

wave-length—an admirable triumph of mathematical power.

He proved (vol. i. p. 227) that the steepest possible wave has a crest of  $120^\circ$ , with slope of  $30^\circ$  down from it before and behind. He *hoped* to work out fully its shape, and would no doubt have succeeded had time permitted.

Four short papers of July, 1845, February, 1846, May, 1846, and July, 1846,<sup>1</sup> show that in those early times Stokes had taken to heart the wave theory of light. His later splendid work on light has given such great results that even in the scientific world Stokes is often thought of only as a worker in optics and the wave theory of light. Truly his work in this province is more than enough for the whole life-time of a hard-working searcher in science.

A short paper of great value,<sup>2</sup> "On the Formation of the Central Spot of Newton's Rays beyond the Critical Angle," touches in its title a physical question of fundamental importance—*What motion takes place in the ether close behind the perfect mirror presented by total internal reflection?* And the answer to it given in the paper is admirably clear and satisfactory.

A little later, we find one of the most important of all of Stokes's papers on light,<sup>3</sup> "The Dynamical Theory of Diffraction." This paper contains the full mathematical theory of the propagation of motion in a homogeneous elastic medium. It contains, also, application of the theory to the disturbance produced in ether by a Fraunhofer grating for the two cases of incident light, (1) with its vibrations *in* the plane of incidence, and (2) with its vibrations *perpendicular to that plane* (therefore parallel to the lines of the grating). Lastly, it contains a description of an elaborate experimental investigation by himself, and a comparison of the results with theory, from which he concluded that the plane of polarisation is the plane perpendicular to the direction of vibrations in plane polarised light. This conclusion, notwithstanding adverse criticism by Holtzmann,<sup>4</sup> was confirmed by Lorenz, of Copenhagen.<sup>5</sup> The same conclusion was arrived at from the dynamics of the blue sky by Stokes and Rayleigh, and from the dynamics of reflection at the surface of a transparent substance by Lorenz and Rayleigh. We may now consider it one of the surest truths of physical science.

The greatest and most important of all the optical papers of Stokes was communicated to the Royal Society on May 27, 1852, under the title "On the Change of the Refrangibility of Light."<sup>6</sup> In this paper, his now well-known discovery of fluorescence is described; according to which a fluorescent substance emits in all directions from the course through it, of a beam of homogeneous light. The periods of analysed constituents of this fluorescent light, in all Stokes's experiments, were found to be longer than the period of the exciting incident light. But I believe fluorescent light of shorter periods than the exciting light has been discovered in later times.

Stokes found that the fluorescence vanished very

quickly after cessation of the incident light. A beautiful supplement to his investigation was made by Edmond Becquerel showing a persistence of the fluorescent light for short times, to be measured in thousandths of a second, after the cessation of the exciting light.

Stokes's fundamental discovery of fluorescence is manifestly of the deepest significance in respect to the dynamics of waves, and of intermolecular vibrations of ether excited by waves, and causing fresh trains of waves to travel through the fluorescent substance. The prismatic analysis of the fluorescent light for any given period of incident light was investigated by Stokes for a large number of substances in his first great paper on the subject, and was followed up by further investigations by Stokes himself in later years, of which some of the results are given in his paper "On the Long Spectrum of the Electric Light" (*Phil. Trans.*, June 19, 1862).

Stokes's great paper on the refrangibility of light is the last paper of the last volume (vol. iii.) hitherto published of his mathematical and physical papers. It is to be hoped that with the least possible delay we shall have a complete collected republication of *all* his other papers. Every one of them, however small, will in all probability be found to be a valuable contribution to science; witness, for example, his paper of twenty-one lines in the *Phil. Mag.* for October, 1872. Let us hope that manuscript may be found for the communication to the Royal Society promised at the end of that paper.

