orientation is at all known, is examined by it, fails, except in rare cases, to be a certain guide to even the system to which such minute crystals belong. It was found that the only satisfactory way of dealing with the problem, was by employing the microscope chiefly as a means of selecting and assorting out of the bruised débris of a part of the meteorite, the various minerals that compose it and then investigating each separately by means of the goniometer and by analysis—finally recurring to the microscopic sections to identify and recognise the minerals so investigated. The present memoir is concerned with the former part of this inquiry. Obviously the amount of each mineral that can be so obtained is necessarily small, as only very small amounts of a meteorite can be spared for the purpose. On this account one has to operate with the greatest caution in performing the analysis of such minerals and the desirableness of determining the silica with more precision than usually is the case in operations on such minute quantities of a silicate, suggested the process which, after several experiments in perfecting it, assumed the following form. After the separation, by alternate treatment with hydrogen chloride and potash, of all silicate that gelatinises with acid, the pounded and weighed mineral was placed in a small retort of platinum with a little ball of the same metal and digested with an excess of pure hydrogen fluoride, containing some 32 per cent. of absolute acid, for two hours, at 100° C. By little platinum delivery tubes with which the retort was provided, a current of hydrogen was allowed to traverse the apparatus and afterwards to bubble through some concentrated aqueous solution of ammonia. After the lapse of the two hours the retort was placed in a bath of paraffin and its temperature slowly raised till 132° C. was reached, at which point the silicium difluoride is evolved and is carried by the current of gas into the ammonia. In a few minutes the operation is complete and it must be repeated with fresh charges of acid and ammonia, till all silicium has been driven into the receiver. This done, a little hydrogen sulphate is introduced into the retort and the retort once again heated in paraffin. If 0.2 gramme of silicate be taken, twice charging of the retort with hydrogen fluoride will suffice; if half a gramme, the process may have to be repeated three or four times. The greater portion of silicium is removed by the first operation and the ammonia becomes semi-solid with deposited gelatinous silica. This is slowly evaporated together with the later ammoniacal charges and the washings of delivery tube and receiver in a platinum dish, and, as the excess of ammonia passes off, a point is reached where the last flock of suspended silica is taken up by the hot solution; the dish is now removed from the water-bath and to its contents, when cold, are added a slight excess of potassium chloride and the requisite volume of absolute alcohol. After 24 hours have elapsed, the precipitated potassium hydro-fluoride is filtered off and weighed in the usual manner. The metallic oxides present in the mineral, remain in the retort as sulphates.

The Busti Meteorite.—This meteorite fell on the 2nd of December, 1852, about six miles south of Busti, a station half-way between Goruckpoor and Fyzabad, in India. The fall was attended by an explosion louder than a thunder-clap and lasting from three to five minutes. The explosion that shattered the meteorite, must have occurred soon after its passing the longitude of Goruckpoor. There was no cloud in the sky at the time. The stone, which weighed about 3lb., was presented to the collection at the British Museum by the Secretary of State for India. The Busti aërolite bears a great resemblance to the stone that fell on the 25th of March, 1843, at Bishopsville, South Carolina, U.S.

The meteorite consists for the most part of the mineral enstatite; at one end, however, were embedded a number of small chestnut-brown spherules, in which again one detected minute octahedral crystals, having the lustre and colour of gold. These two minerals seem scarcely to have been affected by the heat that fused the silicates which surround and encrust them. The brown spherules are sulphide of calcium (named by the author Oldhamite) and they also occur sparsely in the Bishopsville aërolite. This mineral forms small, nearly round spherules, whose outer surface is generally coated with calcium sulphate. It cleaves with equal facility in three directions, which give normal angles averaging 89° 57' and are no doubt really 90°. Its system, therefore, is cubic; indeed, in polarised light it is seen to be devoid of double refraction. Its specific gravity is 2.58 and its hardness 3.5 to 4. With boiling water it yields calcium polysulphides and in acids it easily dissolves with

evolution of hydrogen sulphide. Chemical analysis indicated the following as the composition of the spherules:—

	I.	II.
Oldhamite { Calcium monosulphide	89.369	90.244
Magnesium monosulphide	3.246	3.264
Gypsum	3.951	4.189
Calcium carbonate	3.434	—
Troilite	—	2.303
	100.000	100.000

