a time will aid the passage of lymph; but the anastomosing vessels will carry the embolic ova as well as the lymph. The corresponding glands will then, in their turn, be invaded; and so on, until the entire lymphatic system, connected directly or indirectly with the vessel in which the parent worm is lodged, becomes obstructed.

"This, I believe, is the true pathology of the elephantoid diseases: 1°. Parent Filaria in a distal lymphatic; 2°. Premature expulsion of ova; 3°. Embolism of lymphatic glands by ova; 4°. Stasis of lymph; 5°. Regurgitation of lymph, and partial compensation by anastomoses; 6°. Renewed or continued premature expulsion of ova; further embolism of glands. This process, according to the part of the lymphatic system it occurs in, the frequency of its recurrence, and its completeness, explains every variety of elephantoid diseases." C. V. RILEY.

INTERNAL MOLECULAR ENERGY OF ATOMIC VIBRATION.[1]

THE object of this paper is to examine at length the relative amount of energy which a molecule may possess with respect to any small degree of freedom of motion which its atoms may have as to each other. The theorem of the virial is applied to this motion of the atoms; and it is found, that in a molecule of a perfect gas consisting of but two atoms, which are at a mean distance, r, from each other, and which suffer a small displacement whose mean maximum amplitude is δr under the action of elastic forces, the energy of atomic vibration will be to that of translation parallel to any assumed direction in space as δr to r. It is further shown that this result is of such a character as not to be restricted to molecules of two atoms merely, nor to atoms which are attracted toward their mean position by forces varying simply as the first power of the displacement; so that the result arrived at is of a general nature which may be stated thus: the energy of interatomic vibration depends upon the atomic displacement within the molecule, and in such a way, that, when this displacement is a vanishing quantity compared with the dimensions of the molecule, then this energy of internal vibration is a vanishing quantity compared with the energy of motion of the molecule as a whole.

This result is in confirmation of the results obtained by the author in his previous paper upon 'An extension of the theorem of the virial,'[2] etc., in which he expressed the opinion that the results there obtained led to the conclusion, that "in case partial constraints not amounting to the loss of entire degrees of freedom are introduced, the energy will no longer be equally distributed among the co-ordinates, but will be influenced by their constraints."

This being in direct contradiction to the conclusions which have been deduced by Boltzmann and by Watson from the discussion of the distribution of energy by the method of generalized co-ordinates, an examination is made of the point in this hitherto accepted theory from which the contradiction arises, and an error is pointed out in the method of employing the fundamental expression for the distribution of velocities. The error is of this nature: the law expressing the most probable distribution of velocities with respect to any single co-ordinate is the same as that of the most probable distribution of errors of observation, and contains a single arbitrary constant, to be determined by the observations themselves. It has been assumed that this constant is the same for each co-ordinate, which is, in effect, assuming the very point to be proved. It is here pointed out, that doing this commits an error of the same nature as is done in assigning equal weights to unlike observations without first showing that their weights are equal.

The computations made by means of the virial show conclusively that the mean energy (i.e., the weight) is not at all the same for one degree of freedom as for another; and, in order to find how one is related to another, it will be necessary to take account of the forces acting, as has been done in this paper and in the previous one.

This extension of the theory leads to numerical results in close accordance with observed values of the specific heats of gases, and their ratio, without previous knowledge of these quantities for any gas; thus computing these quantities for the first time solely from the general equations of mechanics.

[1] Abstract of a paper upon a further extension of the theorem of the virial to the internal molecular energy of atomic vibration. By H. T. EDDY, Ph.D., Cincinnati. Read before the Section in physics and chemistry of the Ohio mech. inst. April 26, 1883.

[2] *Sc. proc. Ohio mech. inst.*, March, 1883; SCIENCE, p. 65.

ON THE DEVELOPMENT OF CHLOROPHYLL AND COLOR GRANULES.

THE view has been generally entertained, based largely on the admirable investigations of Arthur Gris, that chlorophyll-granules are produced by direct differentiation of the protoplasm of assimilating cells. Led by his study of certain protoplasmic bodies in the cells where nutritive matters are stored for future use, and following out a suggestion made by Schmitz in his recent work relative to the assimilating bodies in certain Algae, A. F. W. Schimper (*Botan. zeit.*, Feb. and March, 1883) has made a detailed examination of the origin of chlorophyll-granules, which indicates that the views of Gris are erroneous. At the points of growth examined by him, Schimper uniformly found that well-formed granules already exist, and that, from subsequent division of these, all the chlorophyll-granules are produced. From these, and not, as heretofore believed, from the differentiation of the protoplasmic mass in the cell, arise the granules which later, under the influence of light, take on their characteristic color. One of the most interesting cases reported by him is that of Azolla. The point of growth at the root contains bright green chlorophyll-granules about as large as those in the older parts, and in these granules the process of division is to be distinctly traced.

In those points of growth where the tissues are as yet free from color, he has been also able to follow the division, step by step, up to the production of complete green granules. The bodies from which the granules are produced are present, likewise, in all points of growth of seedlings. Just here is found the most interesting feature of this investigation. From these bodies, which he well terms 'plastides,' come three classes of protoplasmic bodies, somewhat resembling one another in shape: namely, 1, the chlorophyll-granules, or *chloroplastides*; 2, the starch-formers, which, with the allied white or colorless bodies, he calls *leucoplastides*; and 3, the bodies which possess colors other than green (for instance, the granules in petals and the like), to which he gives the name *chromoplastides*. To illustrate this from a single case, we will allude to Impatiens parviflora. The very transparent cells at the point of growth contain plainly visible leucoplastides. In cells of the same age they are of the same size, often constricted, always sharply defined. These can be traced by plain transitions into chloroplastides on the young stem and the zone of forming leaves, while, at the point of growth in the root, only leucoplastides are to be seen. Moreover, in following the plastides farther back, he found them present in the seed itself; and this he conjoins with the well-known fact, that chlorophyll-granules are to be found ready formed in certain seeds.

