

immediately to a complete symmetrical theory of equations and algebraic functions, and greatly facilitating the solution of problems in applied mathematics. In fact the complex number, originally introduced tentatively and apologetically, now rules the whole realm of algebra. Even yet, in spite of the infinite value of the thing, no satisfactory philosophical ground can be given for its introduction. Why should a science based on the principle of representing things by symbols require the introduction of a symbol which corresponds to no thing? We can no doubt find intellectual satisfaction in extending our algebraic and originally arithmetical processes to operations; but as we do so we are compelled to modify these very processes. Multiplication, for example, becomes what might be called polar, the value of a product depending on the order of the factors. By such imposed limitations we enrich the significance of a process and extend our methods.

We can but refer to the wide-reaching inquiry into the foundations of geometry, an inquiry which has led to the conception of different kinds of space each with its own consistent though to us unimaginable system of geometry. In the effort after a rigorous foundation of geometry, the mathematical mind has, in short, demonstrated the *possibility* of a kind of space whose properties it is incapable of imagining. The unthinkable and the impossible are not convertible terms.

It is not possible to do more than touch upon the many phases of thought brought forward in Mr. Merz's pages. The difficulty in undertaking a history of scientific thought is to decide what to leave out. Certain broad issues are obvious to every one, such as the doctrine of energy and thermodynamics, the electromagnetic theory of light, the relation of ether and matter; but, in the discussion of these, secondary questions arise in the sifting of which judgment must be exercised. And in this respect Mr. Merz's history is worthy of our highest appreciation. As already pointed out we think the author has excelled himself in the presentation of the modern trends of mathematical thought. All men with any claims to intellectual power know a good deal about energy, electric waves, natural selection, and variation; but to the vast majority projective geometry and function theory are absolutely unknown, "number" suggests no deep philosophical discussion, and "space of four dimensions" is the one hyper-spacial phrase possessing any familiarity. Mr. Merz has done a great service by giving the intelligent reader who has had no training in the higher mathematics an opportunity of becoming familiar with the subtle searchings of some of our keenest intellects.

C. G. KNOTT.

#### BIOLOGICAL SECTION.

In passing from the mechanical and physical views of nature to what may be roughly called 'biological' views, Merz emphasises

the contrast between the abstract study of natural objects and phenomena—a study which introduces us to “the general relations or laws which govern everything that is or can be real,”—and ‘those sciences which study the actually existing forms as distinguished from the possible ones, the “here” and “there,” the “where” and “how,” of things and processes; which look upon real things not as examples of the general and universal, but as alone possessed of that mysterious something which distinguishes the real and actual from the possible and artificial’. This contrast between abstract and descriptive sciences raises the difficulty that in pursuing the latter, especially in their kinetic or physiological aspects, the investigator finds himself ‘abstracting’ just as the chemist and physicist did. Furthermore, the contrast leads the author to an extension of the concepts of the ‘morphological,’ the ‘genetic’ and the ‘vitalistic’ views in a manner which may surprise the morphologist, the geneologist, and the physiologist as they actually exist. For it follows from the classification adopted that the morphologist, for instance, has crystals and minerals, why not also mountain-ranges and river-courses, within his province. To this he may object that what he took to do with was the study of the static relations of *organisms*, that, illogical as it may be, he does not find a long lost brother in the crystallographer or the mineralogist, and that the history of scientific thought in regard to the morphology of organisms must not be mixed up with the doubtless analogous study of the morphology of mineral forms or mountain-ranges, which involve quite different methods and disciplines. On the other hand, we may recall Huxley’s confession that he was not really so much interested in the fact that the animals he so skilfully anatomised were once alive, as in the general problem of their structural ‘make up’; he was, he said, an engineer *in partibus infidelium*. There is much to be said on both sides.

