am standing a little on one side. They go away in the distance' so that 100 is the farthest number I can see distinctly. It is dusky grey, and paler near to me; up to 20 it occupies a disproportionate size. There are sorts of woolly lumps at the tens. These pictures are not of such frequent occurrence in my mind as formerly. The practice of working arithmetic has rather expelled them.

Since the foregoing remarks were first sent to the printer, many additional cases have reached me, which I regret to have no space left to include. One very interesting group consists of three cousins and the daughter of one of them. Another case was brought to my notice by a correspondent; it was published in the *Atlantic Monthly*, February, 1873, p. 199, with an accompanying diagram, and is signed by Miss H. R. Hudson. I have little doubt that many allusions to the faculty of visualising numerals in diagrammatic and coloured shapes might be found to exist scattered here and there in various books.

Of the many results to be drawn from the foregoing extracts, I do not at present care to dwell upon more than these. In the first place I am sure that all will agree with me in saying that the descriptions bear evident marks of careful and trustworthy observation. In the second place, although they refer to characteristics which the majority of my readers may not possess, their language is sufficiently clear to convey a good idea of what is meant to be conveyed. In the third place, these independent statements powerfully corroborate and explain one another. Therefore, although philosophers may have written to show the impossibility of our discovering what goes on in the minds of others, I maintain an opposite opinion. I do not see why the report of a person upon his own mind should not be as intelligible and trustworthy as that of a traveller upon a new country, whose landscapes and inhabitants are of a different type to any which we ourselves have seen. It appears to me that inquiries into the mental constitution of other people is a most fertile field for exploration, especially as there is so much in the facts adduced here, as well as elsewhere, to show that original differences in mental constitution are permanent, being little modified by the accidents of education, and that they are strongly hereditary.

I trust, therefore, that the publication of this memoir may prove to be the means of inducing some persons to furnish me with information of the kind I am now seeking. I want to hear of well-marked and properly-authenticated instances of persons who are able to recall, or represent to their imagination, with great vividness, either sights, sounds, smells, or tastes, and to obtain information that may throw light on the peculiarities of the representative faculty in different families and races.

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ON A MODE OF EXPLAINING THE TRANSVERSE VIBRATIONS OF LIGHT

THERE has been considerable difficulty in arriving at a satisfactory conception of the means by which the transverse vibrations of light are produced in the ether. In the attempt to surmount this difficulty some have gone so far as to conjecture that this structure of the ether must resemble that of a *solid;* for it was imagined that nothing but such a structure could propagate transverse vibrations. Yet the supposition of the ether being anything like a solid appears to be in direct antagonism to the evidence of our senses; for we move about so freely in this "solid" as to be unconscious even of its existence.

My object here is to direct attention more especially to a suggestion thrown out by the late Prof. Clerk Maxwell in regard to this point. This suggestion is contained in the article, "Ether," in the new edition of the "Encyclopædia Britannica," in connection with a notice of a theory of the constitution of the ether (considered in special relation to the problem of gravitation) by the present writer, and published in the *Philosophical Magazine* for September and November, 1877, and February, 1878. After referring to the fact that the present writer "has supposed that the ether is like a gas whose molecules very rarely interfere with each other, so that their mean path is far greater than any planetary distances," Prof. Maxwell continues as follows:—

"He has not investigated the properties of such a medium with any degree of completeness, but it is easy to see that we might form a theory in which the molecules[1] [atoms of ether] *never* interfere with each other's motion of translation, but travel in all directions with the velocity of light; and if we further suppose that vibrating bodies have the power of impressing on these atoms of ether some vector property (such as rotation about an axis) which does not interfere with their motion of translation, and which is then carried along by the atoms of ether, and if the alternation of the average value of this vector for all the atoms of ether within an element of volume be the process which we call light, then the equations which express this average will be of the same form as that which expresses the displacement in the ordinary theory."