The destiny of the plastide depends upon the tissue which is to be developed from the meristem. Some of them remain colorless, that is, as leucoplastides, and serve to produce starch-grains at the expense of assimilated matters; others become chloroplastides to produce assimilated matter; while still others are to furnish colors to flowers and fruits. This simplest of all organs is therefore capable of wide metamorphosis, by which it becomes fitted for its diverse functions.

Nor is this all. The same plastide can become at different stages of its life a leuco-, a chloro-, and a chromo-plastide. But which of these is the primal form? To this the author answers unequivocally, the chloroplastide; and he believes that the others have all been derived therefrom. Reserving some of the other features of this suggestive paper for another notice, it may be said that the terms proposed by Schimper are quite equivalent to those given by Van Tieghem in his Botany, now in course of publication, as *leucites* and *chloroleucites*, and, in part, to his *xantho-leucites;* but, so far as their development is concerned, the latter author follows the accepted view of Gris. G. L. GOODALE.

LETTERS TO THE EDITOR.

Molluscan rock-boring.

IN giving lectures upon building-stones my attention has been often called to the action upon them of boring mollusks, echini, annelids, sponges, etc., when used in submarine constructions.

In Albany Hancock's paper on the above subject (*Ann. mag. nat. hist.*, (2), ii. 225, pl. viii.), are figured numerous siliceous grains, found about the foot and mantel, which he regarded as secreted by the mollusk, and employed in excavating the burrow. While Hancock's conclusions are generally denied, I have not seen any explanation of the observed particles. The forms figured by him, especially in fig. 6, resemble the grains (principally quartz) observed in the microscopic study of mud and other earthy deposits. Such grains would naturally be the result and not the cause of the rock excavation; and it is difficult to see how the animal could be in the position in which it is found, without their presence about it.

Perhaps some zoölogist can state if this explanation has been given before, and whether it be correct or not. M. E. WADSWORTH.

Cambridge, Mass., April 30, 1883.

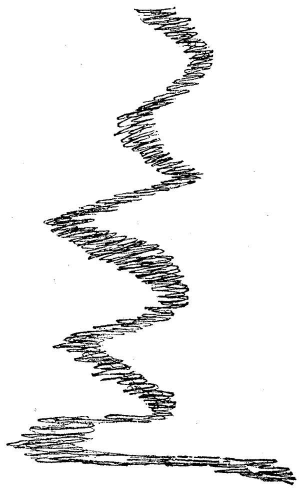
The Lake Superior rocks.

Prof. N. H. Winchell is evidently right in saying, in SCIENCE, No. 12, that, in my letter in No. 5, I misrepresented his position on the unconformity in the St. Croix valley. I had said that he had strenuously denied this unconformity, because my recollection of a conversation on the subject, held with him in 1880, was to that effect. But, on turning to the reference he gives in his First annual report of the geological survey of Minnesota, I see that he had announced such an unconformity as long ago as 1872, which, of course, I should have known before; so that I must have misunderstood him.

As to the other matter, — viz., the relation of the 'St. Croix' or Potsdam sandstone of the Mississippi valley to the 'eastern sandstone' of Lake Superior, — I certainly have understood from his various reports, that he regarded them as distinct. But I am very glad to be set right on these points, though regretting very much having misunderstood Professor Winchell; for it narrows down the question at issue between us very materially. R. D. IRVING.

Track of meteor.

In your first number, Feb. 9, 1883, I saw an account of a meteor witnessed by Capt. Belknap of the U. S. S. Alaska, Dec. 15, 1882, and reference to a similar phenomenon seen at Lake Winnipeg June 29, 1860. On the evening of June 17, 1873, in early twilight, and before any stars were visible, upon coming out of my hotel in Vienna, I found a crowd of persons watching a similar phenomenon, which appeared to be just north of the Kahlenberg. Upon inquiry, I learned that a meteor had been seen to fall a few moments before, but without noise; and a subsequent watch of the daily papers gave no account of any meteorite, which could hardly have escaped observation in this settled section of Austria. It would appear, therefore, that this meteor must have been entirely dissipated in vapor before reaching the earth.



When I first saw the luminous track, I at once supposed it, from appearance and color, to be the flame from a distant zinc-furnace; but it was gradually changed from its straight course to a curved line closely resembling fig. 3 in SCIENCE, No. 1, p. 5, and appeared to be borne to and fro by the gentle currents of air. It extended fully 30° from the horizon, and was distinctly visible for half an hour after my attention was first called to it. From a letter sent by me the next day to a friend in this country, the above facts are taken, in which letter I roughly sketched the appearance of the luminous cloud, after a few minutes from the fall of the meteor, as shown by the accompanying cut. PETER COLLIER.

AUGUSTUS DE MORGAN.

Memoir of Augustus de Morgan; with selections from his letters. By his wife, SOPHIA ELIZABETH DE MORGAN. London, *Longmans, Green, & Co.*, 1882. 10, 422 p., portr. 8°.

IF the degree of interest which attaches to the life of a hard-working mathematician is, from the nature of the case, less than strong; if the biography of De Morgan is in this respect in marked contrast to that of a man whose life is a picture of his time, and who has had himself a distinct effect upon his time, — to the life, say, of Harriet Martineau, which was included within nearly the same years as the life before us, — it is none the less true