The author points out, that “one of the greatest changes which the present age has witnessed has been the breaking down of the old landmarks and of the stereotyped divisions (between the sciences) which existed in the beginning and all through the first half of the (nineteenth) century”; and thus he feels a somewhat slack interest in the much-discussed problem of the classification of the sciences, as detailed, for instance, in Prof. Flint’s recent erudite treatise.

“In the perpetual variety of change the morphological view tries to define those recurring forms or types which present themselves again and again, towards which all changes seem to revert; thus bringing some order into what would otherwise be disorder and confusion.” “On the other side, the genetic view deals with the transit on from one form to another in the course of time; takes more interest in movement and in the process and function; and seeks for their probable laws and regularities.” This introduction to the morphological view of nature is admirably put, but the

historical difficulty remains that the logical distinctions are not, in point of fact, always applicable to the work of the masters who have made our sciences of organisms what they are. Gegenbaur, for instance, perhaps the most illustrious comparative anatomist of the second half of the nineteenth century, was conspicuously a pure morphologist, and yet his whole work—though he seldom said a word about evolution, is pervaded by the genetic idea. A descriptive anatomist, of course he was, and we have not his equal now, but his whole morphology was evolutionist.

Of this difficulty Merz is well aware, and his chapter shows in an interesting way that many of the paths of investigation followed by the morphologists led them into new atmosphere and disclosed horizons much wider than they had dreamed of. Thus there were explorations in the graveyards of the buried past and excursions to far off lands; forms were studied *in situ* and living things visited in their habitats; the microscope revealed the innermost structure of organisms and an enormous creation of minute beings invisible to the living lens by itself; the study of life-stages began to fascinate and morphology became morphogenesis; the great architectural plans on which living creatures are constructed began to stand out clearly, the relatedness and apparent recurrence of definite types could not but arrest attention, and although 'the relationship was mostly looked upon as ideal, not real,' there were isolated morphologists before 1859 who were not ashamed to call themselves genealogists. Prof. Patrik Geddes, with his usual illuminating insight, has pointed out that the progress of morphology as such—from Buffon to Bütschli—is a story of more and more deeply penetrating analysis, from the external form and symmetry of the organism to the internal architecture of the organs, from the organs to the tissues which compose them, from tissues to their elementary units or cells, and from cells to the living matter itself. This summary gives a crispness to the historical retrospect, of which Merz might, we think, have taken more advantage but it must be remembered throughout that he is dealing not with the history of science but with the history of scientific thought, and that the mood or logic of the morphological analyst is the same whether he is studying an elephant or a Bacterium, a fossil or an embryo, a liver or a nuclear complexity of one of its cells. In passing, we doubt the wisdom of speaking of the period 1800-1860 as dominantly morphological; the genealogical and physiological disciplines were often prominent during these decades, and morphology was never stronger than it is to-day.

There is no finer chapter in the book than the ninth which deals with 'the genetic view of nature,'—the view which seeks to give answer to the question, How have things come to be what they are? To Leibnitz with his 'Protogæa,' to Kant (influenced by the cosmical theories of Thomas Wright of Durham) with his 'Natural History of the Heavens,' to Laplace, forty years after

Kant, with his 'nebular hypothesis,' important initiative stimuli are due, but their attempts 'belong to the Romance of Science'. More solid contributions to a real genetic theory of the things of nature are to be found in the researches in palæontology and embryology which are associated with the names of Hutton and Lyell, Wolff and von Baer. Thence, after a glance at Oken and his 'Natur-Philosophie,' the author reaches the pioneers of Evolutionism, such as Lamarck and Treviranus, and finally brings us to familiar ground in the work of Darwin and Wallace, Haeckel and Spencer. The story has been often told, but never better, for the author's unusually broad outlook enables him to give due place to the many collateral influences, *e.g.*, from physics and chemistry, which helped the doctrine of organic evolution to win conviction as a modal formula for the universal "Werden und Vergehen". In reference to this chapter we may call attention to the appreciation of the interesting and unique position which Karl Ernst von Baer occupies in the history of science and thought.

