The Convolutions of the Brain.—*Die Hirnwindungen des Menschen.* By Alex. Ecker, Professor of Anatomy in the University of Freiburg. (Brunswick, 1869. London: Williams and Norgate.)

A SUCCINCT but detailed description of the various Convolutions of the Brain, intended chiefly for the use of physicians. It is illustrated by half-a-dozen outline sketches. The references to the development of the convolutions are not very full, but the author promises a more complete account elsewhere.

The Absolute Value of Knowledge.—*Der Sebständige Werth des Wissens.* By Prof. K. Rokitansky. (London: Williams and Norgate.)

THE Materialist school of philosophy are just now getting very badly treated by men of science, much to the astonishment, it appears, of the general public. Mr. Huxley has startled the world by proclaiming himself in a way a disciple of Berkeley and Kant, and here is Rokitansky, the great master of modern pathological anatomy, walking in a similar path. To many minds pathological anatomy would seem to be intensely materialistic. It is not so, however, to the Viennese professor. This little lecture is chiefly devoted to a development of idealism: of that kind of idealism, moreover, which "makes the objective wholly and in every way dependent on the subjective, for the former is but the projection of the latter."

Tables of Pomona.—*Tafeln der Pomona, mit Berucksichtigung der Storungen durch Jupiter, Saturn, und Mars.* By Dr. Otto Lesser. Publication der Astronomischen Gesellschaft. (Leipzig: Engelmann.)

THESE tables of Pomona are founded on the disturbance of the planets Jupiter, Saturn, and Mars, calculated according to Hansen's method, and published by the author in Nos. 1596–7 of the *Astronomische Nachrichten.* The preface gives a full account of the character of the tables, illustrated in the usual manner by the calculation of the place of the planet Pomona for a given time.

Although it might seem that the construction of a series of tables as full and as elaborate as Bouvard's Tables of Jupiter and Saturn, would be a waste of labour in the case of a minute planet like Pomona, not merely invisible to the naked eye, but not appreciably affecting by its influence any of the great planets of our scheme, yet this is not in reality the case. Though Pomona cannot affect the other planets, yet these affect Pomona. Her sister orb, Themis, has lately been made the means of affording a useful estimate of Jupiter's mass, through the careful consideration of the perturbations which that planet exerts upon the tiny asteroid. Long since Nicolai applied the perturbations of Juno, Encke those of Vesta, Gauss those of Pallas, and Brünnon those of Iris, to the same end. The more such researches are multiplied, the more exact will be our estimate of the mass of the principal planets of the solar system. Therefore, the present tables, by means of which it will be rendered an easy matter to estimate the disturbing action of Jupiter, will have a high value. In a less exact but not unsatisfactory manner, the mass of Mars may be estimated from the same tables, since in certain positions the disturbances of Pomona caused by Mars' attraction can be readily separated from those of Jupiter. R. A. P.

SCIENCE-TEACHING IN SCHOOLS*

THE claims of Physical Science, on *à priori* grounds, to a fair place in the course of school work, have been abundantly vindicated, and are, I suppose, established. But the method and details of its teaching, the books and apparatus which it requires, and the amount of time which must be given to it, are points which can be decided only by experiment, and have not yet been decided at all. I cannot premise too distinctly that the aim of this paper is practical. Of the necessity for teaching science to their boys many good schoolmasters are convinced; as regards the machinery by which it is to be taught, they mostly confess their ignorance, and cry aloud for guidance. In my own school it has been taught systematically for the last five years, and I offer the fruit of this experience, very humbly, to all who are interested in Education.

The subjects to be taught—the time to be spent upon them—the books and apparatus necessary—and the mode of obtaining teachers—are the points on which information seems to be required. I will take them in order.