The presence of such a sulphide in a meteorite, shows that the conditions under which the ingredients of the rock took their present form, are unlike those met with in our globe. Water and oxygen must have alike been absent. The existence of iron in a state of minute division, as often found in meteorites, leads to a similar conclusion. But, if we bear in mind the conditions necessary for the formation of pure calcium sulphide, the evidence imported into this inquiry by the Busti aërolite seems further to point to the presence of a reducing agent during the formation of its constituent minerals; whilst the crystalline structure of the Oldhamite and of the Osbornite next described must certainly have been the result of fusion at an enormous temperature. The detection of hydrogen in meteoric iron by Professor Graham tends to confirm the probability of the presence of such a reducing agent. Osbornite is the name given by the author to the golden-yellow microscopic octahedra imbedded in the Oldhamite, in honour of Mr. Osborne and in commemoration of the important service that gentleman rendered to science in preserving and transmitting to London, in its entirety, the stone which his zeal saved at the time of its fall. These minute octahedra gave the angles of the regular octahedron; but the amount, about 0.002 gramme, was too small for anything but qualitative experiments. These showed the little metallic-looking crystals to contain calcium, sulphur and a metal which gives the reactions of titanium in some singularly stable state of combination. The next mineral described was an augite, of which the measurements and analyses were given in detail. Its formula was ($\frac{2}{3}$ Mg, $\frac{1}{3}$ Ca) Si O₃. The greater part of the meteorite, however, consisted of enstatite, which presents itself in three apparently different characters: in each, however, the mineral is nearly pure magnesium monosilicate. Of this mineral, the measurements and analyses were recorded. The iron contained in small amount in this remarkable meteorite, gave as the result of its analysis 79.069 per cent. iron, 3.205 nickel, and 1.00 per cent. schreibersite.

The Manegaum Meteorite of 1843 was next described and was shown to consist almost entirely of an enstatite, with the formula ($\frac{2}{3}$ Mg, $\frac{1}{3}$ Fe) Si O₃, associated with small quantities of Chromite and of meteoric iron. In publishing the results obtained in the attempt, so far as this memoir goes, to treat exhaustively of the mineralogy of two important meteorites, the author wished to record his obligations to Dr. Flight, assistant in his department at the British Museum, for his valuable aid in the chemical portion of the inquiry.

In March, last year, Prof. Maskelyne recorded in a preliminary note, read before the Society, his discovery in the Meteorite of Breitenbach, of silica in the rhombic system with the specific gravity of fused quartz. It was associated with enstatite with the formula ($\frac{2}{3}$ Mg, $\frac{1}{3}$ Fe) Si O₃. It is singular that the measurements of the crystals of this enstatite, made at the British Museum and published by Prof. Viktor von Lang (Sitzungsb. Akad. Wien, vol. lix., 1869, p. 848), accord closely with those recently published by Von Rath as the crystallographic constants of a kind of enstatite to which he has given the name Amblystegite.

LETTERS TO THE EDITOR

[The Editor does not hold himself responsible for opinions expressed by his Correspondents. No notice is taken of anonymous communications.]

Japanese Sea Shells

SINCE writing the notice of Dr. Lischke's work which appeared in No. 13 of NATURE, I have received from Dr. Lea of Philadelphia a typical specimen of his genus *Hippagus* and the volume of his "Contributions to Geology." For such a valuable communication I would publicly acknowledge my obligation to that veteran conchologist. I was misled by Philippi and Searles Wood, in considering *Hippagus* and *Verticordia* the

same genus. *Hippagus* is closely allied to *Crenella*, as the latter is represented by *C. glandula* of Totten and, indeed, I cannot detect any character to distinguish them generically. These agree in shape, sculpture, hinge, muscular impressions and inflexion of the beaks. The genus *Verticordia* of S. Wood is very different and belongs to another family, viz. that of *Lyonsia*.

Mr. Arthur Adams informs me that he has several Japanese species, which he believes are also found in the Mediterranean, and I have identified many British species with those of North Japan.

J. GWYN JEFFREYS

An Oversight by Faraday

IT is not often that Faraday committed an oversight; but such I think he must have done in his well-known paper concerning the existence of a limit to vaporisation. ("Experimental Researches in Chemistry and Physics," p. 119.*) Faraday showed experimentally, that mercury emitted no appreciable vapour below 20° F. and accounted for this on the ground that "the elastic force of any vapour which the mercury could have produced at that temperature, was less than the force of gravity upon it and that, consequently, the mercury was then perfectly fixed." He adds, "I think we can hardly doubt that such is the case, at common temperatures, with respect to silver and with all bodies which bear a high temperature without appreciable loss by volatilisation, as platina, gold, iron, nickel, silica, alumina, charcoal, &c., and that, consequently, at common temperatures, no portion of vapour rises from these bodies or surrounds them."

Has not Faraday overlooked the fact that though gravity might prevent the rise of vapour, it would assist the fall of vapour from the sides or under surface of a body suspended *in vacuo*? If Faraday's theory had any grounds in truth, it would be possible to distil a substance from above downwards by the sole force of gravity, but I know of no experiment to support the idea. Were all the other forces which could act upon the molecules, exactly balanced in unstable equilibrium, the force of gravity might undoubtedly upset this equilibrium, so that vapour would be produced from the under surface of a suspended solid when it could not be produced from the upper surface. But a very slight estimation of the forces which may enter into such a problem, shows how unlikely it is that the case could ever happen.