"It is from and through organisms, the living things of nature, that we first learnt to look upon the whole of nature as having a history and a life. Imperceptibly we have been led to study life, the genesis of things, on the large scale and in the abstract, and in so doing have lost sight of the life which goes on around and near us. Both the morphological and the genetic views of nature started with a biological interest, but have gradually lost sight of it." Such considerations lead the author to 'the vitalistic view of nature' which inquires into the actual processes of life, though still without any secure convictions as to what 'life' is. As was to be expected, much of his physiological chapter is concerned with the see-saw of the two schools of so-called materialists and so-called vitalists. "After the age of Bichat, and largely through his influence,—*i.e.*, through the cultivation of anatomical researches,—the pendulum swung in the direction of proving more and more the parallelism of organic and inorganic processes. It reached its maximum swing in that direction about the second third of the century. Since then it appears to have again returned in the opposite direction." It is this movement which the author follows with particular care, showing that "the stronghold in which the innermost secret of life is intrenched has been attacked from all sides by all the processes and methods of the mechanical, physical, and chemical sciences, and how it has persistently refused to surrender". The chapter discusses the influence of Lavoisier, who applied the theory of combustion to living creatures; of Liebig, who popularised the conceptions of "Stoffwechsel" (metabolism) and "Kreislauf des Lebens" (the circulation of matter), and was one of the first to look upon nature as an economy or a household; of Claude Bernard and Johannes Müller, of Lotze and Du Bois Raymond, and of many others. Finally, through Virchow and others, we are led to the idea of the continuity of generations,—a continuity of organisation and of metabolic processes—and

thence to Weismannism and the all-embracing dynamic outlook on organic nature which this implies.

Pausing in his fascinating history, the author asks if we have come nearer an answer to the question, *What is Life?* "At one time, for a generation, which is passing away, we apparently had. But a closer scrutiny has convinced most of us that we have not." We are far from being able to translate into mechanical categories the organisation, the metabolism, the adaptation, the selection, and similar formulæ with which we work. "The spectre of a vital principle still lurks behind all our terms." And this leads the author naturally to his chapter on the psycho-physical view of nature, which has to do with the mental, inner, or self-conscious side of the higher forms of living matter, and discloses a new world within the old one, the microcosm in the macrocosm. This will obviously lead on to the third volume, dealing with philosophic thought in the nineteenth century. The twelfth chapter discusses the application of statistical methods to such phenomena as those of variation and heredity—a profoundly interesting and important subject, but we should not have thought that it was worthy of being dignified as 'the statistical view of nature'. It is only the application of a special technical method, and promiseful as its results have been it does not appear to us a new point of view.

There are, the author says, two grand and complementary conceptions which either underlie all scientific inquiry or result from it,—*Order and Unity* (in its most impressive form, *Individuality*). He finds these two conceptions dominant in Biology as also in Physics. "The sciences of life have forced upon us more and more the conception not only of orderly arrangement but also of a unifying principle—that is, *Individuality*." The concept of Order is not merely static, it is progressive, and it leads the scientific mind through the idea of continuity to that of Unity. In other words, the biological concepts of Order and of Unity combine in a concept of Evolution.

As we have given much attention to the history of Biology, since the time of Buffon, we may be permitted to record our appreciation of that part of Merz's volume which deals with the development of biological thinking. The author's erudition is marvellous, yet amidst the trees he never loses sight of the wood. Unembarrassed by his wealth of material from original sources he advances serenely and sanely, disclosing step by step the magistral march of scientific progress. His general ideas are so akin to our own that we naturally find them hard to criticise, and his historical sketch is so much more comprehensive and consequent than that to which we attained that we cannot do more than express our grateful admiration. There are many students—of science, philosophy, and history—who wish and need to know what the trend of biological science has been during the past century. They will find this and much more in the relevant chapters of this remarkable work, which it would be faint praise to call "*Whewell up to date*".

J. ARTHUR THOMSON.