Stokes's scientific work and scientific thought is but partially represented by his published writings. He gave generously and freely of his treasures to all who were fortunate enough to have opportunity of receiving from him. His teaching me the principles of solar and stellar chemistry when we were walking about among the colleges some time prior to 1852 (when I vacated my Peterhouse fellowship to be no more in Cambridge for many years) is but one example. Many authors of communications to the Royal Society during the thirty years of his secretaryship remember, I am sure gratefully, the helpful and inspiring influence of his conversations with them. I wish some of the students who have followed his Lucasian lectures could publish to the world his *Opticæ Lectiones*; it would be a fitting sequel to the "Opticæ Lectiones" of his predecessor in the Lucasian chair, Newton.

The world is poorer through his death, and we who knew him feel the sorrow of bereavement. KELVIN.

#### RECENT METHOD IN PRACTICAL MATHEMATICS.

*Höhere Analysis für Ingenieure.* Von Dr. John Perry. Autorisierte deutsche Bearbeitung von Dr. Robert Fricke und Fritz Süchting. Pp. viii+423. (Leipzig und Berlin: Teubner, 1902).

CONSIDERING the poor opinion the Germans express for the school of mathematics in this country, it is a great honour for Prof. Perry that his "Calculus for Engineers" should be considered suitable for translation as conveying a message of new method worthy of imitation and adoption.

The improvement of the mathematical instruction

<sup>1</sup> M. and P. P., vol. i., pp. 141-157.

<sup>2</sup> Camb. Phil. Soc., December 11, 1848, M. and P. P., pp. 56-81.

<sup>3</sup> Camb. Phil. Soc., November 26, 1849, M. and P. P., pp. 243-328.

<sup>4</sup> *Foggendorff's Annalen*, vol. xcix., 1856, or *Phil. Mag.*, vol. xiii. p. 135.

<sup>5</sup> *Foggendorff's Annalen*, vol. iii., 1860, or *Phil. Mag.*, vol. xxi. p. 321.

<sup>6</sup> *Phil. Trans.* and M. and P. P., pp. 259-407.

required for practical engineers and electricians has been exciting considerable attention in Germany, as shown by a series of addresses by Prof. Klein, Dr. Erwin Papperitz ("Die Mathematik an der deutschen technischen Hochschulen") and others on this subject, thereby attention has been directed to the stimulating method of Perry, who has utilised the idea due originally to Squeers and worked it to a practical result.

The book, as a series of events connected by a slight thread of continuous theory, suggests a mathematical Pickwick the subject is inculcated by a succession of practical problems, chiefly of electrical and engineering interest, always completed very usefully by an arithmetical application to a real case. As in Pickwick, these applications have a personal flavour, which must not be lost by research delayed too late even where they are malicious, as in the story of the theorist who proposed an electrical condenser which would have cost a million, or perhaps even a billion, pounds to build.

The state of mathematics in England, as indeed of most learning, is in a very depressed condition. The school at Cambridge is going down hill; the numbers in the mathematical tripos are diminishing so rapidly that it has sunk from its former proud position to third on the list in size. The decay started when the examination was divided into two parts, and the first half was advanced into the summer time, on the simple innocent plea that it would force the men not to waste their time with gaieties. These gaieties flourish more unrestrictedly than ever, and so the examination is held earlier still so as not to clash with boat races and other frivolous fixtures, and the three years' course, as it is called, is reduced to about two years and a half, to suit the convenience of the college tutors, who are allowed to run the University in their own interest. As showing the danger of ill-considered reform, it is ruled now that a return is impossible to the old system, which worked quite well; and to remedy matters a new scheme was nearly adopted of reducing the time still further, ostensibly to two years, really to one-and-a-half. At this rate, the Cambridge student of mathematics will soon be as extinct as the Bachelor of Salamanca.

As for the second part of the mathematical tripos the standard has been raised not quite to infinity, as there are still a few stray candidates, but they barely outnumber the examiners. Contrast this with the good old days when Lord Kelvin was an examiner and there were fifty wranglers out of a total of one hundred candidates; the men had the advantage then of three years and a half, an extra eight months of the most valuable time, including a third long vacation and fourth October term, to revise their work and digest it thoroughly, not to mention the stimulus for the teaching staff of dealing with a greater variety of subjects than in the present elementary dull round.