I do not mean to say that the force of tenacity of solid substance, is identical with that which is opposed to volatilisation; but it is possibly comparable with it in amount. Now a copper wire, having a section of one square millimetre, will bear a weight of 90 lbs. and this force of tenacity only acts between portions of metal in absolute contact and continuity. Compare now the weight of a film of copper, say $\frac{1}{100}$ part of a millimetre thick, with the force by which it adheres to the remainder of the mass of copper with which it is continuous. Taking the specific gravity at 8.9, the weight will be, per square millimetre, 0.00089 gramme; the force which would be required to tear it from the remainder of the mass would be, for the same surface, 40819 grammes. The force of tenacity, therefore, exceeds the weight rather more than 450,000,000 (450 million) times. This seems to show that the molecular forces which tend to maintain the integrity of a solid metal, are almost infinitely greater than the gravitation of the same molecules towards the earth. To cause these molecules to fly off in free vapours, we must call in the aid of forces of heat, electricity, or chemical affinity which can cope with the prodigious force of solid cohesion. It is practically impossible that we should ever meet with a case, where these forces were so exactly balanced that the exterior force of gravity, many million times less in amount, should produce a perceptible disturbance.

These considerations do not, however, appear to affect the validity of Wollaston's speculations concerning a definite limit to the earth's atmosphere as caused by the gravity of the aerial particles.

Where are the Nebulæ?

I AM unaffectedly glad to find that one whose opinion has such weight as Mr. Spencer's must have, should have anticipated me in the matters to which he directs your attention in his interesting letter. There can be no question as to his priority; since in 1863 I had not only formed no views respecting the nebulæ; but had no further knowledge of astronomy than I derived from a very faint recollection of what I had learned in a hasty two hours' perusal of Goodwin's Astronomy (Course of

Mathematics) the night before our examination on the subject in the "Three days" at Cambridge.

In considering the subject of the nebulæ recently, however, the points touched on by Mr. Spencer had not escaped me. In five papers in the *Intellectual Observer and Student* called "Notes on Nebulæ," "Notes on Star-streams," and "A New Theory of the Universe" (three parts), I touched on these and many other proofs that the nebulæ are not external galaxies; but part and parcel of the sidereal system.

I have since found that Dr. Whewell, in his "Plurality of Worlds," had adopted the same view. But as a matter of fact, we owe the enunciation of clearly convincing evidence respecting the true nature of the nebulæ to Sir John Herschel; while Sir W. Herschel, when as yet the available evidence was incomplete, indicated his belief that the Orion nebula (amongst others) is within the sidereal system.

Strangely enough, the point first dwelt on by Mr. Spencer was boldly quoted by the Rev. C. Pritchard (V.P.R.A.S.) as a proof that the nebulæ are external galaxies, immediately after I had read my communication on the distribution of the nebulæ to the Astronomical Society. I asked at once if we were to regard those vacant spaces as the spy-holes, so to speak, of the sidereal system, through which alone the nebulæ could be hopefully looked for and Mr. Pritchard said "Yes." Mr. Stone, also, pointed out subsequently, that the glare from the stars might elsewhere obliterate the nebulæ (at least the fainter ones) from view. This would be a point to be attentively considered were it not that in the Nebulæ we have evidence that the glare from many stars does not obliterate faint nebulae.

The second point dwelt on by Mr. Spencer affords a remarkable instance of the way in which considerations that should be perfectly obvious, escape even practised astronomers. Strangely enough, I dwelt on this point, only three days ago, in a letter I addressed (not for publication) to the editor of the *Spectator*. It is commonly understood and stated that telescopes which are only just able to show stars of the tenth, twelfth, or fourteenth magnitude as the case may be, are able to exhibit the component stars of certain external galaxies, which must (according to the theory) be thousands of times farther from us than the fourteenth magnitude stars. Not a thought has been given to the obvious conclusion that these component stars, to be thus visible, must be millions of times larger than the members of our galaxy.

In a letter addressed last August to Sir John Herschel (a portion of the answer to which was quoted in my article in *NATURE* for January 27), I pointed out half-a-century of reasons for believing that the sidereal system is differently constituted than has been supposed and that the nebulæ are not external to it. (This would have involved an egregiously long letter had I been writing to an ordinary correspondent, but in the actual case a few words served sufficiently to indicate each reason.) These reasons were not interdependent—each afforded good and most afforded perfectly sufficient ground for rejecting the accepted theory. In his reply, Sir John (always kind, courteous and encouraging) was good enough to speak of the "number and variety of the striking facts brought together and the evident bearing of a large proportion of them on the great problem offered by the sidereal system to man's contemplation." Amongst the facts which afford the strongest evidence of all, are two I left unnoticed in my late paper, viz., (1) the relatively large proper motion of the fainter stars and (2) the drift of whole groups of stars in a definite direction. These facts apply to the structure of the sidereal system, rather than to the position of the nebulæ; but, as a matter of fact, the two matters are so closely related, that evidence bearing on one carries with it conclusions affecting the other also.

RICHD. A. PROCTOR

February 4

Analogy of Colour and Music

I FIND in your number of January 13 an interesting paper by Mr. Barrett on the Correlation of Colour and Sound. It seems to me that Mr. Barrett depreciates the phenomenon of Newton's rings by saying that the "connection between the relative spaces occupied by each colour and the relative vibrations of the notes of the scale" . . . "cannot be more than a coincidence." The diameters of the rings are functions of the wave-lengths and, therefore, expressions of a physical condition. Mr. Barrett's own process is, to say the least, very rough and, after taking "the mean of two limits," rather wide apart for the length of the waves of each colour, he obtains a series of numbers which

* Phil. Trans. 1826, p. 484.