There is one point in the above suggestion I would briefly remark upon, viz., the supposition made by Prof. Maxwell that the atoms of ether "*never* interfere with each other's motion of translation" [*i.e.*, never encounter each other]. This supposition seems to have been called for by the fact previously mentioned in the same article ("Encyc. Brit.," p. 572), viz., that "the ether transmits transverse vibrations to very great distances without sensible loss of energy by dissipation," whereas it is contended that if the ether atoms encountered each other (frequently at least), "the energy of the regular vibrations would be frittered away into that of the irregular agitation which we call heat." But I would venture to suggest that, as we have no proof that no dissipation *whatever* of the energy of light takes place in long distances (but perhaps even some indication to the contrary), it would appear evident that no necessity really exists for supposing that the atoms of ether *never* interfere with each other's motion of translation. I think it will be admitted as a reasonable conclusion that so long as the dissipation of the energy (of the light) attendant on the mutual encounters of the ether atoms is no greater than observation allows us to suppose it to be, all conditions are satisfied. Moreover, it would seem that to suppose the ether atoms *never* to interfere with each other's motion of translation would be equivalent to assuming that their mean path is *indefinitely* great, which appears to involve the assumption that the atoms have no finite size or dimensions, which would put a difficulty in the way of a satisfactory or consistent conception of matter. On this ground I would therefore suggest that the atoms of ether may be considered to have a reasonably long free path [which may be conceived as great as we please, by simply conceiving the atoms small], and thus the dissipation of the energy of the light may be reduced within the limits required by observation. This does not alter in the least in its essential details the above suggestion by Prof. Maxwell as to the mode of production of the transverse vibrations of light, which I would accordingly enlarge upon and elaborate somewhat here (in connection with the special structure of gross matter required by the physical theory of gravity). First it is important to observe that many observed facts lead us to infer that gross matter (probably the molecules[2] themselves) possesses a more or less *open* structure (or possesses a high degree of porosity). The transparency of some bodies, the free passage of the magnetic disturbance through all bodies,

[1] I merely substitute "atoms of ether" in the above passage for "molecules," to avoid any possible ambiguity, as the word "molecules" is often applied to the parts of gross matter.

[2] This is also in harmony with the modern theory of vortex-atoms.

and many other well known independent facts render this inference necessary. The fact that gravity is proportional to mass, on the basis of the dynamical theory (first started by Le Sage) also renders it essential to conclude that gross matter possesses an open structure [so that the atoms producing gravity can penetrate and act upon the interior of bodies]. If we admit this, and figure to ourselves the streams of ether atoms passing in all directions freely through the open structure of gross matter, and further, if we conceive the molecules of gross matter to be in a state of vibration (of regular periods, as proved by the spectroscope), then it is evident that these streams of ether atoms during their passage can, from the very nature of the case, be solely effected by the *transverse* component of the motion of the molecules of the luminous body. It is much as if the meshes of a sieve were in vibration, and a continuous stream of fine particles of sand (impelled by a current of air) were urged through it, when in however many different directions the filament forming the meshes of the sieve might be conceived to be vibrating, the sand particles that passed through in the onward stream could be only affected by the *transverse* component of the motion of the meshes. So the atoms of ether in their passage through the vibrating molecules of gross matter are solely affected by the *transverse* component of the motion of the molecules. The ether atoms passing through the open structure of gross matter would be thus periodically deflected (or the ether atom itself thrown into vibration or rotation), and as the transverse impulses (whatever their exact nature) thus received by the stream of ether atoms would be perfectly ryhthmical or periodic, in harmony with the known periodic vibrations of the molecules through which the ether atoms pass, the *transverse* pulsatory or periodic nature of light would thus be produced. This view would also seem to be capable of surmounting in a very simple manner the difficulty that there has been in conceiving how the ether can transmit transverse vibrations to great distances without sensible loss of energy by dissipation. For it is evident that an ether atom after having passed through a luminous body and received energy from it, would have nothing[1] to give that energy (say vibration or rotation) to during its transit, since, by assuming the ether atom small, we may conceive its mean path as long as we please; so, therefore, the energy carried by the ether atom from the luminous body could not possibly be dissipated during the transit of the atom, but this energy would be carried intact by the ether atom (through its normal motion of translation) until the distant object is reached, where the energy is given up in the form of heat and light. The normal motion of translation possessed by the ether atom performs the part of simple carrier of the energy received by the atom from the luminous body.