Perry's book is probably considered very unsuitable for the Cambridge student, but it would serve as a corrective to the tendency to run after such a singular attraction as the Ostrogradsky Paradox, so recurrent as showing the lack of physical touch in the recent school of thought. The student of physical proclivities is driven away now into the natural or mechanical science tripos. In former days, there was a mathematical school of natural

philosophy which produced Adams, Stokes, Thomson, Tait, Maxwell, Rayleigh and Hopkinson; this school, which the Germans envied, has been thrown into the melting pot, and an attempt is made instead to rival the Germans in their own particular line of pure abstract analysis, starting twenty or thirty years behindhand, and no wonder the Germans despise such servile imitation.

The last century closed with events which have called up heart-searching as to the cause of our state of decadence and decrepitude. Prominent among the causes was the low state revealed of our intellectual ideal in the public service. But what else can be expected from a system which allows our Civil Service Commission to lower this ideal to mere mark-hunting hunger and to play into the hands of the crammer, so that we go forth with jaded, undisciplined brain and intellectual dyspepsia to encounter a keen, intellectual foe? Our Government experts on education for the public service have shown they are ignorant of the psychology of their profession in producing such universal distaste for all the mental resources required to keep the mind in an active, healthy state. We must have a substitute as near to the high ideal of the American West Point Military Academy standard as we can attain if we are to recover lost ground.

With our present system, there is no incentive to effort once the obstacle of the Civil Service entrance examination is past by the aid of the crammer, and so the intellectual pace is set by the slowest. Double as many should be entered as are allowed to pass out, as at West Point, and the weeding-out process should go on continually, so as to excite competition to escape the last place, as great as among the Chinaman's ducks.

"What is to be said of an institution (Coopers Hill) where 20 per cent. of the candidates fail?" Lord George Hamilton asked, thinking perhaps of Sandhurst, where all pass out without exception; what would Lord George have to say about West Point, we wonder, where 50 per cent. do not graduate?

Hitherto, even in the Navy, there was room for improvement in intellectual alertness; the young aspirant was required to show more scripture knowledge than a bishop would exact from a candidate for ordination; but he knew no Greek, so his culture was of the middle class, Hebraistic rather than Hellenistic, as Matthew Arnold has said. He lost the inspiration of the history and strategy of the first great naval power in the Mediterranean to show him the identity of the tactics of the triremes and galleys and of the modern torpedo-flotilla; and it is perpetual stimulus of this kind that is required to keep him fresh and active in mind, like a Nelson, ready prepared by historical analogy for all possible events.

We lost the American colonies from defects in our naval strategy and the absence of loyal cooperation by sea and land; the same will happen again under our present system, where the admiral, with the fear of Byng's court-martial before him, plays his own game regardless of his partner; the force of Voltaire's proverb, *pour encourager les autres*, is not lost on the foreign strategist.

Prof. Perry, in his writings and addresses, has done much to introduce a higher ideal and to combat prejudiced



officialism ; he is having a hard battle, but there are signs of victory in sight ; the appearance of this translation will add to the discomfiture of his antagonists, when they see that he has secured an influential following in Germany.

The translation is very faithful—rather too much so in parts where misprints and slight errors have not been corrected, as, for instance, in § 189, where an attempt is made to show why alternators tend to synchronism when in parallel ; Prof. Perry should develop the facts more thoroughly, as we know now that the tendency to synchronism exists only under very restricted conditions not always to be secured in practical working.

Dr. Robert Fricke's experience as a professor at a technical high school has had a useful effect of correction on the sublimity of his researches in the exalted regions of modular and automorphic functions, and has led him and his colleague to appreciate a work which most professional mathematicians are too prejudiced to understand.

A. G. GREENHILL.

#### A MUSEUM CATALOGUE.

*Descriptive and Illustrated Catalogue of the Physiological Series of the Museum of the Royal College of Surgeons, London.* Vol. ii. Pp. ix + 518. Second edition. (London : Taylor and Francis, 1902.)