The subjects which naturally suggest themselves as most essential are Experimental Mechanics, Chemistry, and Physiology. But it has been urged by high authority, familiar to the members of this Association, that between Chemistry and Physiology Systematic Botany should be interposed, as well because of the charm this science lends to daily life, as from its cultivating peculiarly the habit of observation, and illustrating a class of natural objects which are touched indirectly or not at all by the other sciences named. Whether all these four subjects can be taught depends upon the period to which school education is protracted; but at any rate, let these, and none but these, employ the hours assigned especially to Physical Science, in the scheme of actual work in school. Abundant opportunity will remain for less direct instruction in many other branches of science. The Geographical lectures, if properly treated, will include the formation of the earth's crust, with the classification and distribution of its inhabitants, both animal and vegetable, both extinct and recent. The possession of meteorological instruments, whose observations are regularly taken, and their computations worked by the boys, will almost insensibly teach the principles of atmospheric phenomena; while such books as Maury's "Physical Geography of the Sea," Airy's "Popular Astronomy," and Herschel's "Meteorology," may be given as special matter for annual scientific prizes. The laws of light and heat will be taught as prefatory to chemistry. Electricity attracts boys so readily that with very little help they will make great progress in it by themselves. The mathematical master, whose best boys are well advanced, will not be satisfied till he has obtained a transit instrument and a mural circle. And the wise teacher, living in the country, will not disdain to encourage a knowledge of natural history. He will know that it is not only ancillary to severer scientific study, but in itself a priceless and inexhaustible resource. By country walks, by well-chosen holiday tasks, by frequent exhibitions of his microscope, he will not only add to the intellectual stock of his boys, but will build up safeguards to their moral purity. Indeed, even without such encouragement, boys who are trained thoroughly in certain sciences will of their own accord seek to become acquainted with other and collateral ones. Cases multiply in my own experience where pupils of a chemistry class have taken up electricity, pupils of a geography class mineralogy, pupils of a physiology class microscopy, and I need hardly say that boys make nothing their own so thoroughly as that which they select themselves.

The time to be given to science should not be less than three hours a week. At this rate two years may be given to mechanics, two years to chemistry, one year to botany; while the rest, if any remain, will be free for physiology. We need not be afraid of beginning early. A boy of eleven years old, fresh from an intelligent home, where his love of observation has been fostered, and his inquiries have been carefully answered, is far more fit to appreciate natural laws than a much older boy, round whose intellect, at an old-fashioned school, the shades of the prison house have steadily begun to close. Most schools are now divided into lower, middle, and upper. I would commence the study of mechanics with the junior class in the middle

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school. For the first year the teaching may be *viva voce*, with easy problems and abundant experiment; care being taken that each week's lectures shall be reproduced on paper, and great attention being paid to correct drawing. In the second year the teaching will be more minute and more extended, and a good book will be mastered. At the end of this time the class is fit to pass creditably the Oxford Local Examination for juniors, and has done with mechanics for the present. The third and fourth years will be given to inorganic chemistry. The third year will include only lectures in the class room; a text-book being used, experiments being shown by the master, but no laboratory work being done by the boys. The fourth year's work will be conducted entirely in the laboratory, each boy manipulating with his own instruments at his own table. At the expiration of these two years the class will be qualified for the chemistry examination in the London University Matriculation. The fifth year is given to botany. If a good book is used, if each boy works for himself with lens and knife, if Henslow's Schedules, or a modification of them, are regularly filled up; above all, if plates are not made to do the work of living plants, the pupils will at the year's end thoroughly understand the principles of classification, will know the characteristics of at least all the British orders, and will be able with the help of Bentham or Babington to make out almost any English flower. The boys who have completed this course will be from 16 to 17 years old. Some of them will now be leaving school; those who remain will give the rest of their time to physiology. They will begin with human and will pass to comparative physiology, using in the first Professor Huxley's valuable little book; dependent for the second, of which no school manual exists, on the skill and method of their teacher. But whether at the earlier or the later age, they will pass out into the world immeasurably superior to their contemporaries who know not science, with doors of knowledge opened which can never again be closed; with a fund of resource established which can never be exhausted; with minds in which are cultivated, as nothing else can cultivate them, the priceless habits of observation, of reasoning on external phenomena, of classification, arrangement, method, judgment.

