new species. The species which he considers my *Fusus curtus* is very different from the *F. Sabini* of Gray, or the *F. togatus* and *F. Pfaffi* of Mörch (all enumerated by Friele as synonyms); and I regard the last-named three species as the *F. ebur* of Mörch and not as my *F. Sarsi*. However, notwithstanding any trifling errors, if they be errors, the work of Herr Friele is not only admirable and valuable, but is imbued with that scientific merit and modesty which are peculiar to our fellow-workers in Scandinavia; and we shall look forward with great interest to the continuation of his papers on the Mollusca of the Norwegian North-Sea Expedition.

J. GWYN JEFFREYS

Tables for the Use of Students and Beginners in Vegetable Histology. By D. P. Penhallow, B.S., late Professor of Chemistry and Botany in the Imperial College of Agriculture, Japan. (Boston, 1882.)

THIS little work by no means meets the expectations which its title arouses. The author states, indeed, in his preface that the scope of the work is purposely limited, but the limits are so narrow that the work will not be of much use to the student who has a competent teacher, and it will not be of any use to the beginner who is attempting the study of vegetable histology by himself. The book deals simply with the micro-chemistry of plants; the reagents are enumerated, as are also the various substances to be met with in the cells, but no attempt is made to give an account of the mode of application of the reagents for the detection of the substances, and in certain important cases (the chloriodide of zinc, for example) the mode of preparation of the reagent is not given. Not a word is said about imbedding, nor is any mention made of staining. The general mode of treatment of the subject is thoroughly unpractical. For example, silica is said to appear in plants "as a transparent deposit"; but every histologist knows that the silica in a cell-wall can only be made evident by incinerating with nitric acid.

The priority which the author claims can hardly be granted in view of the fact that Poulsen's valuable "Microchemie" has been in the hands of European histologists for several years. The selection of literature given at the end also betrays the author's want of acquaintance with his subject, inasmuch as no mention is made of such important works as Dippel's "Mikroskop" and De Bary's "Vergleichende Anatomie."

LETTERS TO THE EDITOR

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts. No notice is taken of anonymous communications.*

[*The Editor urgently requests correspondents to keep their letters as short as possible. The pressure on his space is so great that it is impossible otherwise to insure the appearance even of communications containing interesting and novel facts.*]

The Matter of Space

IN his paper on "The Matter of Space," in NATURE, vol. xxvii. p. 349, Mr. Charles Morris has given us an excellent exposition, and, as I believe, in general a perfectly correct one, of the fundamental laws and properties of matter and motion. But as I have for some time been investigating the views which he describes with exactly the results and consequences at which he has arrived (excepting only in one material difference to which I will presently return), a little outline of the mathematical form which I found that the discussion of the subject could receive, and to which it was accordingly submitted in my examinations of its scope and contours, will aid readers of Mr. Morris's paper, perhaps, in attaching clear ideas to some of the expressions which he uses, and in thereby discussing and estimating very easily and fairly the positive truth, in general, or in a few points, of the paper's considerations, the just degree of reliability at all events, which the marvellous maze of internetted motions possesses, which he has most tersely and graphically, and at least in the main, as it appears to me, correctly and truthfully described.

Angular momentum, or (for a particle of unit mass) the rate of description of sectorial areas, is, like actual energy, a quantity of two dimensions in space; it is in fact the vector-product of (or the quadrilateral area between) the two radii of the particle's orbit and hodograph. Tractive momentum, or the product of the unit-particle's radius-vector and the resolved part of the particle's velocity *along* (instead of across) the radius-vector, is equally a quadratic product (but differently estimated) of the two foregoing orbit and hodograph radii. It is not the rate of description of *an area*, like angular momentum, but the time-rate of the square on the orbit-radius. The time-rates of each of these momenta are similar to them in space-relation, and are respectively angular moment or twirl (of a force-couple) and tractive moment or wrest (of a motor-couple). But if a small step of angle is the ratio of a circular-arc step (or of a small step along its tangent) to the circle's radius, this being numerical, a twirl's work through this small step of angle is similar in space-relation to the twirl itself and to its time-effect, or angular momentum.

The same similitude in space-relation will exist between a wrest, or motor-couple, and its time-effect (or tractive momentum), and its small step of work, if, in imitation of the practice for a twirl's or force-couple's action, a wrest's space-step is defined to be the ratio of the particle's *step along* the radius to the orbit-radius. This counterpart of angle-step may be called a traction-step; and it is the small percentage of elongation which the radius undergoes. If this construction is assumed, there ensues from it a close, and evidently significant, analogy between the time-rate of *orbit-radius* square (which denotes at once, in space-relation, a *motor*-couple and its time- and space-effects) and the *hodograph-radius* square (which expresses simultaneously in space-relation a *force*-couple and its time- and space-effects). Although the square of the hodograph-radius signifies the square of the material point's velocity, or its *directed* actual energy, I conceive that the square of the orbit-radius represents a square of undirected velocity, or an undirected energy of "higgledy piggledy" motion of the material point; and its time-rate is *a horse-power of* the point's quaquaversal, or undirected actual energy. Viewed in this light, twirls or force-couples and their time- and space-effects are all graphically synonymous with actual directed energy; but wrests or motor-couples and *their* time- and space-effects are all graphically synonymous with *horse-power* of *undirected* actual energy. For these latter quantities Mr. Morris uses indifferently the various words, "momentum," "heat momentum," "heat velocity," "heat," "motor energy," "heat energy," "heat vibration," "centrifugal energy," and "centrifugal or motor vigour," of a moving point; but while they are all, as he rightly opines, convertible quantities in their relation to graphic space, yet the theory of force-couples with which (*mutato nomine*) they are equally convertible in the same space, teaches us that a twirl-group falls mechanically, according to its association with time and angle, into three distinct divisions, of an action (the couple) and its time- and space-effects (angular momentum and accumulated work). It is so also with the motor-couple's graphic-space measure, "vigour." In proper combinations with time and traction-ratio[1] it becomes either an action or a kind of momentum or a form of work. But in discussing these new quantities' properties two maxims of construction and interpretation must be kept constantly in view.

In the first place, we must not expect a motor-couple (although it tends to alter ϕ) which endows a point with undirected horse-power, to tend to lengthen or shorten the point's radius-vector *in the same way* that a force would do. If by their actions motor-couples can *in any way* oppose the action of a force or force-couple, it must be, not by exerting force themselves, but by giving rise to force where they act. Now motor-couples can no more act intelligibly upon a single point (to range a radius's extremities towards or from each other) than a force-couple can (to turn a radius's two ends round each other). Hence motor-couples must produce force in a material point in virtue of the point's being an aggregation of material points, or in other words the appearance of force is a sign of the compositeness of the material point upon which it acts. *Per contra*, forces can produce force-couples, or

[1] The integral of traction-ratio, $\int d\phi = \int \frac{dr}{r} = \log \frac{r}{c} = \phi$; I identify with Rankine's "thermodynamic function" (for which he uses the same symbol, ϕ) usually termed "entropy" in works on thermodynamics.

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