vessels show an increase in their nuclei and a thickening of the walls.

Multiple sclerosis: a diffuse sclerosis where foci of hardening are scattered throughout the central nervous system, especially in the white matter. The cause of the disease is obscure, and its symptoms vary by reason of the diverse sites of the lesions.

Amyotrophic (*myoatrophic*) *lateral sclerosis*: an affection of the cortico-muscular tract of the cord, appearing as a degenerative atrophy in the lumbar region. Atrophy of the muscles soon supervenes. The hardening of the interstitial tissue goes hand in hand with the swelling of the axis cylinders and atrophy of the motor neurones. The cause of the disease is unknown.

Primary lateral sclerosis (spastic spinal paralysis): this disease is characterized by exaggerated tendon reflexes and paralysis of the limbs.

Combined lateral and dorsal (posterior) sclerosis resembles TABES (q.v.). (H.H.)

Scope (in logic): Ger. *Umfang*; Fr. *étendue, portée*; Ital. *estensione*. The aggregate of subjects to which a term, proposition, reasoning, inquiry, treatise, &c., refers or is intended to refer; the logical *breadth*. Cf. EXTENSION (in logic).

Whether it embraces real individual things external to the mind, or individual percepts, or general terms, is a question upon which there is no agreement among logicians. We may accept the statement of B. Erdmann that the aggregate of species constitutes the scope (Umfang) in the proper sense of the term; while in a broader sense it comprises the collection of single objects. (C.S.P.)

Scotism: Ger. *Scotismus*; Fr. *Scotisme*; Ital. *Scotismo*. The philosophic system and tendencies of Joannes Duns Scotus; opposed to Thomism, the system of ST. THOMAS (q. v., philosophy of). It is characterized by its tendency to separate philosophy from theology (see TWOFOLD TRUTH); its indeterminism, and emphasis upon will (see VOLUNTARISM); and by a movement in the direction of nominalism, although Scotus himself remained a realist. See TERMINISM, OCCAMISM, and REALISM (1). (J.D.)

Scottish Philosophy: see NATURAL REALISM, and REALISM.

Scotus Erigena: see ERIGENA, SCOTUS, and SCHOLASTICISM, I.

Scotus, Joannes Duns: see DUNS SCOTUS, JOANNES, and SCHOLASTICISM, II.

Scriptures [Lat. *scripturae*, from *scribere*, to write]: Ger. *heilige Schrift*; Fr. *Écritures*; Ital. *Sacre Scritture*. The sacred writings or books of any religion containing inspired and authoritative enunciations regarding doctrine, worship, or the conduct of life. In particular, the sacred writings of Judaism and Christianity as contained in the BIBLE (q.v.).

Literature: see BIBLE, and KORAN. (A.T.O.)

Scruple [Lat. *scrupulus*, a small sharp stone]: Ger. *Skrupel*; Fr. *scrupule*; Ital. *scrupolo*. Less important ground of moral hesitation; applied also to moral hesitation without ground. (J.M.B.)

Secondary (or **-darily**) **Automatic**: see AUTOMATIC ACTION.

Secondary Quality: see QUALITY AND QUALE.

Secrétan, Charles. (1818–95.) Educated at Lausanne, and studied at Munich under Schelling. After some years as lawyer and editor of the *Revue Suisse*, he became professor of philosophy at Lausanne (1841), Neuchâtel (1850), and Lausanne again (1866). Besides his work in general philosophy, he was a strong factor in French Protestant theology, and took a prominent part in the social movements of Latin Switzerland.

Secretion [Lat. *secretio*, a dividing]: Ger.