Anglian coasts. Perhaps some of your readers could inform me whether the following difficulty, which has occurred to me, has been already raised, or has received a satisfactory answer. A submarine channel, some 400 fathoms deep, sweeps round the southern coast of Norway from the Cattegat to about the 62nd parallel of latitude, whence it gradually opens out into the deeper water further north. If the 100 fathom-line of soundings were to become the coast margin of north-western Europe, this channel would form a fjord, considerably broader than the straits of Dover, and for the most part 1800 feet deep. A further general upheaval, amounting in all to some 2500 feet, would convert this fjord into a wide valley, sloping gently towards the north, which was bounded on one side by the Scandinavian mountains (then commonly rising to a height of about 5000 to 9000 feet); on the other by a nearly level plateau (with a yet slighter slope, but in the main northward), elevated generally some 2000 feet above the bed of the valley. In such cases, if any trust can be placed on the evidence afforded by Greenland at the present day, the drainage of Scandinavia would obey the law of gravitation, even when in the form of ice, and would be diverted down the fjord or valley towards the northern Atlantic.

T. G. BONNEY.

The Nomenclature of Radiant Energy.

REFERRING to Prof. Simon Newcomb's letter in your issue of November 30 last (p. 100), suggesting a nomenclature for radiant energy—if no one else has already pointed it out, I would suggest that the word *irradiate* might be used in place of *illuminate*. It would be just as expressive, and would have the advantage of consistency; and its use would leave the word "illuminate" to its proper sphere.

A. N. PEARSON.

Melbourne, January 9.

THE FOUNDATIONS OF DYNAMICS.

IT is rather curious that at the present time, when applied dynamics embraces so wide a range, so much attention should be directed to its foundations. One would have thought that the basis of a department of science which is used and used successfully in the investigation of the motion of vortex rings in a fluid, and the propagation of waves of electromagnetic disturbance, had been fully understood, and that no doubt of the firmness of the logical structure on which so huge a weight is laid, was entertained by those who are most active in turning it to practical account. If, as some appear to believe, our dynamical methods are founded on a vicious circle, how is it that the same men have been so successful in applying them to the elucidation of physical phenomena? Surely the repeated attempt to do this ought only to have led, if not to confusion of contradictory results, to continual failure to obtain any explanation at all.

On the other hand the extended use of dynamics has led scientific men themselves to a more general familiarity with dynamical processes. The study of dynamics is now a recognised part of scientific education, and the exigencies of teaching the subject have rendered necessary a much more complete examination of its fundamental assumptions than was usual before, when a few gifted mathematicians, by the force of their own genius, were led, almost "by a way they knew not," to the glorious results of physical astronomy. Again the recognition, more or less clear, that the old action-at-a-distance theories are really mathematical shortcuts, each gathering up into a single formula the result of the physical actions on molar matter of a medium in which it is immersed, has directed attention to the ether, and raised many questions of extreme interest as to the localisation of energy, and the conditions of its transference from place to place. Though a whole race of subtleties has with the new views sprung into being to mock our attempts to find firm footing, we are forced to the conviction that in this action of a medium lies the best means of scientific progress at the present time. As a consequence we are led to the re-

consideration of the theory of energy, and therefore also of the conceptions of force, &c., and discussions as to the foundations of dynamics have been revived and carried on with a keener interest.

No one has worked with more zeal at the task of restating the doctrine of energy on anti-action-at-a-distance principles than Dr. Oliver Lodge, and it happens that recently his views have again been brought to the front by an address on the Fundamental Hypotheses of Dynamics delivered in 1892 by Prof. J. G. MacGregor before the Royal Society of Canada, and an article by the same author in the *Philosophical Magazine* for February 1893. An instructive paper has been presented by Dr. Lodge to the Physical Society, in which he has re-stated and defended his position. The discussion which took place on that paper, and the divergence of opinion then manifested, showed how wide is the interest in this subject, and how far it is still from being completely settled.¹

The chief points in Dr. Lodge's papers are his insistence upon contact action as the cause of all action between bodies, and his re-statement of the principle of the conservation of energy. Only incidentally and as a preliminary, in his last paper at least, are the laws of motion touched upon. On the other hand, the chief burden of Dr. MacGregor's address is the laws of motion, and an attempt so to formulate them so as to give a logical basis for the science of dynamics in its application to physics. In his *Phil. Mag.* paper, however, he deals with Dr. Lodge's views with respect to energy.

I do not propose to restate the positions of the parties to the present controversy, but to endeavour to say how the question appears to an outsider who has felt keenly the difficulty of teaching the elementary principles of dynamics without introducing confusion by unnecessarily obtruding the fundamental *cruces* of the subject; or, on the other hand, slurring over matters of really vital importance.

In the first place, it seems to me that there is in general no sufficiently clear recognition of the fact that abstract dynamics is really abstract, and depends upon certain ideal conceptions just as much as does geometry, and that its application to practical problems must be made on certain assumptions, axiomatic in the proper sense or not, which must be justified by the results of experience. Abstract dynamics is a purely ideal science, geometric in a somewhat extended sense, caused by the introduction of certain notions not ordinarily employed in purely geometrical processes. So long as we confine ourselves to the ideal as we do in geometry, there are about it only difficulties of the same kind as we have in geometrical conceptions, and these I do not here propose to discuss. It is only when we apply the science to the interpretation of nature that we meet with the difficulties that every one must admit do exist, and which there is no blinking if we want to be straightforward, as to absolute direction, uniform motion, &c.

In this application we take some standard for the measurement of time. In this we are guided by the idea derived from the first law of motion, that any body in relative motion, which there is reason to conclude is not changed by the action of other bodies, may be taken as timekeeper. In practice we have recourse to a joint result of this idea and the equality of action and reaction, and take as our standard the rotation of the earth on its axis. [Of course this standard may not agree with some other and preferable standard means of time reckoning, but this will not affect the argument.]

In abstract dynamics we can and do imagine a system of axes of reference of some kind or other, but quite ideal so far, and agree upon or assume the existence of some mode of measuring intervals of time. We then consider the velocities and accelerations of different particles rela-

¹ A rejoinder to this paper appeared in the September number of the *Philosophical Magazine*.