It might possibly be thought at first sight that this theory had some resemblance in principle to the emission theory of light, but this is evidently not the case, as no atoms are emitted by the luminous body, but simply the atoms of ether in their normal state of translatory motion pass through objects in streams equally in all directions —the ether being regarded simply as a gas (according to the modern kinetic theory) with atoms of very long free path. It is a known mathematical fact that no consequence how close the atoms of ether may be together (*i.e.*, no consequence how many in unit of volume) their mean path may become as great as we please, by simply conceiving the atoms adequately small. It further follows from the known principles investigated in connection with the kinetic theory of gases, that these atoms will of themselves automatically adjust their motions so as to move with perfect uniformity or *equally in all directions*; this adjustment being of such a rigid character that if the atoms were imagined to be disturbed or made to move in the most chaotic manner, they would, when left to themselves, instantly correct the irregularity, and return to the above regular form of motion, *i.e.*, so that the atoms move *equally in all directions*. It follows from this, therefore, that if we take any given point (such as where a luminous body is situated), the atoms of ether will "radiate" from and to this point along all the imaginary radii of a sphere described from this point as a centre; so that those ether atoms which have passed through the luminous point (and have carried energy off with them) will diminish in number (per unit of spherical area) as the *square* of the radial distance from the luminous point, the energy, therefore, diminishing in the same ratio, which is the "law" of light. The "law" of gravity (which is found also to diminish as the *square* of the distance) may be accounted for on the same principle.

It has been shown by the present writer (in the papers published in the *Phil. Mag.* previously alluded to) that in accepting Le Sage's ingenious sheltering principle as the fundamental basis of the explanation of gravity, there is no necessity for admitting any of his postulates regarding the particular motions of the atoms (corpuscles) required to produce the result. For it may be shown that the whole of the conditions requisite for gravity will automatically fulfil themselves by simply admitting the existence of a body in space, constituted according to the kinetic theory of gases (and whose atoms have an adequately long free path). There is no necessity to suppose, with Le Sage, the existence of "ultramundane corpuscles," or that the atoms producing gravity come from outside the bounds of the visible universe, so that a continuous supply of matter from without is necessary to maintain gravity within the confines of the visible universe. On the contrary, the conditions are satisfied by merely supposing the universe to be immersed in a gas, which, *as a whole* (like any other gas) is at rest. The motion (in streams) requisite for gravity takes place solely *within the range of free path* of the atoms of the gas; just (as is known) in every ordinary gas the atoms within the range of free path are moving in streams equally in all directions. The only difference is that in the case of the ether, on account of the smallness of the atoms (which is in harmony with their high velocity), the range of free path is great—equal to the range of gravity. We have no proof that the range of gravity extends across stellar distances, and there is clearly no necessity for assuming it to prevail over greater distances than observation warrants. By the explanation of gravity by the physical theory, the remarkable and anomalous distinction between *two kinds* of matter ("ponderable" and "imponderable") vanishes. Matter is shown of its essence to be all alike, "ponderability," or the tendency to approach, not being an occult or magic quality, but simply an effect dependent on differing dynamical conditions,[1] and the variation of the intensity of which as the *square* of the distance it is as necessary to account for dynamically as in the analogous case of light.

It appears, therefore, from the above considerations, that the same medium shows itself to be capable of accounting for, in their essential groundwork, the phenomena of both gravity and the propagation of light. The theory of gravity is based upon the well-known sheltering principle of Le Sage, which has already found favour with some eminent physicists. The normal translatory motion of the atoms of the medium produces gravity, and this motion serves as a vehicle for the propagation of light, while the light itself consists in the

[1] This holds equally true, whether we conceive space as empty, or space to be filled with a perfect (frictionless) liquid that *plays the exact part of empty space*, in so far as it is known to be impossible to operate upon or communicate energy to such a liquid.

[1] The fact of the property of "ponderability" having been attributed to gross matter as an occult quality (not an effect depending on dynamical conditions), has naturally brought the ether—which does not possess this property—into direct contrast with gross matter, as if it were an anomalous substance, of its essence distinct from gross matter. This circumstance has no doubt naturally contributed to produce a distaste for the study of the ether and to cause some to treat this magnificent physical agent as if it were desired rather to ignore than to take a rational interest in its existence.

abnormal *transverse* disturbance produced in the streams of atoms in their passage through the vibrating molecules of luminous bodies.