The subject of books and apparatus, involving as it does the question of expense, is of the highest practical importance. Apparatus need not cost much; but it may, and if possible it should, cost a great deal. While poor and struggling schools may begin cheaply and proceed gradually, institutions which can spend money on racket courts and gymnasiums ought not to grudge it on museums and botanic gardens. We have taught mechanics efficiently, that is to say, we have passed our classes for the last three years in the Oxford Local, with a good air-pump, a set of pulleys, models of the force-pump and the common pump, with Keith Johnston's scientific maps, and with the diligent use during the second year of Newth's "Natural Philosophy." But we have lost no opportunity of making the boys acquainted with machinery; from the crane and the water-mill of our daily walks, to the steam engine and the spinning jenny of the manufactory; for he who has not examined engines at work will never understand them clearly, or describe them correctly. For teaching chemistry, a laboratory is absolutely essential. No matter how rough or shabby a room, so that it be well ventilated, have gas and water laid on, and will hold from sixteen to twenty boys. I hold in my hand the model of a cheap laboratory table, on the scale of two inches to a foot. It is about nine feet by three, and contains eight compartments, each two feet by sixteen inches, with two slight shelves, and a special recess for the teacher. It costs about 4*l.* If made for twice the number of boys, it may be made at about nine shillings per boy. The general laboratory stock, including a still, a stove or furnace, gas jars, a pneumatic trough, a proper stock of retorts, crucibles, tubing, &c., and the necessary chemicals will cost under 12*l.* Each pair of pupils must have also between them a set of test tubes, a washbottle, a spirit lamp, a waste basin beneath their table, and twenty-four bottles of test solutions, while each boy has his own blowpipe, tripod and stand, pestle and mortar, and three beakers. These will cost each boy about eight shillings. He will replace everything that he breaks, and will receive the value of his stock from his successor when he quits the class. The text-book used should be Roscoe's, or Williamson's, and a large black board is quite indispensable. In botany the book for the boys' use is Professor Oliver's Lessons; but the teacher will find great advantage from Le Maout's "Leçons de Botanie." An excellent modification of Henslow's Schedule is published by Professor Babington for the use of his Cambridge classes, and Lindley's "Descriptive Botany," price one shilling, is a most useful help. Every boy should be furnished with a small deal board, a lens, and a sharp knife. The botanical microscope which I exhibit, including a lens fixed or movable, a black glass stage, two dissecting needles and a forceps, is made by Mr. Highley, of Green-street, Leicester-square. If they are ordered by the dozen he will furnish them at six shillings each. Flower trays, such as I hold in my hand, should be kept constantly in use; the boys being encouraged to bring in wild flowers, and to place them in their appropriate niches. Their cost per tray, holding eighteen bottles, is under two shillings. Fitch's diagrams designed for the Committee of Council on Education, which cost 2*l.* 9*s.* the set, are a valuable help to the lectures; and for schools which have large purses or liberal friends, Dr. Auzoux's Models of Plants and Plant Organs, ranging in price from 20 to 100 francs, and ten times the size of life, form a luxuriant assistance to beginners, which only those can appreciate who have worn out their eyesight and their temper over a composite floret or the glume of a small grass. The same excellent modellist, whose catalogue is on the table, provides every organ necessary for the study of comparative and human physiology; and his prices ought not to be beyond the reach of any prosperous school. In any case a skeleton will be necessary, and will cost about £5; and if the Committee of Council were to authorise the reproduction of such typical physiological cases as, from the skilful hands of Mr. Charles Robertson of the Oxford Museum, drew so many admirers in the Exhibition of 1862, these would find immediate purchasers in many of our schools. At present teachers want the skill or the leisure to make their own preparations, and they cannot buy them. A good set of meteorological instruments costs from £16 to £20, but these, with astronomical apparatus, are a costly luxury, and may be left out of the list of indispensable necessities. I cannot think that any school, professing to teach science systematically, will be long satisfied without a typical museum. As scientific work proceeds, specimens of all kinds, some purchased for lecture work, others given by friends or collected by the boys, will gather and increase, till the class-room cupboards and shelves are choked, and a special room must be devoted to them. Here will be arranged, in one place rocks and fossils, in another trays of minerals, in a third zoological specimens, in a fourth physiological preparations. The driest corner in the room will be assigned to the Herbarium, a small library of scientific reference will give promise of the future. Everything not typical will be rigorously excluded; every case will be so carefully arranged and so plainly labelled as to tell the history of its contents to the eye of the least instructed observer. And it will be hard if some corner of the playground cannot be laid out as a botanic garden. In the crowded school premises which we are happily leaving I have found room for nearly four hundred plants, and at the new school to which we are about to migrate, I shall riot in two acres of garden ground, with a pond for water plants and a sheltered rockery for ferns.

It remains only to examine the mode of obtaining teaching power; a point which presses heavily on many head-masters who have themselves no knowledge of science. That all head-masters should have such knowledge is a fact which, if science is to be taught at all, trustees and governing bodies must come to recognise before long: meanwhile every school which teaches science thoroughly is training skilled teachers for a not distant generation. Institutions which can give so high a salary as to command a London bachelor of science or a first class Oxford or Cambridge man, will find no more difficulty than attends the choice of all masters: where this is not the case it is sometimes possible by combining mathematics with physical science to tempt a superior man with a sufficient income; and, if only a small salary can be given, the ordinary pass B.A. of the London University will sometimes make a fairly good teacher. But one point has struck me forcibly in my own experience; namely, the unexpected value of general culture in teaching special subjects. The man who knows science admirably, but knows nothing else, prepares boys well for an examination; but his teaching does not stick. The man of wide culture and refinement brings fewer pupils up to a given mark within a given time: but what he has taught remains with them; they never forget or fall back. I am not sure that I understand the phenomenon, but I have noted it repeatedly.