IT is now more than two years since we reviewed the first volume of this series (NATURE, vol. lxii. p. 385), and to the present one, the second, we are disposed to extend even greater praise than to the first. The book has thrice the bulk of its predecessor, and it is wholly concerned with the descriptions of the nervous system of certain Invertebrates, and the brain and spinal cord, with their membranes and blood-vessels, of Vertebrates. Its main portion is the work of Prof. Elliot Smith, of Cairo, now our foremost authority on the Vertebrate brain ; and in it he describes the brains of the Reptilia and Mammalia in a manner never before attained. He was induced to undertake the task by Prof. C. Stewart, the curator of the museum, at the time at which, in the ordinary course of work, the unparalleled series of mammalian brains which the College possesses were being remounted. Ripe for the opportunity of handling this material, Dr. Elliot Smith has given us, not a mere catalogue, but a masterly treatise teeming with revisionary and new observations, which make for orderly treatment and simplification in a manner surpassing those of most previous essays of the kind.

Some notion of his methods and results may be formed from a brief *résumé* of his work on the "pallium" and "Sylvian fissure," two of the most important things of which he treats. In dealing with the former, he applies to the pyriform lobe and the hippocampus the terms "basal" and "marginal" pallium, in order sufficiently to emphasise, for the first time, the fact that the intervening area or "neopallium," the most variable, is both morphologically and physiologically the most important pallial constituent, and that in the study of this, which he defines as "the organ of associative memory," lies the clue to the chief determination of the real nature of at least the

cerebrum of the leading mammalian types.<sup>1</sup> As to the "Sylvian fissure," we meet with an ever-recurring treatment of it throughout the book ; and in establishing the fact that the cortical areas from which its lips are formed are non-homologous in different mammals, the author shows that by failure to appreciate this in the past an inextricable confusion has arisen. Concluding that the Sylvian fissure proper is in its complete form found only in the human brain, and proving that it results from the meeting of three sulci phylogenetically distinct and variable in extent and interrelationship among the lower forms, introducing a rational terminology, he has systematised this complex subject on entirely new lines ; and it is worthy of remark that he of necessity once more establishes a distinction between the pallial surface of man and the higher apes.

This much is simply revolutionary, but it is characteristic of the whole book ; and when it is seen that the brains of representative members of every family have come under review, that in the case of many extinct forms casts of the brain-cavity have been studied, that there are 220 new illustrations, in themselves as accurate as the text, and that an all-sufficient bibliography is given, the result is one upon which all concerned are to be heartily congratulated.

The book forms the framework of an arch, of which the parts necessary for its completion have been obtained by the study, in Cairo and elsewhere, of such material as was originally lacking. There will shortly appear in the *Transactions* of the Linnean Society two memoirs directly related to this catalogue, which, as read, give promise of results at least equal to those of the author's great achievements with the Edentata, the Monotremes and Marsupialia, now everywhere recognised as of prime importance and in the highest degree luminous. Whenever possible, series of brains of each individual species have been studied, and memoirs and catalogue combined will furnish the finest contribution of the last quarter of a century to the science of cerebral topography and the analysis of the commissural systems of the brain.

The minor portion of the catalogue is contributed by Mr. R. H. Burne, the assistant to the curator, and is based on anatomical preparations fully equal to those through which he has obtained distinction in the building up of the collections. The Echinodermata, Annelida, Arthropoda and Mollusca, with the Protochordata, Cyclostomi, Pisces, Amphibia and Birds, have fallen to his lot ; and he is responsible for the concluding sections on the membranes, blood-vessels, and spinal cord. Accuracy of detail is the distinctive feature of all that he has put on record, and he has introduced a novel method of display. He gives us new and welcome drawings of microscopic sections of the ganglia of not a few invertebrate forms and of the teleostean pallium, with a bibliography sufficient for the first needs of those who may desire further information. He has played a good second to his distinguished co-author, and a magnificent volume has been produced, worthy the best associations of the great institution whence it originates, the

<sup>1</sup> Pp. 465-466, in which the author elaborates this theme, are fascinating reading.