Finally, it may be shown that, quite independently of any consideration of the effects of gravity and light, the inference is a necessary one that the constitution of the ether must in principle be that of a gas, because this solution to the problem of the constitution of the ether exhausts the limits of the conceivable: *i.e.*, if any *rational* solution to the problem or *explanation* capable of appreciation by the reason exists, then it would follow that this must be the true solution to the problem. This will become more and more evident on reflecting on the subject. For it is clear that a motion *in straight lines* is the only motion possible to particles of matter moving freely in space; for particles of matter cannot of themselves change the directions of their motions. They can only do this at their encounters. Hence the inference is necessary that the particles of ether move *in straight lines* (and therefore that the ether is constituted as a gas). Hence in principle it seems apparent that the above is essentially the only conceivable solution of which the problem of the constitution of the ether admits. It seems remarkable that this fact (important as it is) is not more generally recognised and appreciated. Can this be referable in any way to the influence the theory of "action at a distance" has had, and that the endless empty and profitless speculations arising therefrom have diverted attention from the subject?

It might be said that we have expressly assumed the existence of "particles" (or atoms) of matter in the above result as to the constitution of the ether, whereas some might contend that the ether is not *atomic* at all. My answer to this is, that unless we assume the ether to be atomic,[1] we cannot give any explanation of its properties, and these properties can exist solely in virtue of the explanation that underlies them. In connection with this the following remark of Prof. Clerk Maxwell ("On the Dynamical Theory of Gases," *Phil. Trans.*, 1867, p. 49) may be quoted, as to the point:—

"In certain applications of mathematics to physical questions, it is convenient to suppose bodies homogeneous, . . . but I am not aware that any theory of this kind has been proposed to account for the different properties of bodies. Indeed, the properties of a body supposed to be a uniform *plenum* may be affirmed dogmatically, but cannot be explained mathematically."

Hence to assume the ether to be anything else than *atomic*, would be to affirm its properties "dogmatically." If we avoid this, therefore, we must consider it *atomic* (and therefore a gas): for (as we pointed out), atoms in free motion can only move *in straight lines*. It is of course evident that, unless the atoms of ether be *in motion*, we cannot account for any of its properties, unless, indeed, we resort to the now practically defunct theory of "action at a distance," and assume the atoms to be endowed with mysterious and occult powers, which renders any *explanation* impossible, and only increases instead of diminishing the difficulty.

To illustrate somewhat further the insuperable nature of the difficulty involved, unless we assume the atoms of ether to be in motion in their normal state, I quote the following passage from a lecture by Prof. Tait on "The Position and Prospects of Physical Science," delivered November 7, 1860 (p. 15 in pamphlet):—

"If we suppose it [the ether] to consist . . . of detached particles . . . we are met by the further difficulty, *how* do these particles act on each other, and without some such action there could be no transmission of motion—they are not in contact, there must therefore be something between them to convey the effect. This appears certain, for how can action be conceived as exerted across empty space?"

I will merely here remark parenthetically that the fact appears to have escaped notice here that this difficulty is got over by assuming the particles (of ether) to be *in motion;* for then the particles can act on each other by direct impact without the necessity for anything "between them to convey the effect." The passage goes on to say:—

"We must, therefore, have a second medium to fill the interstices between the particles of ether. If this again consist of detached particles, there will be a third required that these may act on each other—and so on. If, then, we would not have an infinite number of different kinds of matter in each element of space, we must suppose one of these—say the ether itself—to be *continuous*, that is, not consisting of ultimate parts. *How* vibratory motions could be transmitted through such a substance, it is difficult to imagine—the whole subject is beset with overwhelming difficulties."

In the above passage the difficulties that attend the assumption of the ether being a *continuous* substance, or uniform *plenum*, are well illustrated. It will be seen that the main dilemma vanishes by assuming the particles of ether to be *in motion* in their normal state. Indeed, this is evidently the only conceivable way of solving the difficulty.

I would, therefore, venture to suggest that the result above arrived at as a solution to the problem of the constitution of the ether might be worthy of the attention of physicists, especially in its bearing on the explanation of gravity (on the basis of Le Sage's fundamental principle now recognised by several eminent authorities, including Sir W. Thomson)—also in relation to a mode of explaining the *transverse* vibrations of light, the main idea involved in which was suggested by Prof. Clerk Maxwell.

