medicine is to be the ultimate product of the scientific studies of to-day; no one can question that it is a far higher and more desirable type than curative medicine that now generally seeks to remedy the ills begotten through ignorance. The loss to the world by preventable disease is enormous; it includes many of the wise and the good, of the best products of human evolution during past centuries, for no selective action determines that the worse element shall be wiped out. In truth, the delicate nervous balance of the highly developed human organism seems to be more easily disturbed by the attacks of disease than the grosser clay in which all energy has gone to physical development. To stop this loss is the greatest problem of the future in medicine. And the very first step in this problem is the positive determination of causes of disease, and of the means by which they are transmitted and multiplied. Without this knowledge rational prophylaxis is impossible; before it and the results of associated investigations of purely scientific character, quackery must yield as the night before the day, schools and theories will disappear and medicine will take its rightful place among the sciences.

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SCIENTIFIC BOOKS.

The Dynamics of Particles and of Rigid, Elastic and Fluid Bodies. By A. G. WEBSTER. Teubner & Co. 1904.

The training of the physicist and that of the engineer are subjects which one can hardly refrain from discussing whenever a new volume designed to furnish some part of the necessary equipment for either appears on the scene. The one which is the subject of this review raises the question in a much more definite way than anything which has appeared for some time past. Most of the books hitherto published are either mathematical treatises on special departments of physics, or are physical text-books in which mathematics are avoided as far as possible. Professor Webster has attempted, as we shall see later on, to combine the two points of view, somewhat on the lines of Thomson and Tait's 'Natural Philosophy,' but better adapted than that work for the class-room.

The latter part of the nineteenth century has seen a far-reaching change passing over those subjects which deal directly with the interactions of particles of matter. Much careful experimental work has been done and laws and principles have been formulated with such accuracy that the time of the all-round physicist has now to be spent as much at the desk as in the laboratory. In spite of this change, the training of the student is still largely devoted to experimental work and the accumulation of facts. But few students realize that the phenomena can nearly all be brought together as the effects of the operation of a few simple laws. They spend so much time and labor in mere manipulation that the end is quite lost sight of in the means. As a matter of fact, many of the earlier experiments are made with highly specialized forms of apparatus and could be quite easily replaced by illustrations to be obtained from the machinery which has become an essential part of the daily life in all civilized communities. A great saving of time, to be better employed in other directions, might be made by thus laying on a foundation which already exists, and the training would be directed towards the principles and the way in which the laws are manifested rather than to the mere effects themselves.

There is, of course, a difficulty which is always present in the mind of every teacher—that of retaining the interest and holding the attention of the student. Comparatively few of the latter take an interest in the methods, chiefly mathematical, by which the phenomena are deduced from the general laws, and these few frequently neglect the physical side entirely. And yet it is only by a combination of theory and experiment that the best results can be obtained. It is useful for a mathematician to have a knowledge of physics, but it is necessary for a physicist to have such a grasp of mathematics that he is able to work out the problems which arise in connection with his experiments. As Professor Webster points out in his preface, there has been far too much neglect with us of the mathematical side, and while this neglect continues we can scarcely hope to produce men of the type of Maxwell, Kelvin, Rayleigh, Helmholtz and others.

In considering, then, the training of the physicist no less than that of the practical engineer, it is necessary to keep two points steadily in view. The first is a full understanding of the primary laws which lie at the basis of all physical investigations, and the second is the ability to apply those laws to specific cases. Simple as are the laws and the methods of applying them, only those who have attempted to teach the subject know how difficult it is for even the best students to acquire a thorough working knowledge of them and how rare it is for the average student to solve the simplest problems when the latter are anything more than mere applications of results previously obtained. The ability to do this is usually obtained only by long practise, and the time at present devoted to acquiring the facility necessary for success is quite inadequate. To take a simple example. Most of the volumes on the calculus which are written solely for students of engineering and physics contain nothing more than the parts which are necessary to understand the mathematics used in solving physical problems. No thorough grasp of the subject is obtained in this way; the student obtains knowledge sufficient perhaps to understand what is presented to him in a finished form, but there is no margin left for independent work on problems which lie a little off the main track.

