

length of the day. Except at the time of the equinox, the gradual lengthening or shortening of the day, as the solstice is approached, most materially affects, especially in the higher latitudes, the total amount of sunshine received in twenty-four hours.

But are there any convenient and readily accessible tables—as there easily might be—which would at a glance show numerically the comparative amounts of sunshine at certain selected times and places? I would wish to see such tables, say, for every tenth day, for the three months from an equinox to a solstice, for about every third degree of latitude in each hemisphere. I see not how, without this, either the causes or the effects of meteorological changes in different regions at different seasons can be justly estimated. I would propose to express the amount of sunshine during twelve hours at the equator at the equinox by, say, 100; the figures rising above this, or falling below it. Thus there would be more than 100 given for the latitude of the Tropic of Cancer at the summer solstice, with a vertical sun and more than twenty-four hours' sunshine; with 100 for a latitude still further north.

REGINALD COURTENAY.

The Imperial Hotel, Sliema, Malta, November 14.

Quaternions.

By the kindness of the author I have just received a copy of Mr. Heaviside's paper "On the Forces, Stresses, and Fluxes of Energy in the Electromagnetic Field" (*Phil. Trans.*, 1892, p. 423), in which he reopens a question debated in your columns some time ago—the question of Quaternions *versus* other methods of vector analysis for the use of physicists.

At present the matter stands thus:—There are two widely-known systems of vector analysis before the public—Quaternions and the *Ausdehnungslehre*—and quite a multitude of less known ones, of which Prof. Gibbs's seems to be one of the least open to objection, and of which, in my opinion, Mr. Heaviside's is by no means so. It would take too long, however, to justify this opinion, but I wish to make an appeal to Mr. Heaviside and Prof. Gibbs on grounds independent of the merits or demerits of their particular systems.

Of the *Ausdehnungslehre* I do not feel competent to speak. As to Quaternions, there are undoubtedly some inconveniences in physical applications, and I am quite willing to concede that a grave one is the very frequent use of the letters S and V (Mr. Heaviside uses the latter). I do not regard the sign of the scalar product which vexes the soul of Mr. Heaviside as of any consequence. But while thus admitting that a better system than Quaternions is conceivable, I think I can show that the position of the dissenters is little short of suicidal.

The band of physicists who use and urge the use on others of vector analysis is woefully small. Let me put a question to two of the justly best known of that band, Prof. Gibbs and Mr. Heaviside. What is the *first* duty of the physical vector analyst *qua* physical vector analyst? I think I may anticipate that the answer will be—to convince the world of mathematical physicists that vector analysis must be unshelved and set to work. The next question that arises is one of tactics. What should be the plan of campaign to bring this desirable result about? Here I am afraid we cannot hope for unanimity even among the members of the small band, and this is to be most grievously deplored. But surely every sane man will agree that what most certainly the analysts should not do is to present their arguments to those they would convince in a dozen different mathematical languages, each of which is puzzling enough to those learned in allied languages. Grant this, and it follows that Quaternions and the *Ausdehnungslehre* should be left in sole possession of the field. The day for Prof. Gibbs's improvements is not yet. Prof. Gibbs and Mr. Heaviside have not yet convinced the rest of the small band—not to say each other—of the merits of their algorithms. Let me implore them to sink the individual in the common cause, and content themselves with the faith that posterity will do them justice.

Apart from the question of notation there seem to be two schools of opinion as to the proper conduct of the campaign. To vary the metaphor, Maxwell, Clifford, Gibbs, Fitzgerald, Heaviside prescribe a course of spoon-feeding the physical public. Hamilton and Tait recommend and provide strong meat. I do not think that harm, but rather good, will come from this double treatment, as one course will suit some patients and the other others. But let the spoon-feeders provide spoon-

meat of the same *kind* as the other physicians. Is not Maxwell, Clifford, and Fitzgerald's food as digestible as Prof. Gibbs's and Mr. Heaviside's?

ALEX. MCAULAY.

Ormond College, Melbourne, October 31.

Animals' Rights.

MR. SALT disputes the justice of the statement that he has given two contradictory definitions of animals' rights, inasmuch as, according to him, that which he has set forth on p. 28 is but a repetition and amplification of the one to be found on p. 9.

By the definition on p. 9 animals' rights are said to consist in a "due measure" of the restricted freedom which constitutes the right of man, *i.e.* (as Mr. Salt notes) the freedom "to do that which he wills, provided he infringe not the equal liberty of any other man"—"a restricted freedom" which guarantees to the harmless individual *the security of his life and liberty*.

But on p. 28 the rights of animals (which were said before to consist in a "due measure" of that just quoted) being here stated to be "subject to the limitations imposed by the permanent needs and interests of the community," are found to be burdened with so serious a qualification that *security for the life and liberty of the harmless individual is by it completely destroyed*.

A European might settle with confidence in an unknown island, on the assurance that he would be allowed a measure of the general right of the natives to the freedom to do that which they would, provided they infringed not the equal rights of any other, but were he afterwards to discover that the "measure" of this right which was considered to be the "due" of a foreigner was in reality limited "by the needs and interests of the community," and that, a community where the custom of enslaving and eating strangers had existed from time immemorial, we venture to assert that his departure from the island would be effected with as little delay as possible. We should much regret misrepresenting Mr. Salt's statements, but the assertion that the second definition of rights is but a repetition and amplification of the first is manifestly untenable, and if, by "*due measure*" for animals of the rights of man, Mr. Salt would have us understand that he meant—only such a measure as is consistent with the nullification of the most fundamental privileges secured by them, he must have been discussing the subject in a vein of sarcasm which we are bound to confess we had quite failed to appreciate.

THE REVIEWER.

The Height and Spectrum of Auroras.

THERE was a magnificent aurora on the evening of the 4th, part of which, from 10h. 46m. to 48m. or 49m., was an intense red. I noted the positions of some of the features at the exact half-hours and also at some other times, for comparison with any observations that may have been made in other places, for ascertaining the height of the phenomenon; and I hope some such observations have been made of the recent display, and will be made of further ones in the future, for Dr. Veeder, of Lyons (New York), has kindly consented to calculate the heights from the observations.

I am surprised that none of our persevering photographers have as yet obtained a good photograph of the auroral spectrum. I do not think it would be more difficult than the stellar photographs that have been taken, seeing that the exposure might go on for hours. It would be desirable to have it done with a camera that could be pointed in any direction at will, so that wherever the observer saw a bright portion of the aurora he could direct the instrument to it.

T. W. BACKHOUSE.

Sunderland, December 6.

The Teaching of Botany.

THERE appeared in NATURE (vol. xxxi. p. 229) a paper entitled "Experiments suitable for illustrating Elementary Instruction in Chemistry," by Sir H. E. Roscoe and W. J. Russell. I have long felt the want of a similar series of experiments in physiological botany. There is not much difficulty in teaching the morphological side of the subject, but it is not easy for the ordinary high-school teacher to devise and carry out a suitable series of experiments for demonstrating the more important aspects of physiological botany. If some master in the