Addendum.—I may mention that I have lately received a book ("Das Räthsel von der Schwerkraft"—Wieweg und Sohn, Braunschweig) through the kindness of the author, Dr. Isenkrahe, of Crefeld, where a theory is applied to the constitution of the ether and to gravity, which resembles in some points that adopted by the present writer. This book bears date 1879, but the MS. was prepared earlier (1877). I may note that a book, "Physics of the Ether" (E. and F. N. Spon), was published by me in 1875, where in principle the same theory of the ether as here given is developed, though it was not applied by me to gravity until 1877. The work of Dr. Isenkrahe contains, in addition, a valuable description and criticism of the various attempts to solve the problem of gravitation. Perhaps I may append, for the benefit of those who are interested in the question, the references to some of the chief of these here, viz.:—

Huyghens' "Discours sur la Cause de la Pesanteur." Leyden, 1690.

Le Sage's theory 1764, given in "Deux Traités de Physique mécanique," by Pierre Prevost.

Sir W. Thomson's development of Le Sage's theory, Royal Society of Edinburgh, 1872, and *Philosophical Magazine*, May, 1873.

Schramm, "Die allgemeine Bewegung der Materie als Grundursache der Naturerscheinungen," Vienna, 1872.

Secchi, "Die Einheit der Naturkrafte" (German edition). Leipzig, 1876.

These facts may show an awakening to the importance of the problem of gravitation, and I may conclude with

[1] It is almost needless to add that the vortex-atom theory is essentially an *atomic* theory. Although it assumes a perfect liquid to fill all space, yet this liquid (outside the portions of it that form the atoms) plays the part of pure space, since it is impossible to communicate energy to the liquid outside the atoms, or to act upon it at all. It is therefore (as far as practical effects are concerned) as if the liquid exterior to the atoms did not exist. The vortex-atom theory does not, therefore, essentially alter (as some might be disposed to imagine) the conceptions of the ancients of indestructible atoms surrounded by space in which they can freely move. The main purpose of the vortex-atom theory is to prove dynamically how atoms can be "*elastic*," and be capable of executing regular vibrations as the spectroscope proves (and actually measures the number of vibrations executed per second, in the case of the molecules of gross matter).

the words of Dr. Isenkrahe [translation]: "One is beginning to recognise that physics has been quietly sleeping for two centuries upon [in the words of Newton] 'a great absurdity,' for which no one less than Newton can be made responsible" [page 125].

S. TOLVER PRESTON

THE NATURAL HISTORY OF THE TRANSIT OF VENUS EXPEDITION[1]

IN 1870 one of our correspondents called attention[2] to the favourable opportunity that would then shortly present itself for the exploration of some very little known parts of the earth's surface. Some of the positions selected by our astronomers for the observation of the Transit of Venus of 1874 were in little known islands of the Pacific and Indian Oceans, and it was pointed out that the addition to the astronomers' staff of a small corps of naturalists would not materially increase the expenditure, and would possibly lead to very interesting scientific results.

The same subject was brought before the notice of the British Association at their Meeting in 1871 by Mr. Sclater,[3] who likewise suggested that so good a chance of adding to our knowledge of the natural history of some of the least known parts of the world should not be thrown away, and urged that Naturalists should be appointed to at least three of the stations to be occupied by the astronomers, namely Kerguelen Island, Rodriguez and the Sandwich Islands.

Subsequently the same idea was taken up by the Council of the Royal Society, who resolved to request the Treasury to attach naturalists to the expeditions destined for the two first above-named localities—"two of the least explored and most inaccessible islands in the southern hemisphere"—and appointed a committee consisting of Sir Joseph Hooker, Prof. Huxley, and Mr. Sclater. to prepare the necessary application to the Government for this purpose. We need not now repeat the arguments which these gentlemen brought before Her Majesty's chief advisers—it is enough to say that they were of a sufficiently cogent character to obtain the sanction of the Treasury to the appointment of four naturalists for the purposes required; three for Rodriguez and one for Kerguelen's Land.

The gentlemen selected for the work by the Council of the Royal Society were for Rodriguez, Mr. George Gulliver, Dr. I. B. Balfour, and Mr. H. H. Slater, and for Kerguelen's Land the Rev. A. E. Eaton. Mr. Gulliver was directed to investigate the fauna of Rodriguez generally, Dr. Balfour was charged with the duties of botanist and geologist, and Mr. Slater was set to dig out the caves of the same island, and to collect the fossil remains of extinct birds known to be imbedded in them. Mr. Eaton was thought to be specially qualified to investigate the fauna and flora of Kerguelen's Land, as having been previously naturalist to one of the Arctic expeditions.