I cannot end this paper without a word as to the educational results which our five years' experience has revealed. The system has brought about this result first of all, that there are no dunces in the school. In a purely classical school, for every promising scholar there are probably two who make indifferent progress, and one who makes no progress at all; and a certain proportion of the school, habitually disheartened, loses the greatest boon which school can give, namely, the habit and the desire of intellectual improvement. By giving importance to abstract and physical science, we at once redress the balance. Every boy progresses in his own subject; some progress in all; no one is depressed, no one thinks learning hateful. Secondly, the teaching of science makes school-work pleasant. The boy's evident enjoyment of the scientific lesson rouses the emulation of other masters. They discover that the teaching of languages may become as interesting as the teaching of science. They realise—a point not often realised—the maxim of Socrates, that no real instruction can be bestowed on learners "*παρὰ τοῦ μὴ ἀρέσκοντος*, by a teacher who does not give them pleasure." Lastly, the effect on the boy's character is beyond all dispute. It kindles some minds which nothing else could reach at all. It awakes in all minds faculties which would otherwise have continued dormant. It changes, to an extent which we cannot over-estimate, the whole force and character of school-life both to the learner and the teacher. It establishes, as matter of experience, what has long been urged in theory, that the widest culture is the noblest culture; that universality and thoroughness may go together; that the system which confines itself to a single branch of knowledge, does not gain, but loses incomparably, by its exclusiveness: that observation, imagination, and reasoning may all be trained alike; that we may, and so we must, teach many things, and teach them well.

W. TUCKWELL

THE LATE PROFESSOR GRAHAM

AT 9 o'clock in the evening of Thursday, the 16th September, 1869, died at his house, No. 4, Gordon Square, a man whose name will be honoured as long as true greatness is appreciated.

Thomas Graham spent his life in reading the book of Nature, and giving to mankind a knowledge of the truths which he found there. His greatness is to be measured not merely by the amount and importance of the knowledge which he thus gave, but even more by the singleness and strength of purpose with which he devoted his whole life to labours of experimental philosophy.

Some men have made important discoveries by occasionally applying to experimental investigation, powers of mind which they exerted usually in the pursuit of their own worldly advancement.

But from an early age Graham's one great object of life was the discovery of new truths, and he appreciated so fully the value of such work that he resolved to make any personal sacrifices which might be needed for its sake. And nobly he kept his resolution; for at an early stage of his career he endured, for the sake of pursuing chemistry, privations and sufferings so severe, that they are believed to have permanently injured his constitution; and at its very end, long after he had attained a world-wide reputation, when his delicate frame sorely needed the repose which was at his command, he continued to labour even more effectively than before, and to enrich science with new discoveries.

It might be difficult to find in history a character so perfect in its noble simplicity and elevation.

Graham was born at Glasgow, on the 21st December, 1805, the eldest of a family of seven, of whom only one survives.

He went to the English preparatory school at Glasgow, in 1811, and was there under the care of Dr. Angus. In the year 1814 he was removed to the High School, where for four years his studies (which included the Latin language) were directed by Dr. Dymock, and subsequently for one year by the Rector, Dr. Chrystal, under whom he studied Greek. It is said that during these five years he was not once absent at school-time. In 1819 he commenced attendance in the University classes in Glasgow.

Thomas Thomson then occupied the Chair of Chemistry, and young Graham benefited by his instruction, as also by that of Dr. Meikleham, the Professor of Natural Philosophy.

By this time he had already acquired a strong taste for experimental science, and formed a wish to devote himself to chemistry. His father, an able and successful manufacturer, had formed different views for his future career, and wished him to become a minister of the Scotch Church. It is hardly to be wondered at that the father should not have seen in the prosecution of science much scope for an honourable or advantageous career; but young Graham had already seen something of the means afforded by experimental science of getting knowledge from the fountain head—from Nature herself. He felt the need of more such knowledge to mankind, and his scheme of life was formed accordingly.

After taking the degree of M.A. at Glasgow, he continued his studies for two years at Edinburgh, and there studied under Dr. Hope, and enjoyed the friendship of Prof. Leslie. On his return to Glasgow, he taught mathematics for some time at the suggestion and under the patronage of Dr. Meikleham, and subsequently opened a laboratory in Portland Street, Glasgow, where he taught chemistry. It is probable that some of the severest trials of his life occurred at about this period.

While absent from Glasgow he was in the habit of writing regularly and at great length to his mother, and from the tenor of these letters it is easy to see what that mother must have been to him. A writer on the social position of women has described the feelings of boys towards their mothers as scarcely amounting to respect! Young Graham's mother seems to have been his guardian angel, sympathising with his hopes and his sorrows; and certainly his feelings towards her would have been very inadequately described by that frigid word. While studying at Edinburgh he earned, for the first time in his life, some money by literary work, and the whole sum (6*l.*) was expended in presents to his mother and sisters.

In 1829 he was appointed lecturer on Chemistry at the Mechanics' Institution, Glasgow, in place of Dr. Clark; but the decisive step of his life was in the subsequent