Professor Webster has fully recognized this fact. It is true that he presupposes only an elementary knowledge of the calculus and of the earlier parts of algebra and analytic geometry, but a student who wishes to make a serious study of the book will require to know these earlier parts thoroughly. Throughout the volume there is no attempt to slur or evade any difficulties because they are mathematical; practically every result obtained is fully worked out and in many parts the author takes his reader far beyond what is merely necessary. Moreover, he never allows himself to be drawn away from the main lines of his subject by side issues which have little or no bearing on the investigation in progress, and he has avoided the use of special mathematical artifices which are of value only in special problems, so that the methods used are those which can be applied to practically all the problems of dynamics.

Part I. consists of the development of the general principles of dynamics. In the first chapter the elements of kinematics and the laws of motion are briefly set forth. Then follows a chapter on special motions of a particle, which include parabolic, harmonic and constrained motions, pendulums and central forces. Professor Webster has avoided the doubtful practise of most of the English text-books which give a disproportionate amount of space to the last, but the eight pages on the spherical pendulum, although the problem is well worked out, might perhaps have been abbreviated by the omission of some of the figures and details. The next two chapters contain an unusually full development of the principles of work and energy and the methods of Lagrange and Hamilton. Here we find worked out, first, by the use of rectangular coordinates, and afterwards with generalized coordinates, D'Alembert's principle, canonical equations, least action, varying action, varying constraint, activity, etc. These chapters are important in view of the increasing prominence now given to methods which are of value in every department of mathematical physics, as Professor Webster shows by his use of them in the later parts of his book. This first part concludes with applications to oscillations in general and to cyclic motions. In dealing with the latter, special cases of the general methods of abstract dynamics are treated: ignoration of coordinates, effect of linear terms in the kinetic potential, gyroscopic terms, and so on. A few examples are worked out to illustrate the manner in which the various methods are to be used.

The second part deals with the dynamics of rigid bodies. The author here develops, with considerable detail, the mechanics of systems which admit of representation by means of vectors, a method used throughout the volume wherever possible. Under this head come screws and wrenches, moments of inertia, and the special kinematics of a rigid body rotating about a fixed or moving point. Special attention is devoted to the dynamics of rotating bodies. The top comes in for detailed treatment and many of the curious phenomena exhibited are deduced from the equations of motion. Pictorial illustrations are given of the instruments and of the curves which have been actually obtained by the author to show how closely observation may be made to agree with theory.

The third part opens with a chapter on the Newtonian potential function. This will probably be found to be the least satisfactory in the whole volume from the student's point of view. Although it may be quite logical to start with the properties of point-functions and develop them in detail before proceeding to the applications, it is frequently tedious to read through many pages of mathematics leading to isolated geometrical results without indications of the uses to be made of those results. A rearrangement in which concrete problems are stated and solved, gradually leading the student step by step to each new mathematical investigation as he sees the need for it, would seem to better achieve the end the author has in view and would avoid the danger of wearying the student and losing his interest. The next two chapters contain the dynamics of deformable bodies. The theory of stresses and strains is worked out and the illustrations are derived chiefly from problems in hydrostatics and hydrodynamics. The final chapter on the latter is perhaps the most interesting in the book. After obtaining the general equations of motion, the author treats briefly, but sufficiently for his purposes, vortex motion, including tidal problems and sound waves. An appendix contains notes on certain portions of algebra and analytic geometry.

It is to be regretted that a little more care has not been exercised in the wording of the statements and definitions, especially in the earlier parts. For example, in the statement of the second law of motion, Newton's 'change of motion' should be paraphrased 'rate of change of momentum,' and not 'acceleration.' On page 31, the reason for the necessary slight modification of Kepler's third law is given as due to the motion of the sun, instead of to the fact that the mass of the planet is not infinitely small compared with the mass of the sun. On page 35 the impression is conveyed that a motion is periodic when a system is in the same *position* after a certain interval of time, whereas it must also have the same *velocities*. It is not clear what is meant by the statement on page 96 that the principles of conservation of energy, of the motion of the center of mass, and of moment of momentum 'suffice for the treatment of all mechanical problems.' On page 131 it is stated that Jacobi's dynamical method furnishes a means of integrating the equations of motion of a dynamical problem; this method is really a transformation which replaces the problem of solving $2n$ ordinary differential equations each of the first order, by that of solving a partial differential equation of the first order in $n+1$ variables.