The collections and observations made by these naturalists fulfilled, as we are informed, the expectations of the Council. The results of them are given in the present work, which is issued as an extra volume (No. 168) of the *Philosophical Transactions*.

The plan upon which the collections were worked out, and which is in fact the only plan upon which a mass of heterogeneous materials can be properly worked out now-a-days, is an admirable one. The different objects were assigned for examination to experts in different branches of science, each of whom has prepared his own report on what was submitted to him. These reports, prefaced by a few introductory remarks, and illustrated by notes of the collectors, constitute the volume now before us. It is divided into two sections, the first relating to Kerguelen, and the second to Rodriguez.

After a chapter by Mr. Eaton on the physical features of Kerguelen, and on the previous visits to it by naturalists, we find a series of essays on the botany by Sir J. Hooker, Mr. Mitten, the Rev. J. M. Crombie, Dr. Dickie, and other well-known authorities. Then follows a similar series of memoirs upon the zoology of the same island.

The zoological and botanical collections made in Rodriguez are next treated of in the same way, and we have here also a valuable memoir on the petrology of Rodriguez by Mr. N. S. Maskelyne. From the last-named essay it turns out that the notion that this island consists of "granite overlaid with limestone, and other recent rocks," which was entertained by the Committee of the Royal Society, misled by previous inaccurate observations, is altogether erroneous. Mr. Maskelyne tells us that "the numerous specimens illustrating the rock formations of the Isle of Rodriguez, collected by Mr. I. Bayley Balfour from different localities, need only a cursory inspection to attest the volcanic character of the whole mass of the island.

"Rodriguez, in fact, consists of doleritic lavas that appear to have been poured out at a considerable number of volcanic orifices at successive periods. It would be difficult, without more minute description of the physical geography of the island than is accessible, to assign any precise date of duration to these volcanic eruptions, or to trace with any certainty the degree to which, and the mode in which, subsequent denudation has helped in giving the island its present remarkable aspect.

"But the fact of that denudation and the degree to which alteration has proceeded in affecting the minerals composing rocks that by their position must have been among the later of the out-poured lavas, would point to a remote date, possibly to one contemporary with the tertiary period, as that of the volcanic activity of Rodriguez."

We have not space here to go separately into the numerous essays that compose this work. For many of them, the name of the author is quite sufficient to assure us of their excellence, some of the most accomplished naturalists of the present epoch having contributed to the volume. But it is quite evident that a thoroughly good and satisfactory piece of scientific work has been thus accomplished at a very small cost, and that the council of the Royal Society, who planned the whole scheme and carried it out, and especially those two members of it (Sir J. Hooker and Dr. Günther), who have so efficiently edited this account of the results attained, are entitled to the warmest thanks of all naturalists. Several other nations sent out expeditions to observe the Transit of 1874, and likewise had naturalists attached to their staffs, who have published some valuable observations. But nothing like the handsome and solid volume now before us, with its fifty-five admirably executed lithographic plates, has been produced on this occasion in France, Germany, or America. There are certainly some advantages in having a Royal Society at the head of Science instead of a Royal Academy!

Having said this much, we will venture on two small criticisms:—First, it is a great pity that there are no *maps* given in the volume now before us. Without reference to maps it is not possible to appreciate the significance of many of the observations made by the naturalists, and as no generally available atlas contains charts of such obscure islets as Rodriguez and Kerguelen, maps ought to have been attached to the work itself. In fact, every zoo-geographical memoir now-a-days ought to be illustrated by a map.

[1] "An Account of the Petrological, Botanical, and Zoological Collections made in Kerguelen's Land and Rodriguez during the Transit of Venus Expeditions, carried out by Order of Her Majesty's Government in the Years 1874-75." *Philosophical Transactions* of the Royal Society of London, vol. clxviii. Extra volume, 1879.

[2] See article on the Transits of Venus in 1874 and 1882. NATURE, vol. i., p. 526.

[3] See "Remarks on a Favourable Occasion for the Establishment of Zoological Observatories." By P. L. Sclater, M.A., Ph.D., F.R.S. Rep. Brit. Ass., 1871, pt. ii., p. 134.