

a system. Why should they? Does the desire to beat competitors stimulate a desire for knowledge? Does it stimulate originality? I or one would willingly see them non-existent.

Up to a certain point, the acquisition of knowledge of facts should be, as at present, tested by examination; but I am convinced that the system is at present pushed to an extreme, and that much better results would be gained by giving a degree for training, and that can be done only by the trainer—the teacher. He will, as a rule, be glad to share his responsibility with, and to benefit by the advice of, an outsider; but with him should ultimately rest the decision as to the merit or demerit of a candidate, as he is the only person able to judge. Under such a system, there would be little plucking; for the student would be advised not to present himself, unless he had sufficiently qualified.

It may also be said that undue advantage would be taken by the teacher in recommending unfit students for graduation. Teachers in such positions are, I believe, generally honourable men; they are chosen after the most careful inquiry into their past career. It is not held fitting in commercial circles to appoint a clerk or an accountant on good recommendations, and after sufficient apprenticeship, and then to surround him with safeguards, in case he turn out incapable or dishonest.

The objection may possibly be raised, that under such a system the standard of degrees would be very uneven; but what of that? As at present, anyone applying for a post of any kind would furnish a reference to his teachers; and a private letter from one well acquainted with the candidate turns the scale, for or against, in spite of every degree in the United Kingdom.

In plain English, degrees, as at present given, are not valued by that portion of the public qualified to judge; and we must face this fact, and endeavour to render a degree a real mark of merit.

I believe, with Mr. Dickins, that the examinations of the University of London have done much in disseminating knowledge, and they have therefore proved of great service, but except in the case of the higher degrees before mentioned, and of the degrees in the Faculty of Medicine where evidence of training is a *sine quâ non*, I greatly doubt whether they have contributed towards the creation of knowledge, or training in originality. And from the very nature of the constitution of the University of London, it is impossible that it should be otherwise. This very morning, I happened to ask a student attending my lectures on organic chemistry why he, a B.Sc. in chemistry, was attending my lectures. His reply was characteristic. "I scamped up enough of the subject privately, sir, to squeeze through; but now I wish to know it." In any right system, such a proceeding should be impossible.

It is therefore with the hope that the creation of a teaching University for London might tend to remedy such evils, that I, for one, would welcome it. I would urge that the distinguished names mentioned by Mr. Thiselton Dyer are surely guarantees that the London Colleges recently possessed men capable of imparting the highest standard of knowledge, and of stimulating true originality; yet I believe that it is by no means "cutting cheese with a razor" to employ just such men in watching over the development even of junior students; and it is not without advantage to the most able men of science and of letters to be obliged periodically to devote consideration to "elements" and to pass in review first principles. It counteracts the tendency towards specialization, which, however valuable, always limits the mental horizon. I will undertake to say that the quality of the most advanced teaching in biology and physiology in University College when the chairs were occupied by Burdon Sanderson, by Michael Foster, and by Lankester knew no limit; and I greatly doubt the wisdom of appointing teachers whose attention is to be devoted exclusively to research. As my predecessor, Prof. Williamson, often remarked, it is more difficult to teach junior than to teach senior students; and while the superintendence of exercise and laboratory work may well be shared by assistants, in order that the professor may have time to devote to research, and to superintendence of advanced students, it would be a serious calamity were the influence of such minds to be withdrawn wholly from the juniors.

It is precisely by such a federation of Colleges such as University and King's, and of other sufficiently qualified institutions which have the will and the power to join, that specialization may ultimately be effected. The future occupants

of the chairs may be chosen so as to represent every side of a subject; and anyone wishing to pursue research in any special branch would have no difficulty in selecting that particular college where his speciality was also the speciality of the teacher.

WILLIAM RAMSAY.

No well-wisher of the University can feel otherwise than grateful to you for affording a portion of your valuable space for the letters of Mr. Thiselton Dyer and Mr. Dickins on this subject. No two men could be found to speak with greater authority from first-hand knowledge of the facts. The arguments on the subject have been too much of an *ex parte* character hitherto, not seldom based on insufficient information or erroneous impressions. Nothing, for example, could be further from the truth than the statement in the *Times* of May 13, by the writer of what was upon the whole a fair and comprehensive leading article, that "there is no reason why the highest honours of the University of London should not be obtained by a person who never set foot in London or even in England." Many, who like myself voted for the projected scheme of the Senate, must have felt, as I did, as a result of a wide and varied educational experience, that it was potential with great good in the future, and could be accepted as the working basis of the future development of the University, although we felt that the one serious blot in it was the abandonment of uniformity in the examinations for the pass degrees. I verily believe that this was the one thing fatal to its success in Convocation; that it was so far in excess of the recommendations of the Royal Commission as to be unwarrantable; and that it put a lever into the hands of the opposition, of which—as the event proved—a practised disputant like Mr. Bompas did not fail to make most effective and disastrous use.

Wellington College, Berks, May 25.

A. IRVING.

Quaternions and the "Ausdehnungslehre."

THE year 1844 is memorable in the annals of mathematics on account of the first appearance on the printed page of Hamilton's "Quaternions" and Grassmann's "Ausdehnungslehre." The former appeared in the July, October, and supplementary numbers of the *Philosophical Magazine*, after a previous communication to the Royal Irish Academy, November 13, 1843. This communication was indeed announced to the Council of the Academy four weeks earlier, on the very day of Hamilton's discovery of quaternions, as we learn from one of his letters. The author of the "Ausdehnungslehre," although not unconscious of the value of his ideas, seems to have been in no haste to place himself on record, and published nothing until he was able to give the world the most characteristic and fundamental part of his system with considerable development in a treatise of more than 300 pages, which appeared in August 1844.

The doctrine of quaternions has won a conspicuous place among the various branches of mathematics, but the nature and scope of the "Ausdehnungslehre," and its relation to quaternions, seem to be still the subject of serious misapprehension in quarters where we naturally look for accurate information. Historical justice, and the interests of mathematical science, seem to require that the allusions to the "Ausdehnungslehre" in the article on "Quaternions," in the last edition of the "Encyclopædia Britannica," and in the third edition of Prof. Tait's "Treatise on Quaternions," should not be allowed to pass without protest.

It is principally as systems of geometrical algebra that quaternions and the "Ausdehnungslehre" come into comparison. To appreciate the relations of the two systems, I do not see how we can proceed better than if we ask first what they have in common, then what either system possesses which is peculiar to itself. The relative extent and importance of the three fields, that which is common to the two systems, and those which are peculiar to each, will determine the relative rank of the geometrical algebras. Questions of priority can only relate to the field common to both, and will be much simplified by having the limits of that field clearly drawn.

Geometrical addition in three dimensions is common to the two systems, and seems to have been discovered independently both by Hamilton and Grassmann, as well as by several other persons about the same time. It is not probable that any especial claim for priority with respect to this principle will be urged for either of the two with which we are now concerned.