Whatever criticisms we may be disposed to make on minor points, we can heartily congratulate Professor Webster on having produced a book which is in many respects a notable contribution to the literature of the subject. Even if it served no other purpose than to draw the attention of students and teachers to the necessity for a more profound study of the mathematics of physics, it will have achieved useful results. As a class book with an efficient instructor, it will be found to be of value for students who have had a fairly good training in algebra, the calculus and elementary mechanics, and who wish to go further either in experimental work or in the mathematics of physics. It will also be found useful as a place of reference for the main outlines of the various subjects treated.

We hope that Professor Webster's work will be the forerunner of other volumes on similar lines intended not to replace, but to be read in conjunction with, the well-known treatise of Thomson and Tait.

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DISCUSSION AND CORRESPONDENCE.

ON THE SPELLING OF 'CLON.'

To the Editor of Science: The original orthography of 'clon' should be retained, in the opinion of the present writer, for the following reasons: '*Clone*,' the form preferred by Mr. Pollard (Science, XXII., p. 87), is already in use as a medical term, and is of different origin and significance from *clon*. If the latter word should take final *e* in order to mark an omega sound in the original, so also should eon, pæon, autochthon, halcyon and similar words in common use.

Linguistic usage does not require, however, that loan-words and derivatives from other languages should always preserve the same vowel quantities, and in transliteration from the Greek no distinction is made between the long and short sounds of *o* and *e*. In fact, η and ω were unknown until the introduction of scholastic writing, and remained long afterwards confused with ε and ο. Final *e* in English derivatives may stand for a distinct syllable in the original, as in the other examples given by Mr. Pollard, or may be added for euphony, but not for the sole purpose of indicating quantity. Sometimes the final vowel is arbitrarily syncopated, whence the resulting variants of metaphor and semaphore, plasm and plasma, hypogyn and hypocrite, rhyme and rhythm, etc.; or we may even write both synonym and synonyme, though the latter form is antiquated.

Scarcely germane to this matter, but suggested by it, is the popular habit of miscalling under a variety of un-English names one of the most famous masterpieces of Greek art. When we say 'Milo,' we are merely following the continental pronunciation of Melos, in which the final *s* is no longer sounded. *Venus de Milo* is the French name of the statue, Aphrodite of Melos the correct English name. The most unpardonable combination of all is 'Venus of Milo,' with the long (English) sound of the *i* in Milo; for in the first place, the Italian goddess is not the precise equivalent of Aphrodite, and in the second place there is no such geographical name as 'Milo,' at least, not in Greece.

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SPECIAL ARTICLES.

THE LAWS OF EVOLUTION.

That account of universal evolution which we owe to Mr. Herbert Spencer may be supplemented by a formulation of certain quantitative laws which Mr. Spencer seems not to have apprehended. Mr. Spencer's own so-called 'Law of Evolution' is in reality only a great generalization, and not in a stricter sense of the word a law at all. It tells us that everywhere the loss and redistribution of the internal motion of a finite aggregate are accompanied by the concentration or 'integration' of mass, a 'differentiation' of arrangements, forms and activities, and a 'segregation' or drawing together of like units. It does not tell us anything about the rate or amount of 'compound evolution' to be expected from any given expenditure of energy under given conditions.

Economists have long been familiar with certain laws of differential cost and gain. They are commonly called laws of increasing and of diminishing return. The usual statement of them in the text-books is inadequate. A more accurate, and possibly a sufficient, statement is, that in any given state of industry and the arts, an increasing outlay of labor and capital in agricultural, manufacturing, or commercial operations conducted upon a given area,[1] will, up to a given limit, yield returns increasing faster than the outlay, and will, beyond that limit, yield returns increasing less rapidly than the outlay.

In the course of my sociological studies I have been led to believe that increasing and diminishing returns, within the realm of economic phenomena, are only special cases of relations that hold good throughout all phenomena, physical, chemical, biological, psychological and social. In a future publication I hope to set forth the grounds of this

[1] Observe, *space* not 'land.'